

**MINNESOTA GEOLOGICAL SURVEY**

*Priscilla Grew, Director*

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**SCIENTIFIC CORE DRILLING IN  
PARTS OF KOOCHICHING, ITASCA, AND  
BELTRAMI COUNTIES, NORTH-CENTRAL  
MINNESOTA, 1987-1989:  
SUMMARY OF LITHOLOGICAL,  
GEOCHEMICAL, AND GEOPHYSICAL RESULTS**

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RESULTS**

**By**

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## INTRODUCTION

This report summarizes the results of scientific core drilling undertaken primarily to gain a better understanding of the bedrock geology in north-central Minnesota. The drilling and concomitant mapping were supported by the Minerals Diversification Program of the state legislature. The study area lies in southern Koochiching, northern Itasca and east-central Beltrami Counties (Figures 1 and 2). This region was selected because data are suggestive of mineral resource potential, but existing geologic maps were too generalized to guide private minerals exploration efforts. The thick cover of glacial deposits in this region requires bedrock geologic mapping to be based largely on the interpretation of geophysical maps. Core drilling and outcrop mapping identify the rock types responsible for the geophysical patterns. It is hoped that geologic mapping by this method will encourage private minerals exploration. In addition, this mapping is an acceleration of on-going efforts by the Minnesota Geological Survey to produce accurate geologic maps of the state to meet existing and future societal, academic and economic needs. The resulting bedrock geologic map at 1:250,000 scale has been released as Minnesota Geological Survey Open-File Report 89-1 which is being reviewed before formal publication. In the course of the drilling program much information was acquired regarding the thickness and lithology of Quaternary surficial deposits and the locally thick weathered bedrock materials (regolith). No formal plans exist at this time to publish an interpretation of these data, but the data are presented here on the geologic logs.

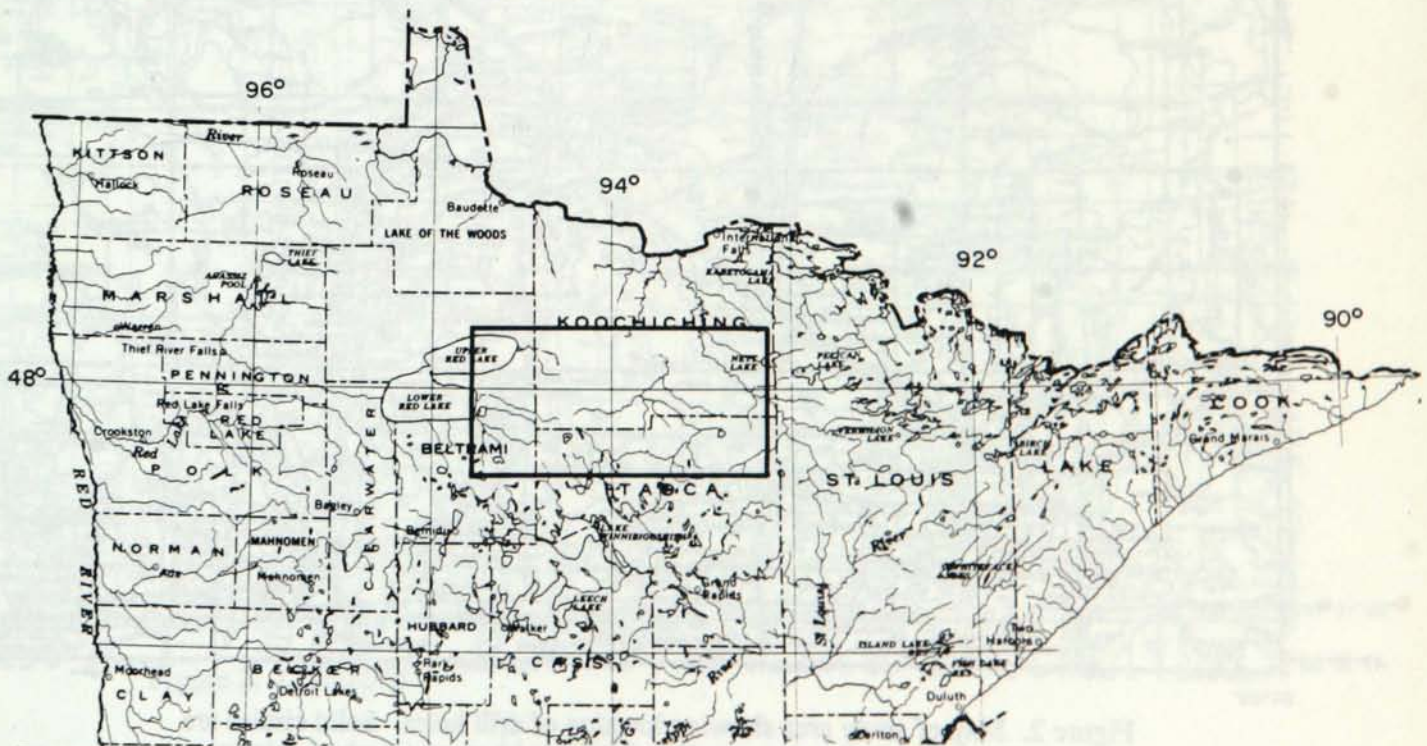


Figure 1. Map of northern Minnesota showing location of study area.

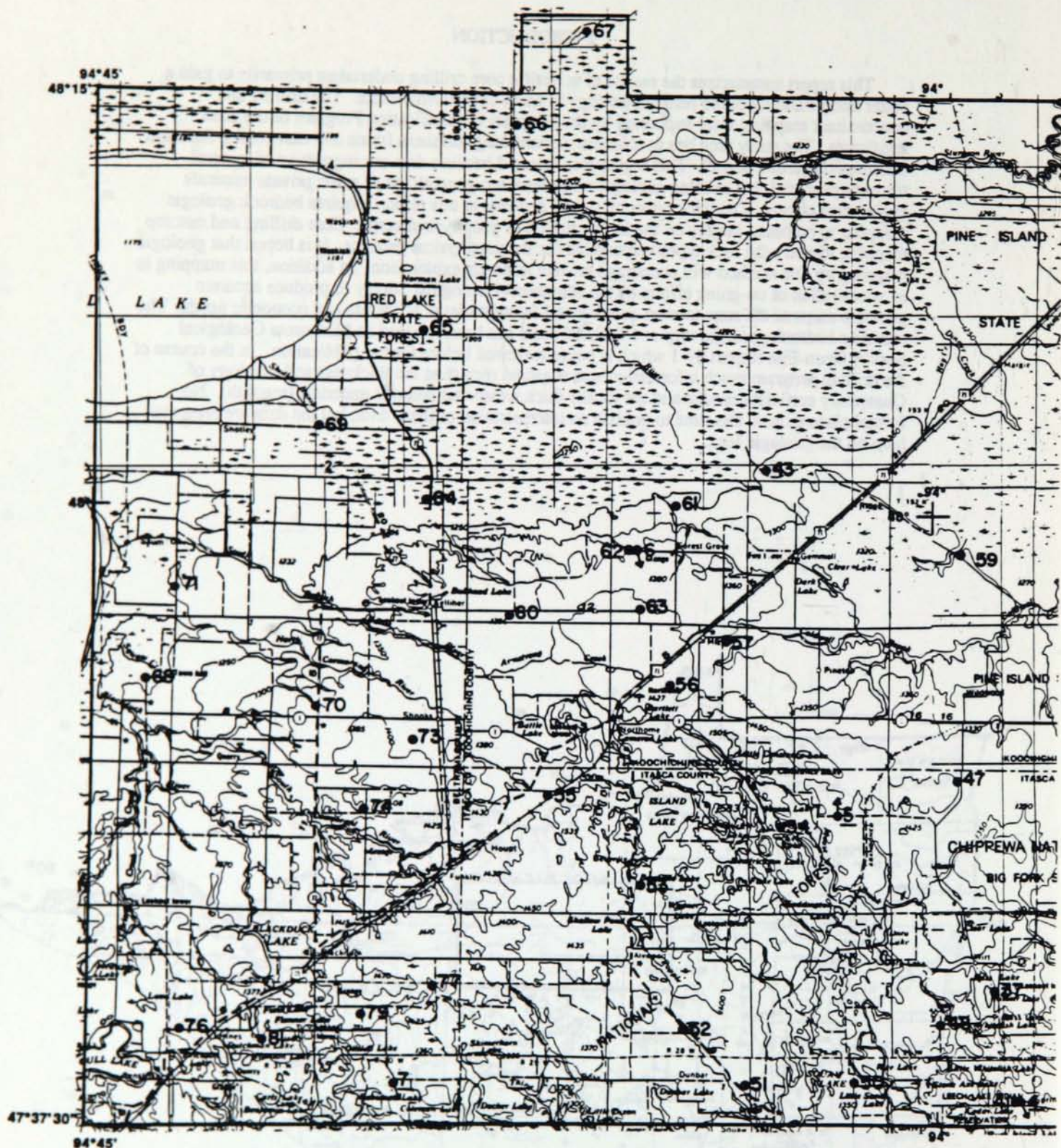


Figure 2. Map of study area showing location of drill holes. Solid circles are vertical KIB-series drill holes, numbered 1-81 (with some numbers missing). Solid circles with arrows are KDH-series drill holes inclined in direction indicated and numbered 1-7, underlined (KDH-3 not drilled).





The bedrock consists mainly of Archean (2.5-2.7 b.y. old) plutonic, metavolcanic and metasedimentary rocks which can be divided into two generalized terranes. The northern terrane of migmatized sedimentary rocks (schist) and granite is the western extension of the Vermilion Granitic Complex and is equivalent to the Quetico Subprovince of the Superior Province. The southern terrane of metavolcanic (greenstone) and plutonic rocks is generally equivalent to the Wawa-Shebandowan Subprovince. The boundary between these terranes trends east-west across the study area at approximately 48° latitude. The Archean units are cut by northwest-trending Proterozoic (2.1 b.y. old) diabasic dikes which vary from a few meters to 90 m in width. The length of some of these dikes extend across the entire study area and beyond.

## DRILL SITE SELECTION AND DRILLING METHODS

Drill hole locations were chosen to provide the best possible geologic framework by penetrating geologic units of broad regional extent. Selection was based on all existing geologic data including outcrops which are abundant in the eastern part of the area, existing records and drill core saved from private exploration projects, and interpretation of high-resolution aeromagnetic maps (Bracken and Godson, 1987, and preliminary maps of the U.S. Geological Survey) and gravity data (Chandler and others, 1985, 1987; Horton and Chandler, 1988; McGinnis and others, 1973; 1978; and file data of the Minnesota Geological Survey). Once geologic "targets" were identified, holes were sited for access and ownership characteristics. An effort was made to select locations that had the best potential to intersect the geologic target and that could be drilled on state, county or federally administered property to minimize impact to the public. Drilling on private property was necessary at some locations, and permission was obtained from owners. The majority of the drill holes, those prefixed KIB in this report, were rotary drilled to sound bedrock and core-drilled 10 feet deeper. Geologists present during drilling operations made geologic logs of all materials, and cuttings samples were taken and are stored at the Minnesota Geological Survey. In addition, six holes, prefixed KDH in this report, were cored more deeply to acquire detailed information at critical locations. Table 1 summarizes some of the logistics of the drilling program.

Table 1. Summary of drilling operations

	Fiscal Year and Contractors <sup>1</sup>				Project Total
	1987-88		1988-89		
	NS	DE	BEW	EJL	
Number of holes drilled	51	1	17	6	75
Holes with core	32	1	17	6	56
Total Footage drilled <sup>2</sup>	10,158	71	5,438	1,507	17,174
Total Core acquired	300	55	158	1,636	2,149
Total footage drilled/cored	10,458	126	5,596	3,143	19,323

1. Contractors: NS, North Star Drilling, Little Falls, MN; DE, Drilling and Engineering, Wyoming, MN; BEW, Ben Ervin Well Company, Olivia, MN; EJL, E.J. Longyear, Keewatin, MN. Holes listed under EJL are the deeper-cored KDH - series drill holes.

2. Includes all materials rotary drilled-glacial drift, weathered rock and some sound rock, but excludes rock that was core drilled.

## EXPLANATION OF DRILLING RECORDS

The drill hole records in this circular include basic geologic descriptions for each hole, together with geochemical and geophysical data where acquired. Components of the records are described below.

### Drill Hole Numbers

Hole numbers with the KIB prefix were rotary drilled and short cores were acquired where possible, and the KDH prefix is used for the deeper core holes. The records are in numerical order in the following section. The smallest numbers generally lie in the eastern part of the study area, with larger numbers toward the west. Many numbers in the sequence are missing, as not all sites initially selected were drilled. Appendix A summarizes pertinent drilling facts by county and township, range, and section.

### Location

The location of drill holes is described by township number (T), range number (R), section number (S) and subdivisions of sections by quarters. The abbreviated T-R-S system used here reflects the fact that all townships are north of a zero standard parallel, and west of a zero principal meridian, thus N and W are implied. The system used to subdivide a section (1 square mile) assigns letters to the quarters of a section where A is the NE $\frac{1}{4}$ , B is the NW $\frac{1}{4}$ , C is the SW $\frac{1}{4}$ , and D is the SE $\frac{1}{4}$ . Each quarter is then subdivided into four more quarters using the letter system. In listing quarters, the largest subdivision is given first and each quarter of a quarter is given in succession. Thus, for hole number KIB-1, the location 61-22-36 DABACC can be read in traditional terminology as "the SW $\frac{1}{4}$  of the SW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of the NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of the SE $\frac{1}{4}$  of section 36, in township 61 N., range 22 W. Its location within section 36 is shown below in Figure 3; and its location within the study area is shown in Figure 2, along with the other drill holes.

### Hole Parameters

All measurements are given in feet. Land surface elevations are estimated ( $\pm 5$  feet) from topographic contours on 1:24,000 - scale quadrangle maps. Core recovery typically is 100%.

### Abbreviated Lithologic Logs

Most descriptions of Quaternary materials are based on field interpretations by geologists from cuttings and drilling characteristics. The descriptions of these materials in KDH-series holes are generalized because of drilling conditions, and some are based on the driller's description. The term regolith refers to materials derived by in-situ weathering of bedrock.

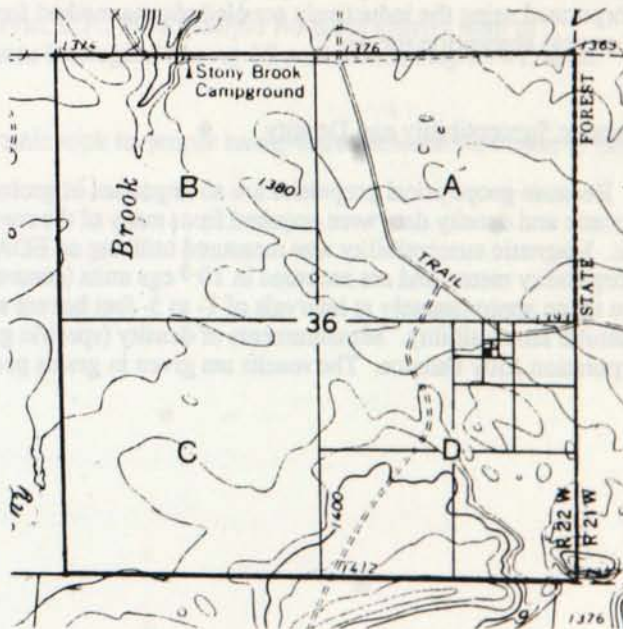


Figure 3. Location of example drill hole KIB-1 within Section 36.

As used here, regolith includes 1) saprolite which is weathered rock that has not been significantly mechanically disturbed, and 2) saprolitic deposits that may have been transported short distances by water or glacial ice and thus contain clasts of erratic composition. Because the weathering process results in a gradational, but locally irregular distribution of saprolite, some zones of saprolite were cored and are described under "sound rock." Conversely, materials described under "regolith" may contain zones of sound, unweathered rock. In most holes where core was not acquired, the cuttings from drilling in bedrock were of sufficient quality to allow generalized determination of rock type. Petrographic and geochemical work was performed on selected rock cuttings.

### Petrographic Description of Core

These descriptions are based on detailed core logging and thin section study. The percentages for relative abundance of individual minerals are visual estimates from the thin sections. The principal rock type names are based on those approximate modes rather than on geochemistry. The nomenclature of plutonic rocks is based on the classification system of Streckeisen (1976). The prefix "meta" is used inconsistently on rock names, but can be implied for all of the bedded rocks. Because the KIB-series holes are all vertical, the dips of planar features are true dips from horizontal. The dips of planar features in the KDH-series holes are given in degrees from the inclined core axis.

### Chemical Data

The results of the chemical analyses (where acquired) are listed with each drill hole record, and also summarized in the appendices. Major and selected minor element analyses (Appendix B) were done by X-Ray Assay Laboratories, Ltd. using X-ray fluorescence for weight percent of most oxides and minor elements, and wet chemical methods for weight percent of H<sub>2</sub>O+, CO<sub>2</sub>, and FeO. Total iron is given as Fe<sub>2</sub>O<sub>3</sub>, the Fe<sub>2</sub>O<sub>3</sub> component was calculated and appears on the tables in parentheses. In addition, a so called "exploration package" of minor element analyses was acquired for some core samples (Appendix C). The analyses were done by Geochemical Services Incorporated using the inductively coupled plasma method for most minor elements, and fire-assay and atomic absorption for Au.

### Magnetic Susceptibility and Density

Because geophysical properties are so important in geologic interpretations of this region, magnetic and density data were acquired from many of the cores and the results are summarized here. Magnetic susceptibility was measured utilizing an EDA Instruments model K-2 magnetic susceptibility meter, and are recorded in 10<sup>-3</sup> cgs units (centimeter-gram-seconds). Measurements were taken approximately at intervals of 1- to 5- feet but are sometimes generalized here into units of similar susceptibility. Measurements of density (specific gravity) were made with an Eberback Corporation Jolly balance. The results are given in grams per cubic centimeter.

## ACKNOWLEDGMENTS

Scientific test drilling was funded by the Minnesota Legislature under the Minerals Diversification Program administered by the Minerals Coordinating Committee. Most of the geochemical analyses were supported by that contract and some were funded by the Public Geologic Sample Program of the Minnesota Department of Natural Resources, Minerals Division. Outcrop mapping in the southeastern quarter of the map area was funded by the State Special appropriation to the Minnesota Geological Survey. Preliminary and derivative geophysical maps used for selection of drill hole locations were provided by the U.S. Geological Survey, Branch of Geophysics, and Val W. Chandler of the Minnesota Geological Survey. The Legislative Commission on Minnesota Resources provided some funds for geophysical work.

## REFERENCES CITED

- Bracken, R.E., and Godson, R.H., 1988, Aeromagnetic map of the northwestern part of the Hibbing 1° x 2° quadrangle, Minnesota: U.S. Geological Survey Open File Report 88-8, scale 1:62,500.
- Chandler, V.W., Jirsa, M.A., and Ikola, R.J., 1985, Simple Bouguer gravity map of Minnesota, Hibbing sheet: Minnesota Geological Survey, Miscellaneous Map M-56, scale 1:250,000.
- Chandler, V.W., Mills, S.J., and Ferderer, R.J., 1987, Simple Bouguer gravity map of Minnesota, International Falls Sheet: Minnesota Geological Survey Miscellaneous Map M-62, scale 1:250,000.
- Horton, R.J., and Chandler, V.W., 1988, Complete Bouguer gravity anomaly map of the Roseau 1°x 2° quadrangle, Minnesota and Ontario: U.S. Geological Survey Open File Report 88-531, scale 1:250,000.
- McGinnis, L.D., Durfee, G., and Ikola, R.J., 1973, Simple Bouguer gravity map of Minnesota, Roseau sheet: Minnesota Geological Survey Miscellaneous Map M-12, scale 1:250,000.
- McGinnis, L.D., Steffy, D.A., and Ervin, C.P., 1978, Simple Bouguer gravity map of Minnesota, Bemidji sheet: Minnesota Geological Survey Miscellaneous Map M-41, scale 1:250,000.
- Streckeisen, A.L., 1976, To each plutonic rock its proper name: *Earth Science Reviews*, v. 12, p. 1-33.

Field number KIB-1

Date completed 10-7-87

MGS unique number 241801

MGS lab number 2673

LOCATION (see map at right)

T-R-S 61-22-36 DABACC

County Itasca

Quadrangle Side Lake 7.5'

HOLE PARAMETERS (feet)

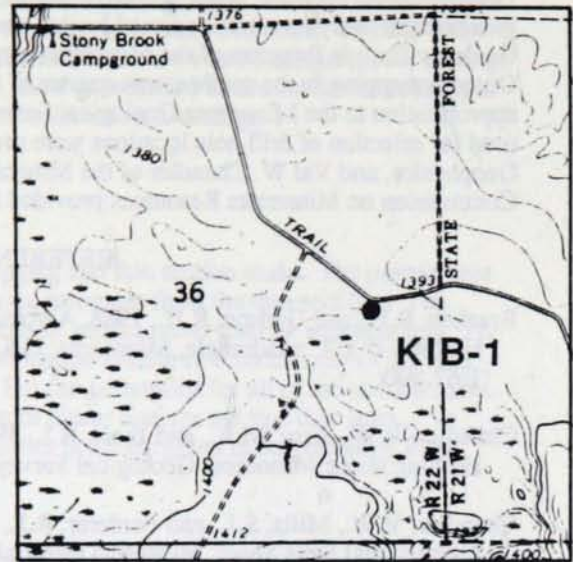
Surface elevation 1380

Total depth 122

Elevation, top of  
Precambrian rock 1274

Core interval 117.5-122

Core recovered 4.5



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-9	Sand and gravel.
9-11	Clay till, gray. Clasts of aphanitic mafic volcanics, granite, carbonate.
11-18	Sandy till, gray.
18-73	Clayey till, gray. contains cobbles and minor gravel.
73-103	Sandy till, gray. Cobbles of biotite schist, granite, minor carbonate and shale.
103-106	Boulders or very bouldery till. Boulders of biotite schist and biotite-bearing leucocratic gneiss.

REGOLITH ON PRECAMBRIAN ROCK

None encountered.

SOUND PRECAMBRIAN ROCK

106-122	Highly fractured garnet, biotite schist; probable protolith of crystal tuff.
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## PETROGRAPHIC DESCRIPTION OF CORE: KIB-1

Principal rock type: Biotite schist.

Mineralogy: Feldspar, Na-plagioclase, slightly sericitized (20-25%); quartz (20-25%); biotite (25%); sericite, possibly after sillimanite or andalusite (10-15%); muscovite, porphyroblastic (1-2%); apatite (trace); opaques (trace); sillimanite (?), trace).

Texture: Fine grained, massive neoblastic texture modified by later, spaced crenulation cleavage at 40° to bedding vestiges. Bedding defined by finer-grained, less biotite-rich beds. Fine-grained sericite concentrated into S<sub>2</sub> crenulation.

Structure: Very fractured, strongly cleaved at 60-65° to core axis, parallel to foliated biotite and eye-shaped concentrations of plagioclase and quartz. Weak crenulation of cleavage at 121 ft. Quartz veins ≤0.5cm wide, oriented nearly parallel to bedding, offset by vertical crenulation.

## CHEMICAL DATA

Rock Type Analyzed: Biotite schist, 118.5 ft. depth

### Minor Elements (ppm)

Ag	0.185
As	2.85
Au	0.004
Cu	69.3
Hg	<0.096
Mo	1.29
Pb	5.34
Sb	<0.24
Tl	1.26
Zn	41.9
Bi	0.251
Cd	0.192
Ga	5.48
Pd	<0.481
Se	<0.962
Te	<0.481

### MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
117.5-122	0.01

### DENSITY

Depth	Density
120	2.75

Field number KIB-2

Date completed 10-13-87

MGS unique number 241802

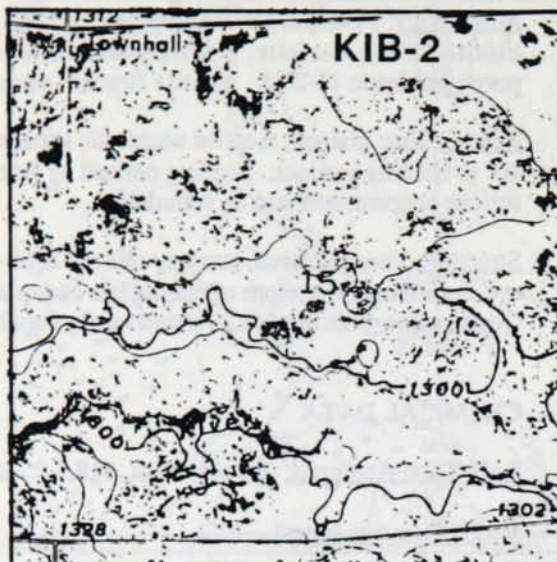
MGS lab number 2674

LOCATION (see map at right)

T-R-S 61-22-15 AABBBB

County Itasca

Quadrangle Togo 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1305

Total depth 73

Elevation, top of  
Precambrian rock 1256

Core interval 63-73

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-8	Sandy till, pale brown, with interbedded sand layers. Clasts dominantly of basalt and granite.
8-42	Lacustrine clay, dark gray.
42-49	Sand, contains abundant basalt, graywacke, granite, quartz, and limestone.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
None encountered; see below for weathered zone in bedrock.	
<b>SOUND PRECAMBRIAN ROCK</b>	
49-54	Metagraywacke.
54-55	Regolith, bluish-gray clay.
55-73	Metagraywacke, tuffaceous.



## PETROGRAPHIC DESCRIPTION OF CORE: KIB-2

Principal rock type: Volcanogenic metagraywacke.

Mineralogy: Feldspar, Na-plagioclase (35-40%); quartz (30-35%); biotite (20-30%); chlorite (2-3%); pyrite (trace).

Texture: Fine-grained to aphanitic, strongly foliated, multilithic rock. Thin-section of a coarser-grained bed contains 0.3-0.5mm quartz and feldspar crystals in a fine-grained matrix of quartz, feldspar, and stubby laths of well-foliated biotite. Volcanogenic graywacke protolith.

Structure: Bedding-parallel cleavage at 60-70° to core axis, locally contains lineated hornblende. Minor quartz veining parallels foliation, is folded and boudinaged. Small scale faulting dip 45-60° from horizontal.

## CHEMICAL DATA

Rock Type Analyzed: metagraywacke/siltstone, 72-73 ft. depth.

### Minor Elements (ppm)

Ag	0.133
As	1.06
Au	0.003
Cu	95.1
Hg	<0.096
Mo	0.191
Pb	1.28
Sb	<0.24
Tl	1.17
Zn	46.6
Bi	<0.24
Cd	<0.096
Ga	6.02
Pd	<0.48
Se	<0.96
Te	<0.48

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
63 - 64	0.01	67 - 70.5	0.01
64 - 65	0.02	70.5 - 72	0.03
65 - 67	0.03	72 - 73	0.02

## DENSITY

Depth	Density
65.5	2.69

Field number KIB-3B

Date completed 3-21-88

MGS unique number 241803-B

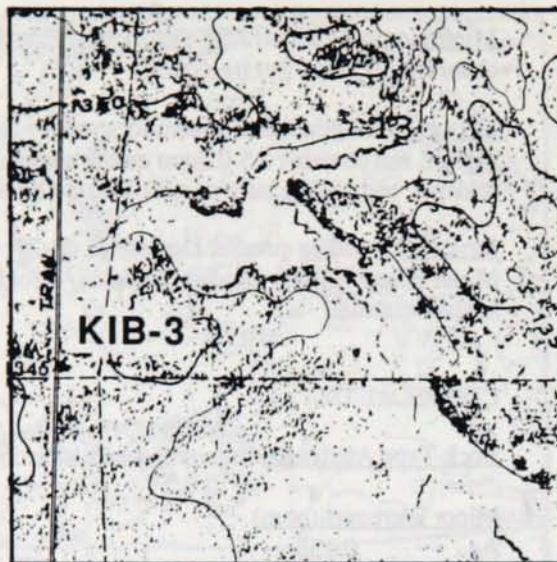
MGS lab number 2675

LOCATION (see map at right)

T-R-S 62-23-14 DDDD

County Itasca

Quadrangle Togo 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1345

Total depth 219

Elevation, top of  
Precambrian rock 1164

Core interval 196-219

Core recovered 23

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-20	Lacustrine clay or clay till, pale olive, smooth, hard. Freshly broken chips show a possible lamination.
20-75	Lacustrine clay, gray smooth, sticky.
75-120	Fine sand.
120-158	Silty clay alternating with fine sand, watery.
158-168	Coarse gravel.
168-181	Sandy bouldery till, gray; becomes very sandy with depth.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
181-187	Regolith, greenish-gray to gray clay, sandy-textured.
<b>SOUND PRECAMBRIAN ROCK</b>	
187-219	Graywacke, interlayered with argillite and conglomerate, dark greenish-gray.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-3B

Principal rock type: Graywacke and argillite.

### Mineralogy:

**Quartz**, angular; **feldspar**, angular, dominantly plagioclase, also orthoclase; **volcanic rock fragments**, felsic and intermediate; **pyrite**; detrital **muscovite**, **zircon**; **epidote**; and **chlorite**. Fine-grained beds contain a very fine-grained birefringent mica of undeterminable mineralogy.

### Texture:

Top foot of core consists of conglomerate with 5 to 8cm clasts which contain angular, felsic, trachytic-textured volcanic fragments. Bulk of core consists of massive, medium-grained lithic graywacke with interbeds of laminated argillite and siltstone. Rock is very pristine, primary features well preserved.

### Structure:

Bedding is at 50° to core axis, and is right side up. Zone of brittle deformation from 206 - 209 ft. is healed with quartz, pyrite, and minor chalcopyrite; other fracture veinlets lined with pyrite and carbonate.

### Comments:

This hole is a redrill of hole KIB-3A, from which no core was obtained. No log of 3A is included here because it was drilled very close to 3B.

## CHEMICAL DATA

Rock Type Analyzed: Argillite, 207-208 feet.

### Minor Elements (ppm)

Ag	0.116
As	7.32
Au	0.003
Cu	64.1
Hg	<0.097
Mo	1.10
Pb	9.25
Sb	<0.242
Tl	1.13
Zn	69.9
Bi	<0.242
Cd	<0.097
Ga	5.69
Pd	<0.484
Se	<0.969
Te	<0.484

### MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
196-197	0.02	199-200	0.01
197-198	0.01	200-201	0.02
198-199	0.01		

### DENSITY

Depth	Density
204	2.74
200	2.94

Field number     KIB-4    

Date completed   10-20-87  

MGS unique number   241804  

MGS lab number     2676    

LOCATION (see map at right)

T-R-S   60-23-3 DAADD  

County     Itasca    

Quadrangle   Sherry Lake 7.5'  

HOLE PARAMETERS (feet)

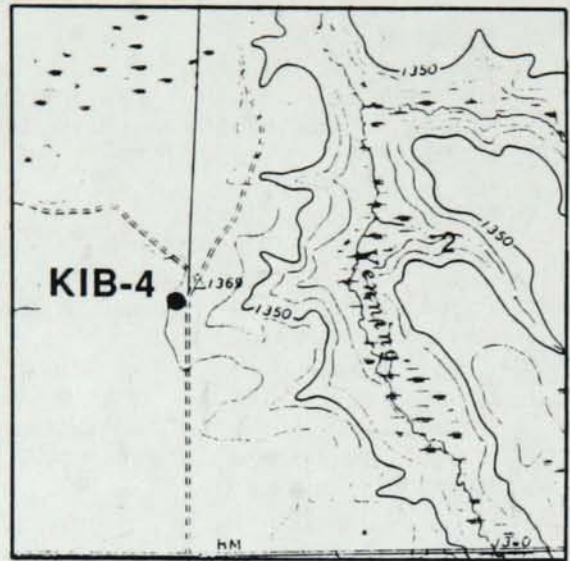
Surface elevation     1369    

Total depth     180.3    

Elevation, top of  
Precambrian rock     1291    

Core interval     170-180.3    

Core recovered     10    



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-17	Silt and fine-grained sand, probably lacustrine.
17-67	Lacustrine clay, olive-gray, silty.
67-78	Bouldery till, yellowish-brown. Boulders of dark green, fine- to medium-grained mafic and granitic rocks.
REGOLITH ON PRECAMBRIAN ROCK	
78-165	Regolith, light greenish-gray, locally yellowish-brown, gritty clay. Chips of chlorite schist and vein quartz as sound bedrock is approached.
SOUND PRECAMBRIAN ROCK	
165-180.3	Mafic to intermediate volcanic breccia.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-4

Principal rock type: Intermediate volcanic breccia

Mineralogy: **Andesite clasts:** feldspar, plagioclase, as phenocrysts and in groundmass; biotite; quartz, in groundmass; epidote; chlorite. **Matrix:** quartz; biotite; chlorite; epidote; actinolite; calcite; epidote.

Texture: Angular to subrounded clasts of fine-grained, porphyritic, amygdaloidal andesite up to 10cm across are chaotically distributed in a fine-grained matrix. Metamorphic actinolite and biotite are well foliated in both clasts and matrix.

Structure: Unsorted, matrix has moderate foliation which anastomoses around weakly foliated clasts. Foliation dips 50° from horizontal. Minor quartz veining (irregular) with pyrite, pyrrhotite.

Comments: Possibly a slightly reworked explosive volcanic breccia.

## CHEMICAL DATA

Rock Type Analyzed: andesite agglomerate, 176.4-176.7 ft (whole rock); 179-180 ft. (assay)

<u>Major Element (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	62.5	Cl	50	Ag	0.079
Al <sub>2</sub> O <sub>3</sub>	14.7	Cr	106	As	1.96
CaO	3.87	Rb	<10	Au	0.003
MgO	3.84	Sr	201	Cu	47.4
Na <sub>2</sub> O	4.26	Y	33	Hg	<0.097
K <sub>2</sub> O	0.32	Zr	107	Mo	0.178
(Fe <sub>2</sub> O <sub>3</sub> )	(1.11)	Nb	22	Pb	1.28
FeO	5.0	Ba	120	Sb	<0.241
MnO	0.11			Tl	0.890
TiO <sub>2</sub>	0.58			Zn	48.8
P <sub>2</sub> O <sub>5</sub>	0.11			Bi	<0.241
H <sub>2</sub> O	2.2			Cd	<0.097
CO <sub>2</sub>	0.52			Ga	5.89
S	0.02			Pd	<0.483
LOI	2.62			Se	<0.965
Total	99.7 (normalized)			Te	<0.483
Total iron as Fe <sub>2</sub> O <sub>3</sub>	6.67				

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
170-180.3	0.01

## DENSITY

Depth	Density
175	2.86

Field number KIB-5B

Date completed 10-22-87

MGS unique number 241805-B

MGS lab number 2678

LOCATION (see map at right)

T-R-S 60-24-36 ADBcenter

County Itasca

Quadrangle Horsehead Lake 7.5'

HOLE PARAMETERS (feet)

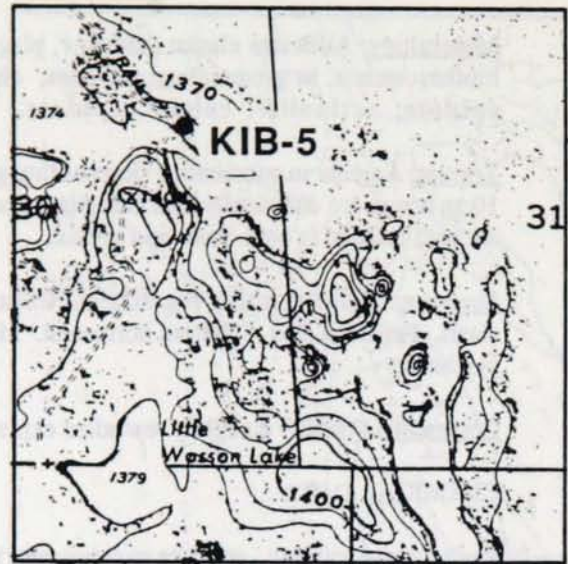
Surface elevation 1384

Total depth 164

Elevation, top of  
Precambrian rock 1257

Core interval 154-164

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-6	Sandy to gravelly till, yellowish-brown. Pebbles of typical Archean rocks, no carbonate noted.
6-34	Coarse sand and gravel, with scattered granitic cobbles.
34-100	Silty lacustrine clay, greenish-gray.
100-112	Interlayered silt and fine silty sand. Volume of sand increases with depth. Gradational into next unit.
112-127	Coarse sand, boulders of pink granite and black amphibolitic gneiss near bottom.

**REGOLITH ON PRECAMBRIAN ROCK**

127-138	Regolith, pale greenish-white clay.
138-144	Regolith, dark greenish-gray clay.
144-147	Regolith, pale greenish-white clay.

**SOUND PRECAMBRIAN ROCK**

147-164	Tonalite/trondhjemite, pinkish-white, medium-grained, foliated.
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PETROGRAPHIC DESCRIPTION OF CORE: KIB-5B

Principal rock type: Leuco-tonalite/trondhjemite

Mineralogy: Plagioclase, sodic (75%); quartz (15-20%); orthoclase anhedral-interstitial (1-2%); biotite (2-5%); epidote (tr-1%); oxides (tr).

Texture: Medium grained, weakly foliated via mild cataclasis and aligned biotite laths.

Structure: Foliation at 40° to core axis defined by wisps of biotite. Thin pink orthoclase-biotite stringers are spaced 15 to 30cm apart, perpendicular to foliation.

CHEMICAL DATA

Rock Type Analyzed: Leucotonalite/trondhjemite, 158-158.3 ft depth

<u>Major Element (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	72.8	Cl	30
Al <sub>2</sub> O <sub>3</sub>	15.5	Cr	19
CaO	2.57	Rb	28
MgO	0.37	Sr	539
Na <sub>2</sub> O	6.41	Y	<10
K <sub>2</sub> O	0.98	Zr	31
(Fe <sub>2</sub> O <sub>3</sub> )	(0.31)	Nb	10
FeO	0.5	Ba	479
MnO	0.03		
TiO <sub>2</sub>	0.13		
P <sub>2</sub> O <sub>5</sub>	0.05		
H <sub>2</sub> O	0.3		
CO <sub>2</sub>	0.01		
S	nil		
LOI	0.54		
Total	100.4(normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	0.87		

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
154-160	0.07
160-161	0.09
161-162	0.10
162-163	0.12
163-163.5	0.10

DENSITY

Depth	Density
161	2.88

Field number     KIB-6    

Date completed   10-23-87  

MGS unique number   241806  

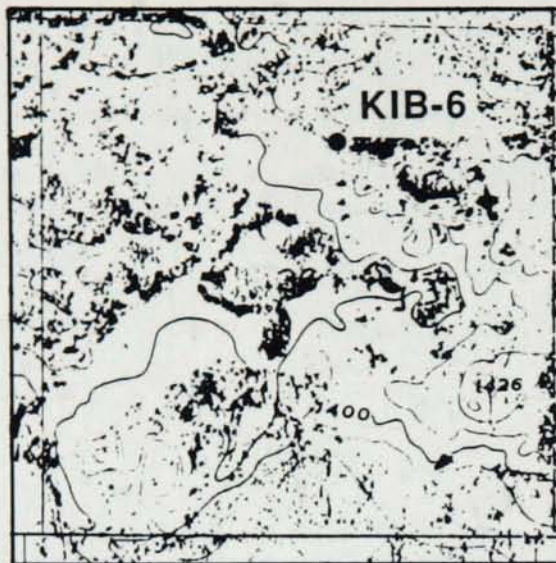
MGS lab number     2679    

LOCATION (see map at right)

T-R-S   61-25-36 ABCC  

County     Itasca    

Quadrangle   Anderson Lake 7.5'  



HOLE PARAMETERS (feet)

Surface elevation   1414  

Total depth     43.3    

Elevation, top of  
Precambrian rock   1399  

Core interval   34 - 43.3  

Core recovered     10.3    

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-15	Moderately sandy till, light brown, with random pebbles of amphibolite, granite, and carbonate.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
Regolith encountered in weathered zones in rock (see below).	
<b>SOUND PRECAMBRIAN ROCK</b>	
15-43.3	Syenite, coarse-grained, pinkish-gray. Thin zones of white regolith at 18.5, 27, and 32 ft.



PETROGRAPHIC DESCRIPTION OF CORE: KIB-6

Principal rock type: Garnet-bearing syenite

Mineralogy: **Mesoperthite** (orthoclase), subhedral, tabular (65-70%); **antiperthite** (plagioclase), late interstitial (4-5%); **hornblende**, deep green, igneous, possibly Na-pyroxene in part (2-3%); **garnet**, deep brown, poikilitic (2-3%); **amphibole**, colorless (tr-1%); **sphene** (tr-1%); **muscovite** (tr-1%); **sericite**(?), low relief secondary mineral interstitial to feldspar, forms a decussate patchwork (10-15%); **apatite** (tr).

Texture: Coarse to very coarse-grained, hypidiomorphic-granular.

Structure: Vertical igneous foliation defined by tabular crystals of perthite.

CHEMICAL DATA

Rock Type Analyzed: Syenite, 34.6-35 ft. (whole rock); 36.5-37.5 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	57.7	Cl	150	Ag	0.049
Al <sub>2</sub> O <sub>3</sub>	17.8	Cr	<10	As	1.69
CaO	5.45	Rb	100	Au	0.002
MgO	0.42	Sr	3700	Cu	11.2
Na <sub>2</sub> O	5.75	Y	81	Hg	<0.092
K <sub>2</sub> O	5.80	Zr	64	Mo	1.77
(Fe <sub>2</sub> O <sub>3</sub> )	(2.38)	Nb	15	Pb	5.56
FeO	0.3	Ba	2530	Sb	<0.231
MnO	0.07			Tl	0.909
TiO <sub>2</sub>	0.26			Zn	8.18
P <sub>2</sub> O <sub>5</sub>	0.11			Bi	<0.231
H <sub>2</sub> O+	1.4			Cd	<0.092
CO <sub>2</sub>	0.59			Ga	1.58
S	Nil			Pd	<0.461
LOI	2.77			Se	<0.923
Total	99.6 (normalized)			Te	<0.461
Total iron as Fe <sub>2</sub> O <sub>3</sub>	2.71				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
34-36	0.02
36-43.4	0.01

DENSITY

Depth	Density
38	2.60

Field number KIB-7

Date completed 10-27-87

MGS unique number 241807

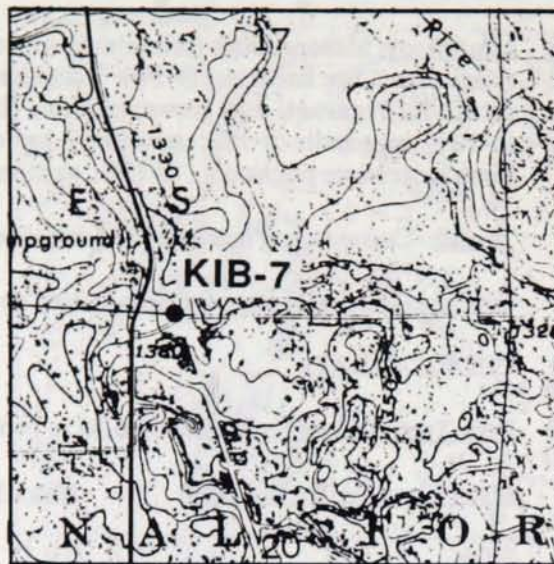
MGS lab number 2680

LOCATION (see map at right)

T-R-S 60-26-20 BABAA

County Itasca

Quadrangle Bigfork 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1365

Total depth 225

Elevation, top of  
Precambrian rock 1167

Core interval 215 - 225

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-8	Sandy till, reddish-brown, contains many pebbles.
8-18	Hard sandy till, pale brown, contains a low volume of carbonate, fine-grained mafic volcanic rock, amphibolite, granite, and quartz pebbles.
18-25	Sandy till, gray, similar to above till in lithology. Transitional from above.
25-34	Gravel, 6 in. cobble of black amphibolite at 34 ft.
34-61	Sandy till, gray. Pebbles of typical Archean rocks, carbonate. Cobbles at 36, 37, 53, 60 ft.
61-78	Fine sand. Thin layer of gray clay 68-69 ft. Abrupt transition from above.
78-194	Interlayered fine sand and gray silty lacustrine clay. Contains abundant black lignite chips throughout interval. Cobbles 140-147 ft. Thickness of sand and clay layers typically 6 in. to 1 ft.
194-198	Coarse sand and boulders.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
198-210	Regolith, light gray, gritty, homogeneous. Becomes more coarsely gritty and bluish-gray with depth.
<b>SOUND PRECAMBRIAN ROCK</b>	
210-224.9	Granite, pink, medium- to coarse-grained, weakly foliated. Slightly brecciated, with chlorite lined fracture surfaces.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-7

Principal rock type: Granite

Mineralogy: **Plagioclase**, zoned, euhedral, weakly sericitized (25%); **orthoclase**, anhedral, perthitic, poikilitic (45%); **quartz**, anhedral (25%); **hornblende** (2-3%); **biotite** (trace-1%); **epidote** (trace); **opaque oxides** (2%); **chlorite** (tr); **apatite** (tr).

Texture: Medium-coarse grained, massive.

Structure: Breccia zone 222-223 ft. depth; brittle fractures generally oriented 45° to core axis, chlorite-lined slickensides on fracture surfaces plunge 45° to core axis. Hornblende shows weak igneous foliation at 40° to core axis.

## CHEMICAL DATA

Rock Type Analyzed: Granite, 218.6 - 218.8 ft. depth

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	69.7	Cl	50
Al <sub>2</sub> O <sub>3</sub>	15.7	Cr	22
CaO	1.87	Rb	165
MgO	0.51	Sr	1210
Na <sub>2</sub> O	5.67	Y	<10
K <sub>2</sub> O	3.51	Zr	90
(Fe <sub>2</sub> O <sub>3</sub> )	(1.39)	Nb	<10
FeO	0.4	Ba	1340
MnO	0.04		
TiO <sub>2</sub>	0.20		
P <sub>2</sub> O <sub>5</sub>	0.09		
H <sub>2</sub> O+	0.7		
CO <sub>2</sub>	0.01		
S	NIL		
LOI	0.70		
Total	100.2 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	1.84		

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
215-218	0.01	221-222	0.04
218-219	0.10	222-223	0.01
219-220	0.03	223-224	0.03
220-221	0.07		

## DENSITY

Depth	Density
219	2.60

Field number KIB-8

Date completed 10-29-87

MGS unique number 241808

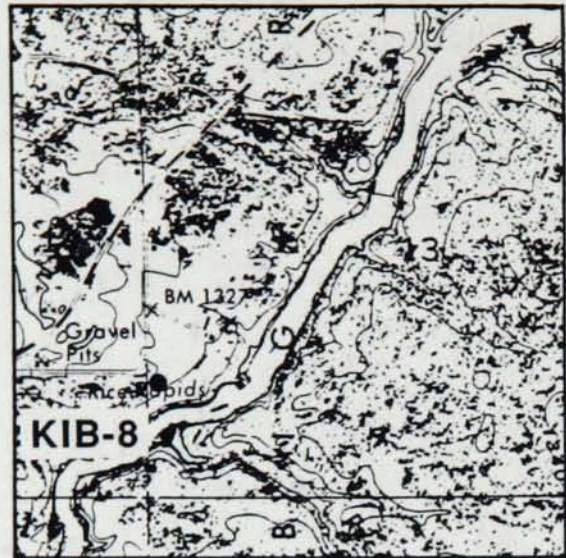
MGS lab number 2681

LOCATION (see map at right)

T-R-S 61-26-13 CCB BB

County Itasca

Quadrangle Effie S.E. 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1330

Total depth 72.5

Elevation, top of  
Precambrian rock 1273

Core interval 66 - 72.5

Core recovered 6.5

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-3	Gravelly loam till. Dark brown, gradually lightens in color to unit below.
3-25	Till, light brown. Contains a low volume of pebbles and granules of amphibolite, granite, mafic volcanic, and carbonate. Granite boulder at 8 ft., fine-grained amphibolite boulder at 9.5 ft. Increasingly sandy in last 3 feet of interval.
25-30	Fine sand.
20-39	Gravel and coarse sand.
39-57	Very bouldery sand; possibly a very thin layer of gray till at top of interval. Drilled semicontinuously through boulders of amphibolite and pink granite, with numerous 6 inch to 1 foot intervals of fine sand.

**REGOLITH ON PRECAMBRIAN ROCK**

None encountered.

**SOUND PRECAMBRIAN ROCK**

57-72.5	Tonalite, medium-to coarse-grained, brecciated. Small amount of pale greenish-pink clay regolith along fractures near top of interval.
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PETROGRAPHIC DESCRIPTION OF CORE: KIB-8

Principal rock type: Leucotonalite/trondhjemite

Mineralogy: Plagioclase (45-50%); quartz (35-40%); calcite (6-7%); sericite (2%) orthoclase (tr); chlorite (tr-1%); pyrite (tr).

Texture: Coarse-grained igneous texture, weakly mortar-textured and transected by narrow, irregular zones of mechanical deformation.

Structure: Rock contains numerous chlorite- and pyrite- lined brittle fractures of varying orientations.

CHEMICAL DATA

Rock Type Analyzed: Trondhjemite, 67.2-67.9 ft. depth

Minor Elements (ppm)

Ag	0.02
As	1.01
Au	0.002
Cu	7.54
Hg	<0.092
Mo	0.792
Pb	0.725
Sb	<0.23
Tl	0.706
Zn	21.1
Bi	0.240
Cd	<0.092
Ga	1.71
Pd	<0.46
Se	<0.919
Te	<0.46

MAGNETIC SUSCEPTIBILITY (depths in feet)

Footage	Reading( x 10 <sup>-3</sup> cgs units)
66-72	0.00 (ave. = 0.01)

DENSITY

Depth	Density
66	2.68

Field number KIB-9

Date completed 11-3-87

MGS unique number 241809

MGS lab number 2682

LOCATION (see map at right)

T-R-S 61-26-28 AAACAA

County Itasca

Quadrangle Effie 7.5'

HOLE PARAMETERS (feet)

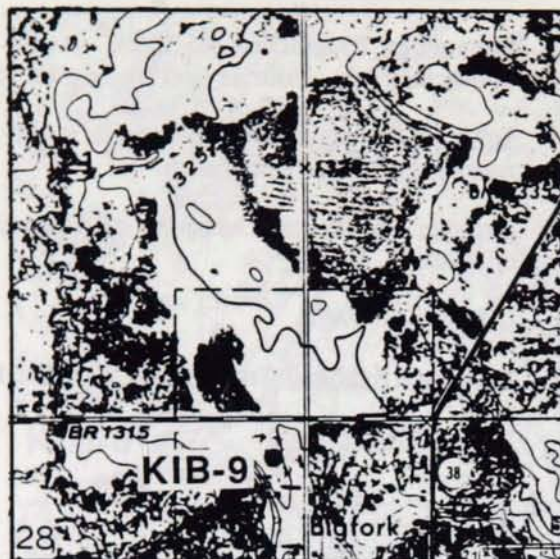
Surface elevation 1320

Total depth 273

Elevation, top of  
Precambrian rock 120

Core interval cuttings only

Core recovered none



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-15	Lacustrine clay, dark brown, hard, smooth, with streaks of gray and yellowish-orange clay; possibly laminated.
15-33	Fine sand.
33-40	Lacustrine clay, gray. Coarse sand layer 38-39 ft. depth.
40-66	Fine sand interlayered with smooth gray clay. Significant clay layers at 50-51, 56-58 ft. depth, also other thinner layers.
66-71	Lacustrine clay, gray, smooth.
71-78	Gravel, with thin layer of gray clay at 74-76 ft. Abrupt transition from above clay.
78-115	Sandy, cobbly till, gray. Encounter 6 inch cobbles every 2 to 4 feet. Contains 2-3 mm granules of Archean rocks, carbonate.
115-119	Large boulder of quartzose amphibolite.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
119-131	Regolith, grayish-green, clayey. Becomes darker green with depth.
131-135	Schist, dark green, apparent protolith of mafic volcanic rock.
135-189	Regolith, grayish-green to dark green clay interspersed with thin zones of hard rock.
189-192	Regolith, light grayish-tan, very smooth and slow drilling
192-197	Regolith, yellowish-red to reddish-brown, slightly gritty clay. Possible chips of fine-grained syenitic rock.

197-201	Regolith, mixed reddish-brown and very light pinkish-white, similiar in texture to above.
201-209	Regolith, green, with large percentage of medium greenish-gray to pinkish-gray volcanic rock chips.
209-220	Hard rock. Light green, locally light gray and red, altered intermediate volcanic rock. Contains 5-15% disseminated fine-grained sulfides.
220-234	Partially weathered rock similiar to above. Pass in and out of hard rock, samples consist of white to light green clayey regolith mixed with chips of sheared sericite-pyrite schist.
234-250	Regolith, dark green, mixed with zones of hard dark green epidotized basalt or andesite.
250-273	Regolith similiar to 226-234 ft., drill very inconsistently from hard rock to regolith. Chips are dominantly of quartz-sericite-chlorite-pyrite schist.

PETROGRAPHIC DESCRIPTION OF CUTTINGS: KIB-9

Principal rock type: Andesite-dacite, altered (?).

Mineralogy: (from cuttings chips) Two dominant rock types consist of well-foliated quartz-sericite schist (felsic volcanic) and poorly foliated quartz-epidote-chlorite schist (intermediate volcanic) which has a well-preserved trachytic flow texture defined by tabular plagioclase phenocrysts. Calcite veining is pervasive, and calcite heavily permeates the rock locally. The calcite in the veins has been recrystallized to a foliated granoblastic aggregate. Overall, the cuttings give the impression that the rock has been pervasively sheared and altered.

Texture: Fine-grained, well foliated. Many chips show strong trachytic flow texture. Some of the quartz-sericite schist chips are less deformed and show a protolith of cherty-appearing, recrystallized felsic volcanic rock.

CHEMICAL DATA

Rock Type Analyzed: Andesitic to dacitic chips, 200-270 ft.

Minor Elements (ppm)

Ag	0.092
As	<0.942
Au	0.005
Cu	29.2
Hg	<0.094
Mo	0.719
Pb	0.861
Sb	<0.235
Tl	0.868
Zn	48.8
Bi	<0.235
Cd	<0.094
Ga	4.56
Pd	<0.471
Se	<0.942
Te	<0.471

MAGNETIC SUSCEPTIBILITY (depths in feet)

Not determined.

DENSITY

Not determined.

Field number KIB-10

Date completed 10-29-87

MGS unique number 241810

MGS lab number 2683

LOCATION (see map at right)

T-R-S 61-26-29 BBAAA

County Itasca

Quadrangle Effie 7.5'

HOLE PARAMETERS (feet)

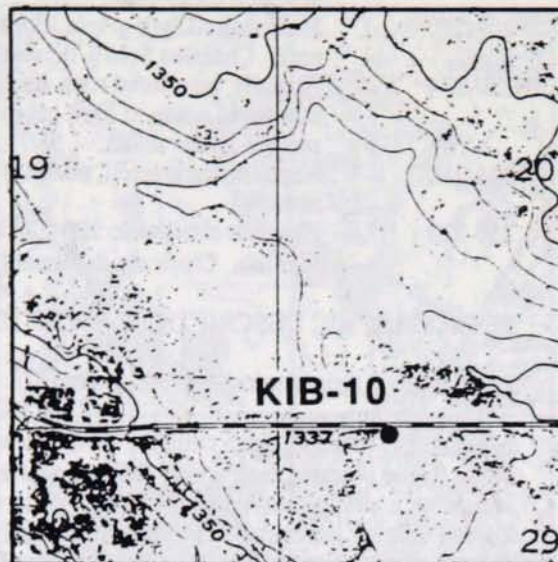
Surface elevation 1335

Total depth 99

Elevation, top of  
Precambrian rock 1254

Core interval 89 - 99

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-23	Lacustrine clay, yellowish-brown (0-10 ft.) to darker brown, mottled gray.
23-27	Smooth till, gray. Contains pebbles of carbonate and typical Archean rocks.
27-42	Gravel and coarse sand. Varies from fine sand (minor lithology) to cobbles.
42-62	Sandy till, gray. Pebbles of amphibolite, felsic volcanics, granite, quartz, and carbonate.
62-74	Coarse sand (2 - 3mm diameter). Cobbles and boulders near bottom of interval.
74-81	Large boulder or possibly 2 closely spaced boulders of black amphibolitic gneiss. Begin to see some green regolith near bottom of interval.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
81-84	Regolith, grayish-green gritty, clayey.
<b>SOUND PRECAMBRIAN ROCK</b>	
84-99	Quartz-bearing diabase, dark green, heterogeneous, fine- to medium-grained.



## PETROGRAPHIC DESCRIPTION OF CORE: KIB-10

Principal rock type: Deuteroically altered quartz diorite intrusive into a finer grained equivalent or altered mafic volcanic rock.

Mineralogy: Feldspar, moderately altered to granular epidote (23-27%); quartz (8-10%); chlorite, pennine (50-55%); opaque oxides, secondary, rimmed by sphene (6-7%); sphene (6-7%); calcite (1%); epidote (1%); pyrite (tr). Rock has undergone moderately heavy retrograde metamorphism.

Texture: Fine- to medium-grained primary igneous protolith apparent, retrograded to a decussate, non-foliated texture.

Structure: Thin chloritized and epidotized shear planes are normal to brittle veinlets of quartz and calcite. A later calcite vein transects these brittle veins (in thin section).

## CHEMICAL DATA (Depths in feet)

Rock Type Analyzed: Retrograded quartz diorite, 89.3-89.8, 96.5-97 ft. depth

	<u>Minor elements (ppm)</u>	
	(89.3-89.8)	(96.5-97)
Ag	0.67	0.68
As	<0.988	1.11
Au	0.002	0.003
Cu	34.6	56.3
Hg	<0.099	<0.095
Mo	0.558	0.365
Pb	1.54	0.942
Sb	0.331	<0.236
Tl	1.33	1.13
Zn	64.0	69.1
Bi	<0.247	<0.236
Cd	<0.099	<0.095
Ga	8.31	5.73
Pd	<0.494	<0.473
Se	<0.988	<0.945
Te	<0.494	<0.473

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
89-90	0.04	94-95	0.01
90-91	0.03	95-96	0.02
91-92	0.02	96-97	0.03
92-93	0.01	97-98	0.02
93-94	0.02		

## DENSITY

Depth	Density
97	2.85

Field number KIB-11

Date completed 12-7-87

MGS unique number 241811

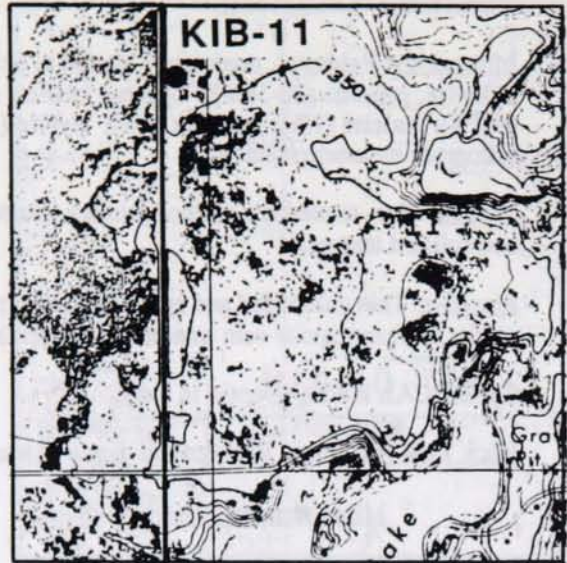
MGS lab number 2684

LOCATION (see map at right)

T-R-S 61-26-10 AADDD

County Itasca

Quadrangle Effie 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1350

Total depth 81

Elevation, top of  
Precambrian rock 1300

Core interval 71 - 81

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-5	Lacustrine clay, dark brown, organic-rich.
5-40	Lacustrine clay, gray, smooth. Contains minor small pebbles and sand grains.
40-50	Clayey till, gray. Slightly sandy with many carbonate pebbles, black basalt cobble at 50 ft.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
50-60	Regolith, gray smooth clay, slightly sandy-textured.
<b>SOUND PRECAMBRIAN ROCK</b>	
60-81	Meta-basalt or andesite, well-foliated.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-11

Principal rock type: Amygdaloidal basalt or andesite, metamorphosed to the amphibolite grade.

Mineralogy: Hornblende, lineated (20%); chlorite (17%); quartz (35%); feldspar, very heavily altered to sericite (25%); opaque oxides (2%); epidote (1%). Local clots of epidote alteration consist of 85% epidote and 15% quartz.

Texture: Fine-grained, well foliated, clots of epidote alteration are massive and granular-textured. Rock contains amygdules of quartz and chlorite.

Structure: Thin brittle calcite-filled fractures oriented normal to, nearly parallel, and  $\pm 10^\circ$  to foliation noted in thin section. Foliation of rock dips at  $75^\circ$  from horizontal.

CHEMICAL DATA

Rock Type Analyzed: Altered basalt, 71-71.4 ft (whole rock), 79-79.7 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	56.0	Cl	50	Ag	0.05
Al <sub>2</sub> O <sub>3</sub>	15.6	Cr	49	As	<0.963
CaO	7.70	Rb	27	Au	0.003
MgO	3.84	Sr	215	Cu	40.7
Na <sub>2</sub> O	3.24	Y	19	Hg	<0.096
K <sub>2</sub> O	0.70	Zr	78	Mo	0.326
(Fe <sub>2</sub> O <sub>3</sub> )	(1.88)	Nb	15	Pb	0.701
FeO	7.1	Ba	124	Sb	<0.241
MnO	0.16			Tl	1.13
TiO <sub>2</sub>	0.92			Zn	28.4
P <sub>2</sub> O <sub>5</sub>	0.15			Bi	<0.241
H <sub>2</sub> O+	1.2			Cd	<0.096
CO <sub>2</sub>	0.20			Ga	2.41
S	NIL			Pd	<0.482
LOI	1.08			Se	<0.963
Total	99.2 (normalized)			Te	<0.482
Total iron as Fe <sub>2</sub> O <sub>3</sub>	9.77				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth units)	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs
71-72	0.03	76-77	0.17
72-73	0.02	77-78	0.09
73-74	0.01	78-79	0.03
74-75	0.02	79-80	0.03
75-76	0.01	80-81	0.03

DENSITY

Depth	Density
79.7	2.92

Field number KIB-12

Date completed 11-4-87

MGS unique number 241812

MGS lab number 2685

LOCATION (see map at right)

T-R-S 62-26-24 AADDDD

County Itasca

Quadrangle Effie SE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1367

Total depth 177

Elevation, top of  
Precambrian rock 1222

Core interval 167 - 177

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-9	Sandy loam, light brownish gray.
9-80.5	Clay till, gray, contains small clasts of carbonate and black volcanic rock. Content of sand and of clasts increase in volume below 35 ft. depth. Cobbles at 59.5, 67.5, 74 ft.
80.5-84.5	Fine- to coarse-grained sand, dominant lithologies are carbonate and basalt.
84.5-105	Till, gray clay, slightly sandier than above. Cobbles at 94, 96 ft.
105-107	Large boulder of medium-grained white granite.
107-132	Sandy clay (lacustrine?) some small cobbles at 120 ft.
132-136	Clayey sand with cobbles and pebbles of black biotite schist, granite, volcanics, trace carbonate. Coarsens with depth (becomes more cobbly).
136-138	Granite boulder.
138-145	Coarse sand, cobbles, and boulders.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
145-160	Regolith, white to light gray, contains sand-sized quartz. Weathering product of granite.
<b>SOUND PRECAMBRIAN ROCK</b>	
160-177	Leucocratic granodiorite, pink, medium- to coarse-grained, massive.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-12

Principal rock type: Leuco-granodiorite

Mineralogy: Plagioclase, zoned, blocky, moderately altered (50%); quartz (34%); orthoclase (14%); biotite, altered to chlorite (1%); sphene, apatite, opaque oxides, epidote (trace of each).

Texture: Coarse grained, massive. Large masses of anhedral microcline poikilitically enclose blocky, zoned plagioclase crystals. Anhedral-interstitial biotite is retrograde altered to chlorite and sphene. Euhedral magmatic sphene is common.

Structure: Very weak primary igneous fabric, defined by oriented feldspars, is at 40° to core axis. Minor clay-lined joints at 45° to core axis.

## CHEMICAL DATA

Rock Type Analyzed: Leuco-granodiorite, 174.7-175 ft.

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	71.4	Cl	<50
Al <sub>2</sub> O <sub>3</sub>	14.8	Cr	14
CaO	2.13	Rb	101
MgO	0.39	Sr	588
Na <sub>2</sub> O	4.62	Y	<10
K <sub>2</sub> O	3.51	Zr	25
(Fe <sub>2</sub> O <sub>3</sub> )	(0.74)	Nb	17
FeO	0.4	Ba	494
MnO	0.04		
TiO <sub>2</sub>	0.13		
P <sub>2</sub> O <sub>5</sub>	0.05		
H <sub>2</sub> O+	0.5		
CO <sub>2</sub>	0.02		
S	NIL		
LOI	0.70		
Total	99.1 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	1.18		

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth units)	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs
167-168	0.04	172-173	0.25
168-169	0.07	173-174	0.25
169-170	0.12	174-175	0.64
170-171	0.10	175-176	0.32
171-172	0.28	176-177	0.14

## DENSITY

Depth	Density
176.8	2.68

Field number     KIB-13    

Date completed   12-17-88  

MGS unique number   241813  

MGS lab number   2686  

LOCATION (see map at right)

T-R-S   62-25-33 CBBBBB  

County   Itasca  

Quadrangle   Effie SE 7.5'  

HOLE PARAMETERS (feet)

Surface elevation   1301  

Total depth   125  

HOLE ORIENTATION (degrees)

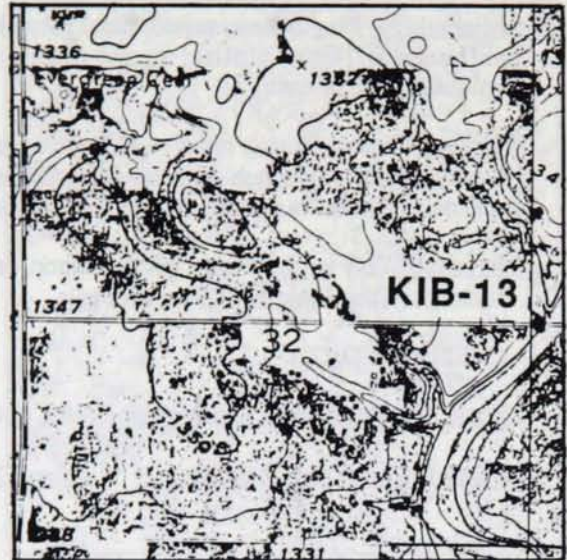
Azimuth   N/A  

Inclination   Vertical  

Elevation, top of  
Precambrian rock   1232  

Core interval   70.5-125  

Percent recovery   100  



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-10.5	Road Fill.
10.5-13.5	Silty sand, brown, contains organic material.
13.5-20	Silty clay.
20-46	Clay till, gray, contains scattered pebbles.
46-65.5	Sand, coarse to fine grained.
65.5-69	Cobbles, gravel, and sand.

**REGOLITH ON PRECAMBRIAN ROCK**

None encountered.

**SOUND PRECAMBRIAN ROCK**

69-125	Meta-andesite and breccia.
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PETROGRAPHIC DESCRIPTION OF CORE: KIB-13

Principal rock type: Metabasalt and felsic breccia.

Core Description: Interbedded metabasalt and felsic breccia. Metabasalt contains thin, discordant dikes of hornblende-bearing lamprophyre. Core contains pervasive veins of quartz, carbonate, and pyrite. Earliest set is nearly vertical, second is conjugate. Pyrite is most abundant in mafic rocks.

70.5-71.2 Felsic breccia with angular to round clasts of greenish-yellow silicic volcanic rock in a dark green tuffaceous matrix. Contact with below and foliation dip 35-55° from horizontal.

71.2-93.5 Dark green, fine-grained, weakly foliated amygdaloidal basalt with pervasive carbonate alteration. Contains a 3-inch thick lamprophyre dike which dips 65° from horizontal, contains hornblende phenocrysts that parallel contact. Thin section of this dike shows hornblende phenocrysts to be greenish-brown, zoned, in a groundmass of fine-grained chlorite, epidote, sericite, carbonate, possibly quartz and feldspar. Thin section of basalt shows platy plagioclase phenocrysts to 1mm across in a matrix of fresh, decussate, lathy plagioclase, chlorite, fibrous actinolite, epidote.

93.5-99.5 Felsic breccia containing blocky to wispy light green quartz-phyric fragments, cut by an irregular dike of dacite porphyry. Thin section made at 93.5 ft. shows the basalt to have a hard chill against the felsic rock, and two types of felsic-intermediate volcanic clasts (a lapilli breccia with well-preserved pumice fragments and a fine-grained 'cherty'-appearing tuff). Thin section at 95.2 ft. in porphyry shows saussuritized plagioclase phenocrysts up to 4 mm across, and hornblende pseudomorphed by sphene and epidote, in a fine-grained sericitic groundmass.

99.5-115.5 Dark green, fine-grained metabasalt, contains 2 discordant hornblende-bearing lamprophyre dikes that also contain minor pyrite and garnet.

115.5-125 Rhyolite agglomerate/breccia, clast-supported, unsorted. Thin section shows two rock types, a quartz-phyric variety and an aphyric variety of rhyolite.

CHEMICAL DATA

Rock Type Analyzed Basalt (71.8-72.5,84-84.4, 100-101, 123-124 ft.) felsic volcanic clast (120 ft.).

Sample	84-84.4 ft.		120 ft.		71.8	100	123	
Major Elements (wt. % oxides) (ppm)	Minor Elements (ppm)		Major Elements (wt. % oxides)	Minor Elements (ppm)		Minor Elements		
SiO <sub>2</sub>	50.5	Cl 50	SiO <sub>2</sub> 81.7	Cl 160	Ag	0.364	0.149	0.05
Al <sub>2</sub> O <sub>3</sub>	16.1	Cr 177	Al <sub>2</sub> O <sub>3</sub> 7.22	Cr 32	As	1.95	4.35	1.98
CaO	5.61	Rb 28	CaO 5.96	Rb 16	Au	<0.046	<0.046	<0.048
MgO	8.15	Sr 92	MgO 0.34	Sr 103	Cu	94.8	122.	9.02
Na <sub>2</sub> O	3.75	Y 21	Na <sub>2</sub> O 0.38	Y 34	Hg	<0.091	<0.093	<0.096
K <sub>2</sub> O	0.74	Zr 73	Na <sub>2</sub> O 0.33	Zr 76	Mo	1.07	1.16	3.62
(Fe <sub>2</sub> O <sub>3</sub> ) (2.48)	Nb <10		(Fe <sub>2</sub> O <sub>3</sub> ) (2.26)	Nb 24	Pb	7.79	5.49	4.19
FeO	7.4	Ba 302	FeO 0.2	Ba 88	Sb	0.288	0.462	0.239
MnO	0.19		MnO 0.04		Tl	<0.455	<0.465	<0.478
TiO <sub>2</sub>	0.71		TiO <sub>2</sub> 0.28		Zn	100.	94.8	19.63
P <sub>2</sub> O <sub>5</sub>	0.32		P <sub>2</sub> O <sub>5</sub> 0.05		Bi	0.302	<0.232	<0.239
H <sub>2</sub> O+	3.3		H <sub>2</sub> O+ 0.3		Cd	0.0175	0.097	<0.096
CO <sub>2</sub>	0.22		CO <sub>2</sub> 0.31		Ga	8.02	6.59	1.04
S	0.01		S 0.05		Pd	<0.455	<0.465	<0.478
LOI	3.47		LOI 1.08		Se	<0.911	<0.929	<0.956
Total	100.3		Total 99.9		Te	<0.455	<0.465	<0.478
Total iron as Fe <sub>2</sub> O <sub>3</sub>	0.7		Total iron as Fe <sub>2</sub> O <sub>3</sub>	2.48				

Magnetic susceptibility and density not determined.

Field number KIB-14

Date completed 3-16-88

MGS unique number 241814

MGS lab number 2687

LOCATION (see map at right)

T-R-S 63-24-29 ABDD

County Koochiching

Quadrangle Deer Lake NW 7.5'

HOLE PARAMETERS (feet)

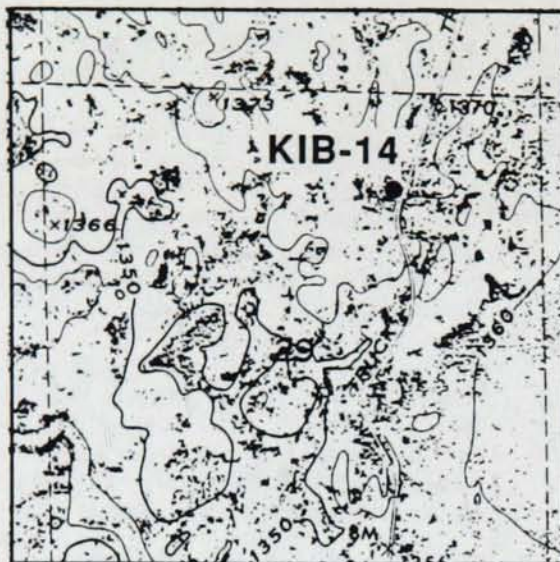
Surface elevation 1365

Total depth 320

Elevation, top of  
Precambrian rock 1189

Core interval cuttings only

Core recovered none



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-5	Till, dark brown, organic.
5-20	Smooth hard clay till, yellowish-brown. Contains a moderate amount of pebbles which are predominately carbonate.
20-60	Clay till, gray. Color change from above till is transitional over 10 feet. Contains abundant granules of carbonate.
60-125	Lacustrine silty clay or clayey till, gray. More silty and watery than above till. Thin sandy layer at 95 ft. depth, shaly parting noted in clay near 110 ft.
125-140	Fine sand, in abrupt transition with above unit.
140-186	Coarse gravel, cobbles, and boulders of fine-grained amphibolitic gneiss and coarse pink granite.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
186-191	Regolith, olive-yellow clay with grit. Contains grains of quartz and feldspar derived from partially weathered granitic bedrock.
191-296	Regolith, greenish-gray clay with abundant quartz grains, very smooth drilling, possibly derived from a biotite-hornblende schist. Thin zones of hard rock at 192-193, 210-220 ft. Drills smoothly with knocking at 2 to 3 ft. intervals to 235 ft., becomes hard 235-240 ft. Below 236 ft. is sandy-textured, gray, with some chunks of green, white, and purple variegated regolith. Washed and sorted cuttings from this interval consist of fine- to medium- grained pink to gray granitic gneiss.
296-320	Regolith, yellowish-brown, gritty, of granitic protolith.





Field number KIB-16

Date completed 2-29-88

MGS unique number 241816

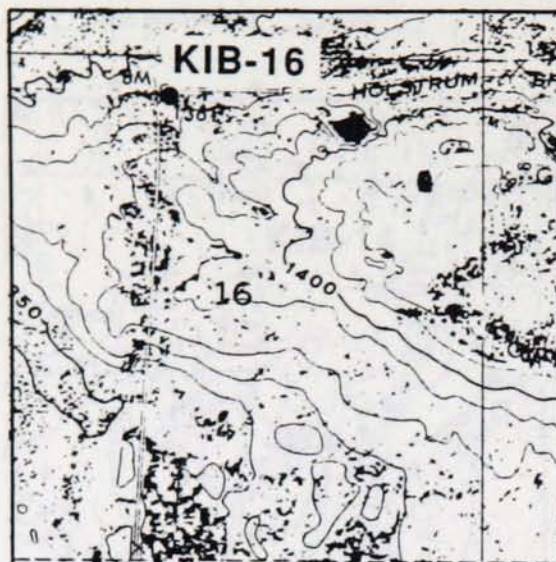
MGS lab number 2688

LOCATION (see map at right)

T-R-S 63-24-16 BABD

County Koochiching

Quadrangle Deer Lake 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1361

Total depth 288

Elevation, top of  
Precambrian rock 1135

Core interval cuttings only

Core recovered none

#### ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

#### QUATERNARY DEPOSITS

- |         |  |
|---------|--|
| 0-11    | Till, yellowish-brown, contains pebbles of carbonate (abundant) and red granite (minor). Small boulder at 11 ft.   |
| 11-41   | Till, gray, silt-rich. Contains 2 - 3mm granules of carbonate, otherwise very smooth and greasy. Becomes smoother with depth, possibly lacustrine clay.  |
| 41-58   | Coarse, homogeneous, granular sand. Grains are 2 - 4mm in diameter, angular, and consist of fine-grained black volcanic rocks, quartz, gneiss, black slate, felsic volcanics.                        |
| 58-121  | Silty lacustrine clay, gray, watery and greasy. Contains minor fine sand throughout and a few cobbles from 72-73 ft., becomes quite bouldery from 100-121 ft..                                       |
| 121-129 | Coarse granite-rich sand and gravel with many cobbles and boulders. Layer of watery silt/sand from 125-127 ft.   |
| 129-150 | Silty sand with lenses of silt.  |
| 150-161 | Fine-grained sand and silt, rich in cobbles and boulders.  |
| 161-226 | Sequences of gray silty clay and sand grading to gravel with depth. Very similar to the interval 129-150 ft. Several 2-3 ft. layers which ranging from silt to sand to gravel through this interval. |

#### REGOLITH ON PRECAMBRIAN ROCK

- |         |  |
|---------|--|
| 226-282 | Regolith, grayish-green, gritty, clayey. Becomes whiter below 231 ft. depth (kaolin), then grayer below 240 ft. depth. |
|---------|--|

#### SOUND PRECAMBRIAN ROCK

- |         |   |
|---------|---|
| 282-288 | Tonalite, black and white, medium-grained, weakly foliated. |
|---------|---|



Field number KIB-17

Date completed 2-29-88

MGS unique number 241817

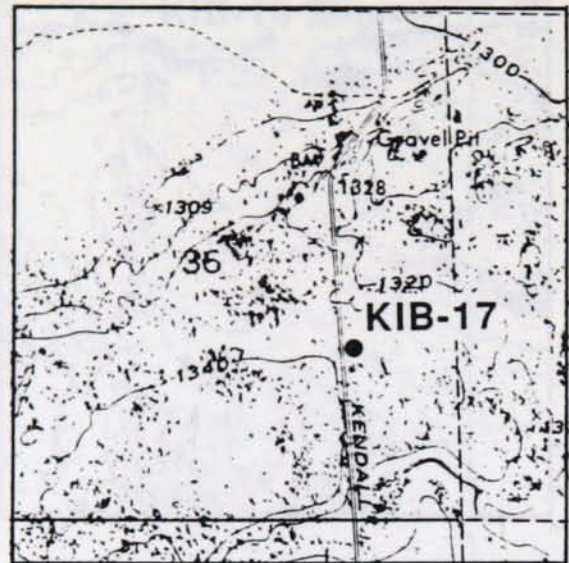
MGS lab number 2689

LOCATION (see map at right)

T-R-S 64-24-36 DACB

County Koochiching

Quadrangle Deer Lake NE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1337

Total depth 31

Elevation, top of  
Precambrian rock 1315

Core interval 22 - 30.7

Core recovered 8.7

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-6	Slightly sandy till, yellowish-brown. Contains small carbonate granules up to 4mm in diameter.
6-22	Till, gray; color transition from above brown, to brownish-gray with streaks of dark gray, to gray. Contains small carbonate clasts.

**REGOLITH ON PRECAMBRIAN ROCK**

None encountered.

**SOUND PRECAMBRIAN ROCK**

22-31	Sheared metabasalt, dark greenish-gray, fine-grained
-------	--

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-17

Principal rock type: Amphibolitized metabasalt

Mineralogy: Hornblende, poikilitic (50%); quartz, granoblastic (44%); opaque oxides (5%); calcite(1%); chlorite (tr-1%); epidote (tr).

Texture: Fine- to medium-grained, foliated, original texture totally obliterated by neocrystallization.

Structure: Strong shear foliation dips 65-70°, is locally kinked by a second poorly defined fabric at a lower (30-50°dip) angle. Thin clots of quartz and calcite parallel foliation, represent boudinaged veins, minor quartz veining also parallels second kink fabric. Local cm-scale zones of late shear-parallel foliation.

## CHEMICAL DATA

Rock Type Analyzed: Metabasalt, 30.3-30.7 ft. (whole rock), 27.2-28 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	47.6	Cl	150	Ag	0.08
Al <sub>2</sub> O <sub>3</sub>	13.2	Cr	106	As	<0.969
CaO	11.6	Rb	17	Au	0.004
MgO	4.13	Sr	70	Cu	105.
Na <sub>2</sub> O	1.82	Y	31	Hg	<0.097
K <sub>2</sub> O	0.27	Zr	74	Mo	0.213
(Fe <sub>2</sub> O <sub>3</sub> )	(2.61)	Nb	12	Pb	0.647
FeO	11.6	Ba	61	Sb	<0.242
MnO	0.31			Tl	0.908
TiO <sub>2</sub>	1.35			Zn	30.0
P <sub>2</sub> O <sub>5</sub>	0.13			Bi	<0.242
H <sub>2</sub> O+	0.7			Cd	<0.097
CO <sub>2</sub>	2.59			Ga	3.39
S	0.09			Pd	<0.484
LOI	2.31			Se	<0.969
Total	98.3 (normalized)			Te	<0.484
Total iron as Fe <sub>2</sub> O <sub>3</sub>	15.5				

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
22-23	0.03	27-28	0.06
23-24	0.04	28-29	0.03
24-25	0.03	29-30	0.04
25-26	0.03	30-31	0.03
26-27	0.03	31-31.8	0.07

## DENSITY

Depth	Density
22.3	3.00

Field number KIB-18

Date completed 4-5-88

MGS unique number 241818

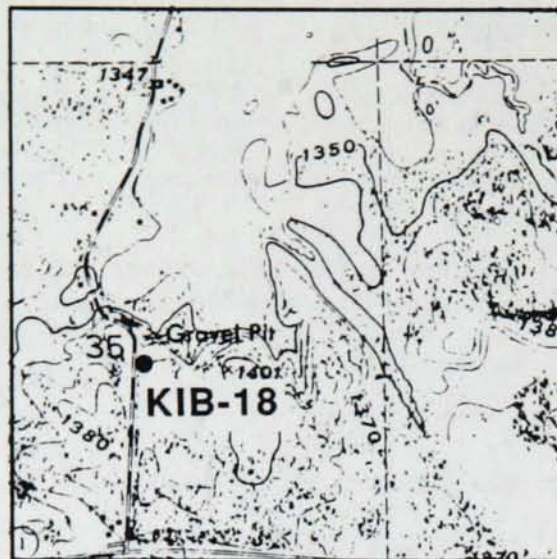
MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 62-24-35 DBBB

County Itasca

Quadrangle Deer Lake East 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1375

Total depth 375

Elevation, top of  
Precambrian rock 1207

Core interval 359 - 375

Core recovered 16

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-2	Artificial road fill (gravel).
2-24	Sandy clay, brown, contains fine- to medium-grained sand, gravel below 12 ft.
24-38	Sand and gravel.
38-85	Interlayered coarse- to fine-grained sand, with thin lenses of clayey sand).
85-111	Cobbly sand and gravel, interlayered fine-grained sand.
111-168	Reworked regolith. Drills alternately hard and soft, hard zones show a diversity of Archean rock types. Soft zones 129-129.5, 131-134.5, 135-136 ft. of white to gray regolith material. Orangish-brown clayey regolith 137.5-149.5 ft.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
168-180	Regolith, gray to grayish-green clay. Contains chips of black aphanitic volcanic rock.
180-223	Regolith, gray clay, with chips of black biotite schist, grayish-green 'greenstone'.
223-228	(Hard rock zone) Light gray fine-grained leucogranite.
228-236	Regolith, gray clay with gray feldspathic material and greenish argillite cuttings.
236-240	(Hard zone) Dark to light grayish-green foliated argillaceous material.
240-288	Regolith, pinkish-tan clay with hard cuttings of grayish-green argillite similar to above.
288-350	Regolith, creamy white clay with local clots of pinkish clay. Rare chips of light green argillite.
350-359	(Hard zone) Light green to greenish-gray foliated and veined feldspathic material (argillite or felsic volcanic); also white clayey regolith.
<b>SOUND PRECAMBRIAN ROCK</b>	
359-375	Fragmental crystal tuff, dacitic to andesitic, carbonate-altered.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-18

Principal rock type: Altered crystal-lithic tuff

Mineralogy: **Plagioclase**, as phenocrysts and in groundmass; **quartz**, as phenocrysts and in groundmass; **carbonate**, rhombic (10-15%); **sericite**; **hematite** (? semi-opaque, granular); **chlorite**; **pyrite**; **chalcopyrite**.

Texture: Scattered quartz and feldspar phenocrysts are in a fine-grained cherty-appearing tuffaceous groundmass, which is locally recrystallized into poikilitic quartz patches. Thin section from upper part of core shows very fine-grained, feathery trachytic feldspar in groundmass. Carbonate alteration is pervasive as rhombs overprinted onto preexisting texture. Fragmental texture is locally visible in core hand sample.

Structure: Weakly foliated fabric dips 50-60° from horizontal. Rock is transected by deformed quartz-carbonate veins and later, rather flat and more regular chlorite-quartz-carbonate veins.

## CHEMICAL DATA

Rock Type Analyzed: Carbonate-altered crystal-lithic tuff, 363-364 ft. and 373-374 ft. depths.

### Minor Elements (ppm)

	[363 ft.]	[373 ft.]
Ag	0.038	0.023
As	2.42	<0.926
Au	0.002	0.001
Cu	9.06	17.3
Hg	<0.094	<0.093
Mo	0.520	0.100
Pb	1.38	0.976
Sb	0.339	0.362
Tl	1.23	1.25
Zn	27.0	40.8
Bi	<0.235	<0.231
Cd	<0.094	<0.093
Ga	<0.469	<0.463
Pd	<0.469	<0.463
Se	<0.938	<0.926
Te	<0.469	<0.463

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
359-360	0.00	366-369	0.00
360-361	0.02	369-370	0.01
361-364	0.00	370-372	0.00
364-365	0.01	372-375	0.01
365-366	0.02		

## DENSITY

Depth	Density
361.7	2.77
367	2.77

Field number KIB-19

Date completed 3-14-88

MGS unique number 241819

MGS lab number 2690

LOCATION (see map at right)

T-R-S 64-24-25 DDA

County Koochiching

Quadrangle Deer Lake NE 7.5'

HOLE PARAMETERS (feet)

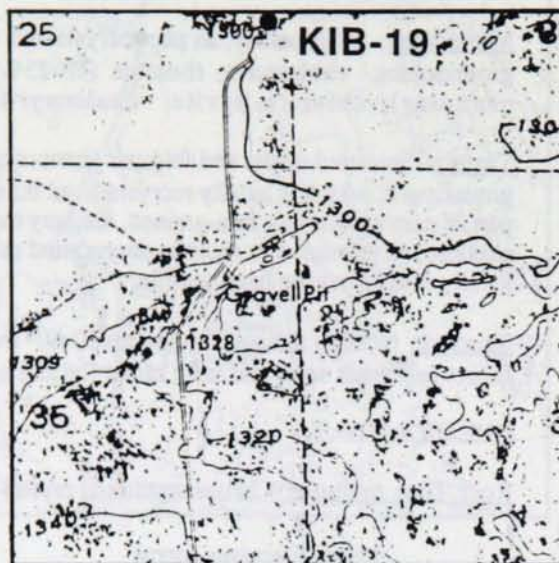
Surface elevation 1300

Total depth 81

Elevation, top of  
Precambrian rock 1232

Core interval 71 - 81

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-12	Clay till, light brown. Low volume of sand and pebbles, the latter of which are dominantly carbonate.
12-68	Clay till, medium gray to dark olive-gray. Cobble at 39 ft. Till is lighter gray, more watery and silty 39 - 50 ft.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
	None encountered.
<b>SOUND PRECAMBRIAN ROCK</b>	
68-81	Metamorphosed mafic tuff or flow, dark green, epidotized.



PETROGRAPHIC DESCRIPTION OF CORE: KIB-19

Principal rock type: Magnetic metabasalt

Mineralogy: Hornblende (55-70%); biotite (tr-20%); quartz (tr-20%); feldspar (0-20%); chlorite; muscovite; sphene; apatite; pyrite; Fe-Ti oxides; calcite (trace if each); garnet and diopside (trace), in calcite vein.

Texture: Metamorphic texture, shows much variability in hand sample including layering, boudinaged epidote-calcite veins, possible relict flow-top features. Layering possibly due to shear, defined by variations in hornblende, biotite, quartz-feldspar content. Epidote and carbonate found in veins or knots.

Structure: Foliation and layering dip 50-60° from horizontal. Late brittle fractures are subhorizontal.

CHEMICAL DATA

Rock Type Analyzed: Metabasalt, 71.2-71.4 ft. (whole rock); 73.5-74.5 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	51.4	Cl	100	Ag	0.127
Al <sub>2</sub> O <sub>3</sub>	14.5	Cr	519	As	<0.967
CaO	9.56	Rb	66	Au	0.002
MgO	6.32	Sr	126	Cu	169.
Na <sub>2</sub> O	2.92	Y	23	Hg	<0.097
K <sub>2</sub> O	1.17	Zr	48	Mo	<0.097
(Fe <sub>2</sub> O <sub>3</sub> )	(3.49)	Nb	12	Pb	1.31
FeO	7.3	Ba	204	Sb	<0.242
MnO	0.33			Tl	0.961
TiO <sub>2</sub>	0.96			Zn	47.2
P <sub>2</sub> O <sub>5</sub>	0.10			Bi	<0.242
H <sub>2</sub> O+	0.9			Cd	<0.097
CO <sub>2</sub>	0.03			Ga	4.17
S	NIL			Pd	<0.484
LOI	0.77			Se	<0.967
Total	99.8 (normalized)			Te	<0.484
Total iron as Fe <sub>2</sub> O <sub>3</sub>	11.6				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
71-72	0.03	76-77	0.08
72-73	0.02	77-78	0.32
73-74	0.60	78-79	0.02
74-75	2.60	79-80.3	0.08
75-76	1.60		

DENSITY

Depth	Density
74.5	2.99
75.7	3.07

Field number KIB-20

Date completed 3-2-88

MGS unique number 241820

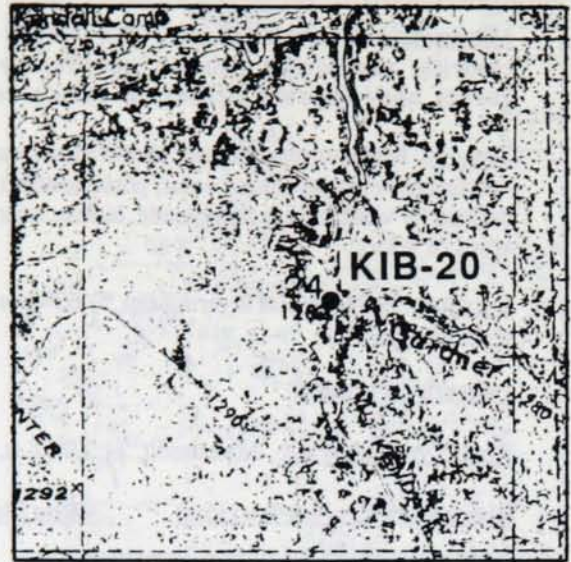
MGS lab number 2691

LOCATION (see map at right)

T-R-S 64-24-24 DADB

County Koochiching

Quadrangle Nett Lake River SE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1282

Total depth 246

Elevation, top of  
Precambrian rock 1091

Core interval 236 - 246

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-80	Till, brownish-gray to gray, becomes grayer with depth. Contains abundant cm-sized pebbles of carbonate, minor granite and other Archean rock types. 6" cobble at 70.5 ft.
80-140	Lacustrine clay, gray, smooth and sticky, pebble-free.
140-155	Coarse gravelly sand and boulders.
155-174	Sandy till, gray, contains a low volume of carbonate pebbles.
174-191	Coarse gravel with many boulders. Large pinkish-gray, fine-grained amphibolitic gneiss boulder at 174-180 ft. Bouldery gravel 180-185 ft., coarse sand with a couple boulders 185-191 ft. Thin zone of gray watery clay near bottom of interval.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
191-201	Mostly hard rock (gneissic) with minor amounts of gritty bluish-green to army green regolith at top and along fractures which are spaced a foot apart.
201-217	Regolith, bluish-green gritty clay and red, fine-grained aplitic granite; local cuttings of white kaolinitic regolith.
217-218	Hard zone of black aphanitic, porphyritic mafic volcanic rock.
218-220	Regolith, bluish-green, gritty clay; derived from granitic rock.
<b>SOUND PRECAMBRIAN ROCK</b>	
220-246	Foliated, fine-grained meta-arkosic sandstone, dark greenish-black, intruded by granitic stringers.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-20

Principal rock type: Meta-arkose, quartz monzonite.

Mineralogy: (Meta-arkose) **Quartz** (40%); **feldspar**, sericitized (42%); **chlorite** (17%); **epidote**; **apatite**; **zircon**; **pyrite**; **oxides** (trace of each).  
(Quartz monzonite) **Plagioclase** (42%); **orthoclase** (40%); **quartz** (8-10%); **epidote** (3-4%); **sphene** (2%); **pyrite** (1%); **chlorite** (1%); **apatite** (tr-1%); **oxides** (tr%); **calcite** (tr).

### Texture:

Meta-arkose shows original texture of well-sorted, fairly clean sandstone. Subsequent brittle shear has resulted in chlorite-lined shear planes which anastomose between elongate and variably recrystallized (strained, mortar-textured) quartz and feldspar grains.

Quartz monzonite shows moderately strong brittle shear deformation, via shadowy and mortar-textured quartz, broken feldspar, and mm-wide zones of intense granulation.

Structure: Foliation and bedding dip at 50 to 60°. Early stringers of intrusive granodiorite are foliated and deformed, later intrusions of quartz monzonite have undergone only brittle deformation. Chloritized shear zones are steeply inclined, entire rock is moderately brecciated.

## CHEMICAL DATA

Rock Type Analyzed: Dacitic tuff, 241.3 ft.; quartz monzonite, 245.2 ft.

### Minor Elements (ppm)

	241.3 ft.)	245.2 ft.)
Ag	0.046	0.042
As	0.975	<0.954
Au	0.002	0.002
Cu	43.1	24.4
Hg	<0.095	<0.095
Mo	0.149	0.857
Pb	3.87	2.80
Sb	<0.237	<0.239
Tl	1.13	1.11
Zn	75.2	31.9
Bi	<0.237	0.267
Cd	<0.095	<0.095
Ga	8.30	3.40
Pd	<0.474	<0.477
Se	<0.949	<0.954
Te	<0.474	<0.477

### MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
236-237	0.02	242-243	0.00
237-239	0.00	243-244	0.01
239-241	0.01	244-246	0.00
241-242	0.02		

### DENSITY

Depth	Density
241.3	2.71
245.2	2.70

Field number KIB-21

Date completed 3-8-88

MGS unique number 241821

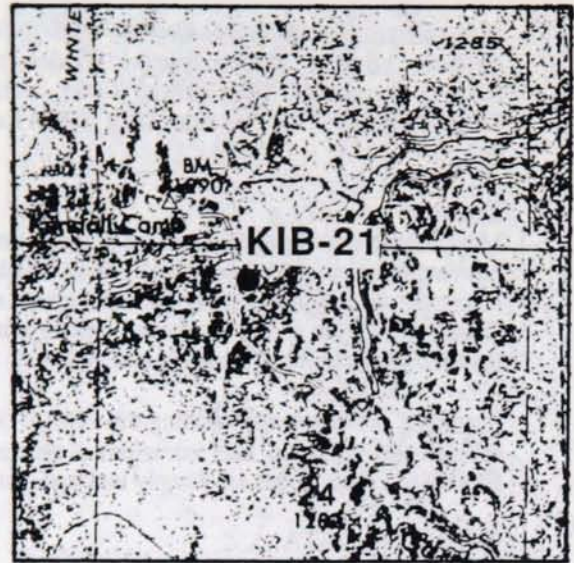
MGS lab number 2692

LOCATION (see map at right)

T-R-S 64-24-24 BABB

County Koochiching

Quadrangle Nett Lake River SE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1280

Total depth 315

Elevation, top of  
Precambrian rock 1057

Core interval cuttings only

Core recovered none

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-12	Clay till, light brown, contains a low volume of pebbles which are dominantly carbonate.
12-80	Clay till, gray, similiar to above.
80-125	Smooth clay, gray, probably lacustrine.
125-143	Cobbly, sandy till, light gray. Cobble-rich zones at 125-128, 130-132, 137-138 ft.
143-174	Clayey to sandy till, gray. Pebbles are dominantly granite and fine-grained biotite schist.
174-170	Sand.
179-181	Pink granite boulder.
181-195	Sandy till. Abundant pebbles of biotite schist, granite, quartz, and epidotized granite.
195-219	Fine- to coarse-grained sand. Abundant cobbles and boulders below 217 ft.
219-223	Large boulder, possibly of migmatite.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
223-250	Regolith, smooth green clay.
250-290	Regolith, dark brown to medium green (epidote green) clay.
290-300	Chips of black metasedimentary rock with epidote veins in regolith which is similiar to above.
<b>SOUND PRECAMBRIAN ROCK</b>	
300-315	Fine-grained volcanogenic metagraywacke, light gray.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-21

Principal rock type: Metagraywacke, with felsic volcanic component.

Mineralogy: Feldspar (35-40%); quartz (30-35%) chlorite (15-20%); calcite, variable (tr-15%) epidote (1-2%); opaques (tr-1%); sericite; amphibole; biotite, altered to chlorite (trace of each).

Texture: (cuttings chips only) Fine-grained, foliated, variably altered to calcite. Larger quartz and blocky plagioclase crystals are in a fine-grained quartzo-feldspathic, chloritic groundmass, are relatively undeformed and fresh.

Structure: Indeterminable from cuttings sample, no core.

## CHEMICAL DATA

Rock Type Analyzed: Volcanogenic graywacke, 300-315 ft. depth.

### Minor Elements (ppm)

Ag	0.07
As	4.72
Au	0.002
Cu	43.1
Hg	<0.095
Mo	0.235
Pb	5.19
Sb	<0.238
Tl	0.937
Zn	74.1
Bi	<0.238
Cd	<0.095
Ga	11.8
Pd	<0.476
Se	<0.952
Te	<0.476

### MAGNETIC SUSCEPTIBILITY (depths in feet)

Not determined.

### DENSITY

Not determined.

Field number KIB-23

Date completed 3-29-88

MGS unique number 241823

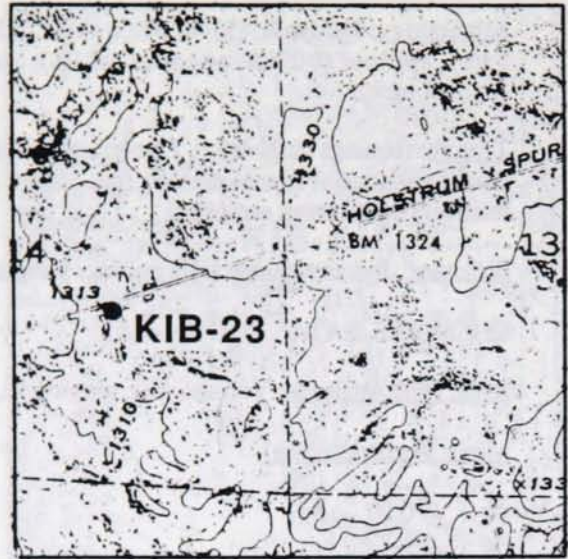
MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 63-25-14 DBcenter

County Koochiching

Quadrangle Deer Lake NW 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1316

Total depth 120

Elevation, top of  
Precambrian rock unknown

Core interval none

Core recovered none

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

QUATERNARY DEPOSITS

0-12	Clay till, light brown. Pebbles dominantly of carbonate, lesser granite.
12-116	Clay till, gray. Drier and dark gray to slightly greenish-gray below 25 ft.
116-120	Medium- to coarse-grained sand consisting dominantly of black metabasalt, granite, carbonate.



Field number KIB-24

Date completed 3-24-88

MGS unique number 241824

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 63-25-15 CDA

County Koochiching

Quadrangle Cragville 7.5'

HOLE PARAMETERS (feet)

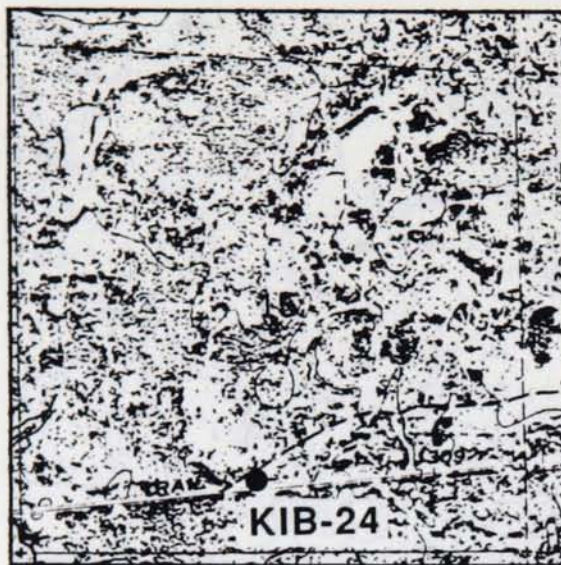
Surface elevation 1304

Total depth 360

Elevation, top of  
Precambrian rock 1170

Core interval cuttings only

Core recovered none



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-10	Clay till, brown, contain abundant pebbles of carbonate. Becomes grayish-brown after 8 ft., grades into gray till below.
10-82	Clay till, gray. Contains scattered pebbles of carbonate and various Archean rock types.
82-115	Sticky clay till, gray. Similiar to above gray till but contains very few clasts.
115-134	Poorly sorted bouldery gravel, brown. Thin layer of lacustrine clay 123-125 ft.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
134-195	Regolith, pale green, sandy clay. Hardens slightly around 136 ft., but softens quickly. Becomes darker green beyond 150 ft., also note chunks of white kaolin, quartz grains, pink feldspar fragments, pieces of black biotite or amphibole. Lighter grayish-green and very greasy near 182 ft.
195-240	Begin to note hard green and white granitic rockz chips in regolith similiar to above, also noted minor darker gray, slimy regolith (compared to light greenish-gray and sandy). Hardens slightly around 230 ft. and 235-240 ft.; note chips of green and white, medium-grained tonalitic rock.
240-340	Regolith again becomes very slimy, hardens slightly 290-295 ft.. Very soft and slimy to 340 ft.
<b>SOUND PRECAMBRIAN ROCK</b>	
340-360	Massive tonalite/granodiorite, dark green and white, medium-grained.





Field number KIB-26

Date completed 5-24-88

MGS unique number 241826

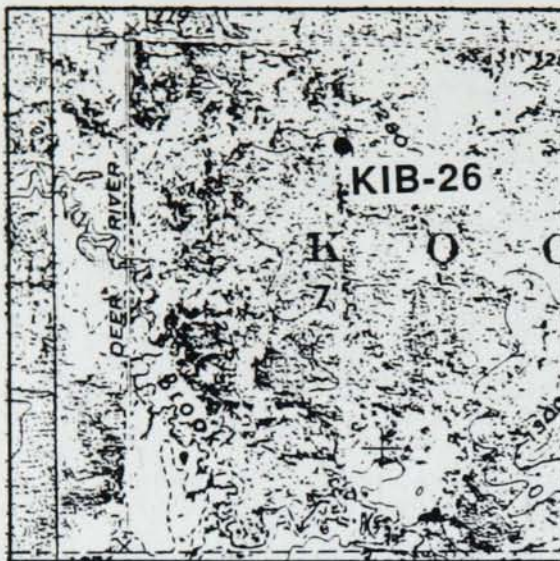
MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 63-25-7 ABCCC

County Koochiching

Quadrangle Craigville 7.5'



**HOLE PARAMETERS**

Surface elevation 1283

Total depth 110

Elevation, top of  
Precambrian rock 1193

Core interval 100 - 110

Core recovered 10

**ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)**

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-82	Sandy till, gray to brownish-gray. Clay is dense, dry and sticky, contains fine- to coarse-grained sand and minor coarse sand to pebble-sized carbonate clasts. Less sandy and more watery below 45 ft.
82-89	Fine-grained sand.
89-90	Boulder of mafic composition.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
90-100	Regolith, light brownish-white, sandy, deficient in clay. White kaolinitic chips with hornblende or chlorite 99-100 ft.
<b>SOUND PRECAMBRIAN ROCK</b>	
100-110	Weakly foliated quartz monzonite, light gray, medium- to coarse-grained.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-26

Principal rock type: Quartz monzodiorite.

Mineralogy: Plagioclase (45%); orthoclase, perthitic (10%); quartz (9%); hornblende (23%); opaque oxides (tr-1%); sphene; epidote; apatite; biotite (trace of each).

Texture: Large (3-7mm), aligned plagioclase and hornblende crystals are set in a matrix of fine-grained, allotriomorphic-granoblastic quartz, perthitic orthoclase, plagioclase, and myrmekite. Minor brittle deformation texture is manifested in bent plagioclase crystals.

Structure: Igneous foliation dips at 50° from horizontal; minor epidote veining dips 80° from horizontal.

## CHEMICAL DATA

Rock Type Analyzed: Quartz monzonite, 100.6 ft.

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	59.8	Cl	100
Al <sub>2</sub> O <sub>3</sub>	17.7	Cr	17
CaO	6.34	Rb	45
MgO	2.58	Sr	1260
Na <sub>2</sub> O	4.96	Y	<10
K <sub>2</sub> O	1.58	Zr	66
(Fe <sub>2</sub> O <sub>3</sub> )	(3.25)	Nb	19
FeO	2.1	Ba	626
MnO	0.10		
TiO <sub>2</sub>	0.56		
P <sub>2</sub> O <sub>5</sub>	0.27		
H <sub>2</sub> O+	1.0		
CO <sub>2</sub>	0.02		
S	0.04		
LOI	0.54		
Total	100.2 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	5.58		

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading ( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
100-101	0.53	105-106	0.02
101-102	0.29	106-108	0.02
102-103	0.09	108-110	0.07
103-104	0.05	110-111	0.09
104-105	0.03		

## DENSITY

Depth	Density
100	2.76

Field number KIB-30

Date completed 5-4-88

MGS unique number 241830

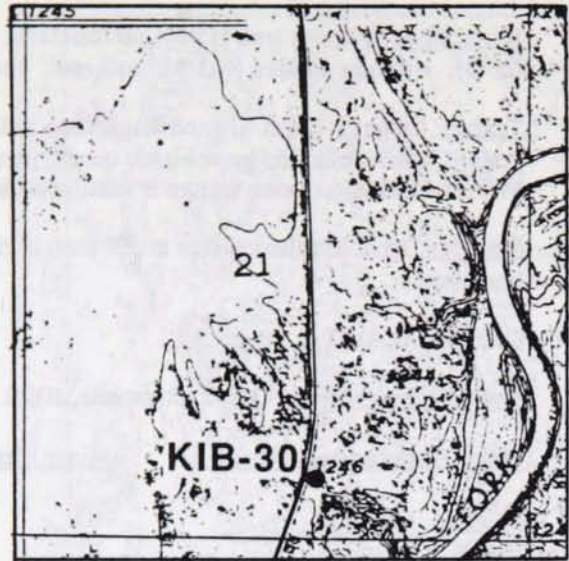
MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 65-26-21 DCCABB

County Koochiching

Quadrangle Johnson Landing 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1243

Total depth 241

Elevation, top of  
Precambrian rock 1027

Core interval 231 - 241

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-5	Gravel and gravelly clay, gray to brownish-gray.
5-195	Gravelly till, brownish-gray. Pebbles dominantly carbonate, granite and mafics.
195-215	Fine sand and silt.
215-216	Boulders.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
216-220	Regolith, light gray to greenish-gray clay.
<b>SOUND PRECAMBRIAN ROCK</b>	
220-241	Brecciated metagraywacke (possibly dacitic to andesitic tuff).

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-30

Principal rock type: Brecciated metagraywacke (arkosic).

Mineralogy: Quartz; feldspar, variably sericitized; chlorite, after biotite; muscovite; garnet (trace); epidote (1-2%); adularia (tr, in veins); pyrite (trace-1%); chalcopyrite (tr).

Texture Fine-grained, foliated chlorite after biotite is in a groundmass of granoblastic quartz and feldspar (plagioclase) of indeterminable proportions. Several phases of veins are present, including early deformed quartz and later undeformed quartz, adularia, and garnet-chlorite veins. Texture and mineralogy suggest that the most likely protolith is arkosic graywacke/sandstone. In hand sample the core appears brecciated, this is most likely a tectonic breccia, as thin sections show apparent mechanical breakage, followed by recrystallization.

Structure: Bedding dips at 30° from horizontal. Numerous veins occupying fractures and shears transect core at various angles, most have a relatively high dip.

## CHEMICAL DATA

Rock Type Analyzed: Metagraywacke, 237 ft. (whole rock); 237.5-238 ft. (assay).

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	64.8	Cl	<50	Ag	0.202
Al <sub>2</sub> O <sub>3</sub>	14.3	Cr	213	As	1.10
CaO	1.56	Rb	154	Au	0.007
MgO	3.00	Sr	313	Cu	96.6
Na <sub>2</sub> O	1.37	Y	13	Hg	<0.095
K <sub>2</sub> O	3.57	Zr	130	Mo	1.83
(Fe <sub>2</sub> O <sub>3</sub> )	(1.77)	Nb	16	Pb	9.15
FeO	4.8	Ba	904	Sb	<0.238
MnO	0.11			Tl	<0.476
TiO <sub>2</sub>	0.63			Zn	88.3
P <sub>2</sub> O <sub>5</sub>	0.16			Bi	0.811
H <sub>2</sub> O+	1.9			Cd	0.098
CO <sub>2</sub>	<0.01			Ga	10.8
S	0.27			Pd	<0.476
LOI	2.77			Se	1.64
Total	99.6 (normalized)			Te	<0.476
Total iron as Fe <sub>2</sub> O <sub>3</sub>	7.10				

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
231-241	0.00 - 0.01

## DENSITY

Depth	Density
233.6	2.69
235	2.73

Field number KIB-32

Date completed 5-5-88

MGS unique number 241832

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 63-27-26 BDCDD

County Koochiching

Quadrangle Wildwood NE 7.5'

HOLE PARAMETERS (feet)

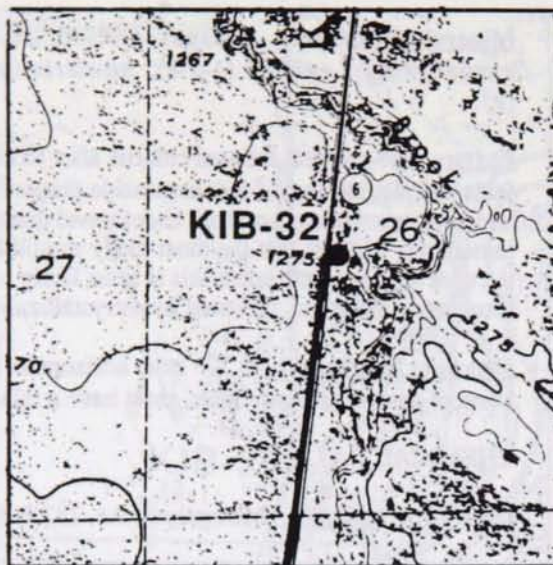
Surface elevation 1273

Total depth 107.5

Elevation, top of  
Precambrian rock 1206

Core interval 105 -107.5

Core recovered 2.5



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

QUATERNARY DEPOSITS

0-2	Sand and gravel, brown .
2-50	Sandy and gravelly till, dark brown and slightly variegated, becomes more consistent and grayish-brown in color below 25 ft.. Dense, dry, and compact below 10 ft.. Clasts of carbonate, granite, and mafic rocks.
50-55	Sandy clay, gray, watery. Clast lithology similiar to above.
55-67	Zone of boulders, dominantly granite and mafic schist.

REGOLITH ON PRECAMBRIAN ROCK

67-105	Regolith, gray to greenish-gray clay, contains abundant chips of garnet, biotite schist.
--------	--

SOUND PRECAMBRIAN ROCK

105-107.5	Fine-grained, well-foliated, quartzofeldspathic biotite schist (metagraywacke).
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## PETROGRAPHIC DESCRIPTION OF CORE: KIB-32

Principal rock type: Biotite schist (metagraywacke)

Mineralogy: **Plagioclase**, variably altered to sericite (50%); **quartz** (25%); **biotite** (22%); **opaques**, dominantly oxides (1-2%); **apatite** (1%); **zircon**, subhedral; **chlorite**; **hornblende**; **sillimanite** (trace of each).

Texture: Fine grained, well foliated (defined by aligned biotite, veined with quartz  $\pm$  feldspar. Strongly recrystallized, granoblastic quartz and feldspar.

Structure: Foliation dips 70° from horizontal, parallels bedding.

## CHEMICAL DATA

Rock Type Analyzed: Biotite schist, 107-107.5 ft. depth.

### Minor Elements (ppm)

Ag	0.113
As	0.998
Au	0.006
Cu	60.2
Hg	<0.098
Mo	2.03
Pb	7.31
Sb	0.245
Tl	<0.49
Zn	74.7
Bi	<0.245
Cd	0.117
Ga	8.03
Pd	<0.49
Se	<0.98
Te	<0.49

### MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( $\times 10^{-3}$ cgs units)
105	0.01
106	0.00

### DENSITY

Depth	Density
105	2.75
107	2.76

Field number KIB-35

Date completed 12-15-87

MGS unique number 241835B

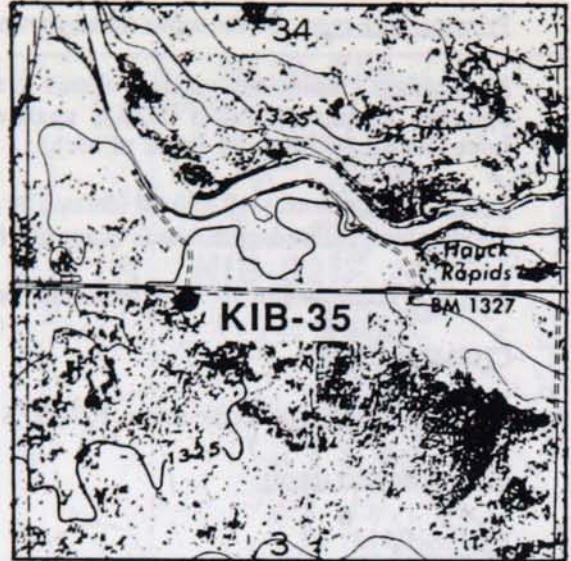
MGS lab number 2695

LOCATION (see map at right)

T-R-S 149-25-3 ABBBB

County Itasca

Quadrangle Wildwood SE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1325

Total depth 360

Elevation, top of  
Precambrian rock 1132

Core interval cuttings only

Core recovered none

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-14	Lacustrine clay, light yellowish-brown with thin laminae of light brownish-gray clay. Minor black organic material.
14-21	Lacustrine clay, olive-gray to dark gray.
21-35	Thin layer of of gravelly sand underlain by silty gray lacustrine clay.
35-67	Lacustrine clay, gray, smooth, hard and dry, with streaks of light gray and yellow clay.
67-69	Sand.
69-83	Lacustrine clay, gray, smooth, contains thin lighter-colored laminae.
83-140	Till, gray, sandy, transition from above marked by small boulder. Contains abundant small cobbles of fine-grained amphibolite, granite, minor carbonate. Becomes very sandy 100-110 ft. depth.
140-179	Bouldery till, gray, sandy. Boulders 158-160 ft, nearly continuous boulders of fine-grained mafic amphibolitic schist and metagabbro 160-179 ft.
179-193	Sandy till, gray. Pebbles of carbonate and fine-grained mafic volcanics.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
193-249	Regolith, white and light bluish-green clay containing fine grit. Vague igneous texture visible in cuttings.
249-252	Hard zone, chips of pink and green granite.
252-340	Regolith, chalky green and white with minor streaks of green and reddish-brown clayey material.
<b>SOUND PRECAMBRIAN ROCK</b>	
340-360	Granite, pink, coarse-grained, homogeneous, quartz-rich.





Field number KIB-37

Date completed 5-17-88

MGS unique number 241837

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 149-26-23 BDA

County Itasca

Quadrangle Wirt 7.5'

HOLE PARAMETERS (feet)

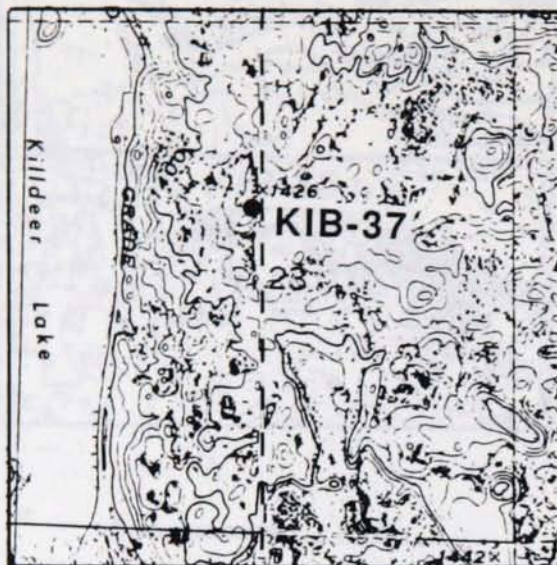
Surface elevation 1412

Total depth 225.5

Elevation, top of  
Precambrian rock 1302

Core interval 220 - 222.5

Core recovered 2.5



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-10	Sand, brownish-tan, clayey.
10-30	Clay, medium gray, sandy.
30-45	Clayey sand (as in 0-10 ft. above) contains brown and gray variegated clay.
45-80	Clay, dark gray, sandy.
80-110	Medium-grained sand.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
110-200	Regolith, dark gray clay, changes to light green to greenish gray with depth. Note white and green feldspar (135-140 ft.), and schist, granite, and gabbroic rock chips.
200-220	Harder regolith, cuttings of green clay and mafic rock chips with hornblende and plagioclase. At 204 ft. note pink granite or syenite chips. Below 210 ft. chips are dominated by gabbroic to dioritic rock types.
<b>SOUND PRECAMBRIAN ROCK</b>	
220-222.5	Metadiorite, medium to coarse grained, weakly porphyritic.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-37

Principal rock type: Meta-(quartz)diorite

Mineralogy: Hornblende, relict (31%); chlorite (22%); epidote and clinozoisite (20%); plagioclase, relict (15%); quartz (9%); calcite (2%); muscovite (tr-1%) apatite; sphene; opaques oxides (trace).

Approximate mineralogy of protolith: hornblende (40%); plagioclase (50%); quartz (9%); opaque oxides (1%).

Texture: Primary coarse-grained plutonic igneous texture modified by metamorphism to present moderately foliated metamorphic texture; relict igneous texture still evident. Cut by later, mm-thick veins of pink quartz-plagioclase.

Structure: Foliation dips near vertical.

## CHEMICAL DATA

Rock Type Analyzed: Meta-(quartz)diorite, 221.5 ft. depth

Major Elements (wt. % oxides)      Minor Elements (ppm)

SiO <sub>2</sub>	53.5	Cl	50
Al <sub>2</sub> O <sub>3</sub>	17.2	Cr	72
CaO	8.35	Rb	32
MgO	5.20	Sr	252
Na <sub>2</sub> O	2.79	Y	12
K <sub>2</sub> O	0.59	Zr	24
(Fe <sub>2</sub> O <sub>3</sub> )	(2.87)	Nb	<10
FeO	4.7	Ba	148
MnO	0.12		
TiO <sub>2</sub>	0.55		
P <sub>2</sub> O <sub>5</sub>	0.07		
H <sub>2</sub> O+	2.3		
CO <sub>2</sub>	0.07		
S	0.03		
LOI	2.54		
Total	99.1 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	8.09		

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
220	0.02
221	0.01
222.5	0.00

## DENSITY

Depth	Density
221	2.85

Field number KIB-38

Date completed 11-21-87

MGS unique number 241838

MGS lab number 2696

LOCATION (see map at right)

T-R-S 149-25-31 AAAA

County Itasca

Quadrangle Wirt 7.5'

HOLE PARAMETERS (feet)

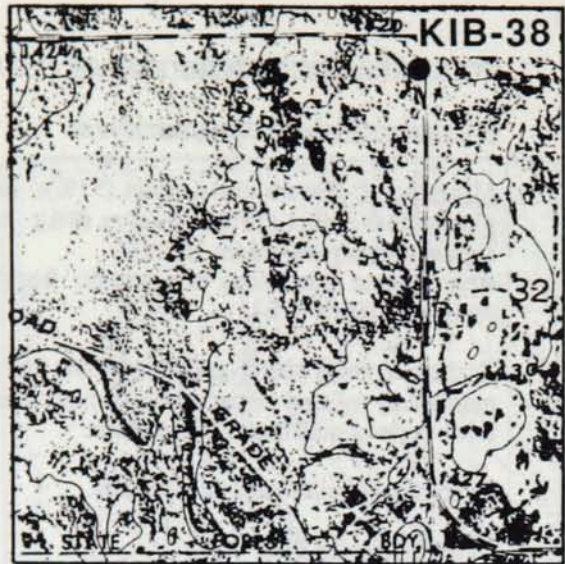
Surface elevation 1428

Total depth 268

Elevation, top of  
Precambrian rock 1231

Core interval cuttings only

Core recovered none



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-15	Pebbly till, brown, contains pebbles of carbonate, mafic schist, amphibolite, quartz.
15-49	Sandy till, gray, with black lignite chips, possibly lacustrine sandy/silty clay. Sand layer 15-17 ft.
49-76	Coarse cobbly gravel, gray. Soupy clay and silt-rich gravel 60-62 ft.
76-91	Gravel, reddish-brown, boulders at 89 and 90 ft. of amphibolite and granite.
91-122	Sandy till, gray, contains only minor amount of pebbles. Near 120 ft. note abundant pebbles of carbonate, fine grained amphibolite, granite, and dark green intermediate volcanics.
122-130	Coarse gravel.
130-160	Dry sandy till. Encounter scattered cobbles of amphibolite below 140 ft., becomes more sandy and watery near 160 ft.
160-191	Coarse clayey sand, gray, soupy; gradational from above. Grades to dark gray, smooth silty clay at 169 ft., mixed intervals of clay, silt and sand to 191 ft.
191-197	Sandy till, gray, dry.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
197-265	Regolith, light greenish-gray clay with white and dark gray streaks. Near 205 ft. changes to interlayered deep bluish-green and dark grayish-brown clay, also minor reddish-brown and white kaolinitic clay near 243 ft. Overall appearance suggests protolith of a layered rock. Drilled through several 2-3 foot-thick hard zones, cuttings of coarse-grained granodioritic rock.
<b>SOUND PRECAMBRIAN ROCK</b>	
265-268	Hornblende-bearing granite, pink, coarse-grained.



Field number KIB-39

Date completed 11-24-87

MGS unique number 241839

MGS lab number 2697

LOCATION (see map at right)

T-R-S 148-25-9 BBCBBB

County Itasca

Quadrangle Spring Lake 7.5'

HOLE PARAMETERS (feet)

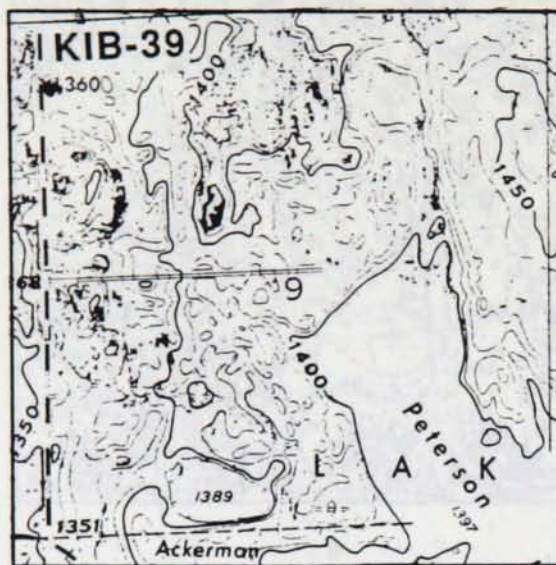
Surface elevation 1360

Total depth 169

Elevation, top of  
Precambrian rock 1211

Core interval 165-169

Core recovered 4



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-6.5	Clay till, brown.
6.5-16	Sand and gravel, fine- to coarse- grained.
16-34	Silty, sandy clay till, gray, interlayered with gray silty clay (17 - 24 ft.) and sand (24 - 25 ft.)
34-52	Fine to coarse sand with some clay; gravel at top.
52-93	Silty to sandy clay, gray.
93-146	Sandy till, gray, with minor pebbles, cobbles.
146-149	Silty sand, gray, fine- to coarse-grained, with minor pebbles; possibly a very sandy till.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
None encountered.	
<b>SOUND PRECAMBRIAN ROCK</b>	
149-169	Monzonite, pink, medium- to coarse-grained, weakly linedated.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-39

Principal rock type: Pyroxene monzonite

Mineralogy: Plagioclase (45%); orthoclase, perthite (31%); augite (8%); opaque oxides (3%); apatite (1%); hornblende (1%); chlorite (1%); sphene (1%); biotite (1%) quartz (0-tr).

Texture: Medium grained, seriate; well-defined igneous foliation/lineation defined by rectangular augite and plagioclase. Augite is sub- to euhedral, feldspars are anhedral, both augite and plagioclase vary in grain size from medium to fine grained, orthoclase is anhedral-interstitial.

Structure: Igneous foliation/lineation is near vertical.

CHEMICAL DATA

Rock Type Analyzed: Pyroxene monzonite, 168-168.3 ft.(whole rock), 168.6-169 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	60.2	Cl	50	Ag	0.289
Al <sub>2</sub> O <sub>3</sub>	17.2	Cr	36	As	3.22
CaO	3.55	Rb	129	Au	0.005
MgO	1.85	Sr	2180	Cu	190.
Na <sub>2</sub> O	6.30	Y	17	Hg	<0.095
K <sub>2</sub> O	4.40	Zr	253	Mo	0.283
(Fe <sub>2</sub> O <sub>3</sub> )	(2.83)	Nb	14	Pb	27.9
FeO	1.0	Ba	1970	Sb	<0.238
MnO	0.08			Tl	0.988
TiO <sub>2</sub>	0.42			Zn	55.0
P <sub>2</sub> O <sub>5</sub>	0.32			Bi	0.248
H <sub>2</sub> O+	0.5			Cd	<0.095
CO <sub>2</sub>	0.02			Ga	2.76
S	NIL			Pd	<0.475
LOI	1.00			Se	<0.951
Total	99.8 (normalized)			Te	<0.475
Total iron as Fe <sub>2</sub> O <sub>3</sub>	3.94				

MAGNETIC SUSCEPTIBILITY (depth in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
165-166	0.69	167-168	0.78
166-167	0.99	168-169	0.67

DENSITY

Depth	Density
168.5	2.67

Field number KIB-40

Date completed 12-1-87

MGS unique number 241840

MGS lab number 2698

LOCATION (see map at right)

T-R-S 148-25-15 CCCA

County Itasca

Quadrangle Spring Lake 7.5'

HOLE PARAMETERS (feet)

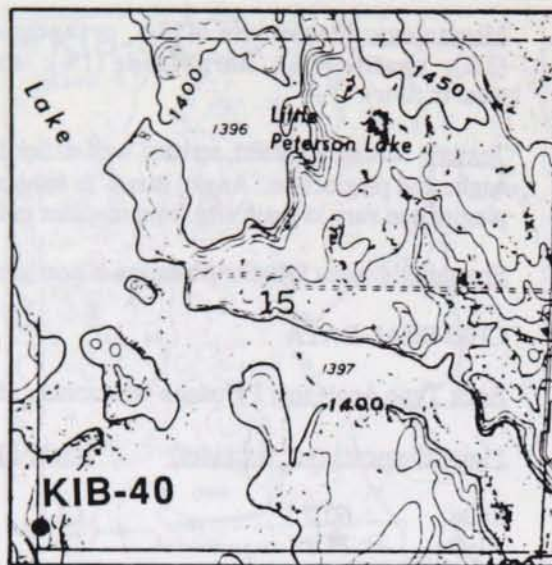
Surface elevation 1411

Total depth 305

Elevation, top of  
Precambrian rock 1168

Core interval 297-305

Core recovered 8



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0 - 5	Coarse gravely sand.
5-16	Till, brown, contains abundant pebbles of carbonate, granite, amphibolite.
16-38	Smooth till, dark gray, contains pebbles of carbonate, basalt, black slate, granite, amphibolite, also lignite.
38-59	Gravel, coarse bouldery, clay packed, with thin layers of grayish-brown sandy clay and dark gray smooth clay.
59-87	Sand, coarse granular, angular; layer of wet greasy clay 72-74 ft., 85-87 ft.
87-94	Gravel.
94-178	Sand, coarse, granular.
178-200	Bouldery till, gray.
200-239	Interlayered gravel, silty sand, boulders.
239-243	Bouldery basal till, gray, sandy. Boulders of tonalite and amphibolite.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
243-280	Regolith, dark gray, smooth, clay. Becomes green below 248 ft., mostly hard rock by 260 ft.
<b>SOUND PRECAMBRIAN ROCK</b>	
280-305	Hornblende granodiorite to monzodiorite, pink, medium grained.



PETROGRAPHIC DESCRIPTION OF CORE: KIB-40

Principal rock type: Monzonite

Mineralogy: Orthoclase, perthite (46%); plagioclase (40%); hornblende (8%) quartz (3%); opaque oxides, hematite, and leucoxene (3%); apatite, epidote, and chlorite (trace of each)

Texture: Medium grained. Subhedral, lineated prismatic hornblende is in an allotriomorphic-granoblastic matrix of plagioclase and orthoclase.

Structure: Foliation/lineation of hornblende dips 60° from horizontal. Chlorite-lined brittle fractures dip 35-40° from horizontal.

CHEMICAL DATA

Rock Type Analyzed: Monzonite, 299.3-299.6 ft. depth.

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	63.9	Cl	<50
Al <sub>2</sub> O <sub>3</sub>	17.4	Cr	26
CaO	2.16	Rb	135
MgO	1.28	Sr	1340
Na <sub>2</sub> O	6.13	Y	41
K <sub>2</sub> O	4.47	Zr	303
(Fe <sub>2</sub> O <sub>3</sub> )	(2.21)	Nb	14
FeO	1.0	Ba	1470
MnO	0.07		
TiO <sub>2</sub>	0.35		
P <sub>2</sub> O <sub>5</sub>	0.18		
H <sub>2</sub> O+	0.4		
CO <sub>2</sub>	0.01		
S	NIL		
LOI	0.77		
Total	100.4 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	3.32		

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
297-298	0.03	301-302	0.01
298-299	0.05	302-303	0.02
299-300	0.01	303-304	0.01
300-301	0.02	304-305	0.02

DENSITY

Sample	Density
302.5	2.64

Field number KIB-41

Date completed 12-3-87

MGS unique number 241841

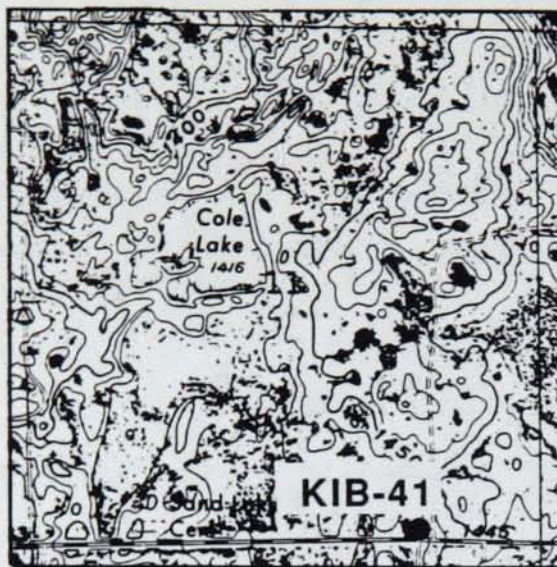
MGS lab number 2699

LOCATION (see map at right)

T-R-S 148-26-11 DDCCC

County Itasca

Quadrangle Wirt 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1442

Total depth 281

Elevation, top of  
Precambrian rock 1289

Core interval 275-281

Core recovered 6

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-22	Sand, brown, fine-grained, silty matrix.
22-52	Clayey till, gray, with clasts of carbonate (dominant), black shale, and rare volcanics.
52-69	Sand with abundant cobbles and boulders of carbonate, granite, biotite schist, black shale.
69-113	Sand, fine- medium-grained, includes silty lenses, becomes cobbly in lower portion).
113-129	Gray clayey till.
129-153	Sand and cobbles.

**REGOLITH ON PRECAMBRIAN ROCK**

153-268	Regolith, light brown, sandy, possibly reworked in part, contains minor gray clay.
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**SOUND PRECAMBRIAN ROCK**

268-281	Phyllite (felsic tuff origin).
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## PETROGRAPHIC DESCRIPTION OF CORE: KIB-41

Principal rock type: Phyllitic biotite, sericite schist (intermediate volcanic).

Mineralogy: Feldspar, quartz (75% combined); biotite (13%); sericite (10%); pyrite (2%); chlorite (tr); epidote (tr).

Texture: Fine grained, strongly foliated biotite and sericite in granoblastic quartz and feldspar groundmass. Minor plagioclase phenocrysts indicate volcanic tuff protolith. Thin biotite segregations parallel foliation; thin deformed quartz veins present.

Structure: Foliation dips 75° from horizontal. Numerous, complex, thin biotite segregations indicate possible premetamorphic shear planes, multiple deformations.

## CHEMICAL DATA

Rock Type Analyzed: Felsic metavolcanic, 277-277.5 ft.

### Minor Elements (ppm)

Ag	0.183
As	1.42
Au	0.004
Cu	147.
Hg	<0.093
Mo	0.228
Pb	6.42
Sb	<0.231
Tl	1.02
Zn	114.
Bi	<0.231
Cd	<0.093
Ga	6.61
Pd	<0.463
Se	<0.926
Te	<0.463

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
275-281	0.00

## DENSITY

Depth	Density
277	2.72

Field number KIB-43B

Date completed 8-25-88

MGS unique number 241843.B

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 153-27-31 DBCA

County Koochiching

Quadrangle Ridge SW 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1289

Total depth 442

Elevation, top of  
Precambrian rock 434

Core interval 436-442

Core recovered 6

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

QUATERNARY DEPOSITS

0-15	Sand and gravel, brown.
15-17	Sandy till, brown.
17-37	Sandy till, gray.
37-38	Boulder lag.

REGOLITH ON PRECAMBRIAN ROCK

38-134	Regolith, greenish-gray, reworked. Alternating clayey and fine sandy textures. Rock cuttings include gneiss, granite, carbonate, mafic volcanics.
134-335	Regolith, green/brown/gray, clayey to sandy textured. Random zones of harder, weathered phyllitic schist, vein quartz, yellowish- or reddish-brown clay.
335-434	Clay regolith, gray, interlayered with fresh, black phyllitic schist of volcanic protolith.

SOUND PRECAMBRIAN ROCK

434-442	Felsic crystal-lithic tuff, gray.
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PETROGRAPHIC DESCRIPTION OF CORE: KIB-43B

Principal rock type: Felsic crystal-lithic tuff.

Mineralogy: Quartz, phenocrysts (10%); plagioclase, phenocrysts (20%); quartzofeldspathic groundmass (39%); felsic lithic fragments (4%); chlorite (12%); sericite (7%); calcite (7%); opaque oxides (1%); pyrite, apatite, zircon, sphene (trace of each).

Texture: Quartz and plagioclase crystals up to 1 mm across are in a fine-grained, foliated groundmass of fine cherty-textured quartz plus feldspar, sericite, and chlorite. Foliation weaves around crystals and lithic fragments in an elliptical fashion; most lithic fragments are no longer recognizable from matrix. Assymmetric pressure shadows behind crystal phenocrysts give indication of shear. Deformed foliation-parallel quartz-carbonate veins are cut by a late foliation-normal calcite vein. Bedding is vague, defined by grain size variation, parallels foliation.

Structure: Bedding and foliation are near vertical; late calcite-pyrite veins dip 0-45° from horizontal, occupy brittle fractures.

CHEMICAL DATA

Rock Type Analyzed: None

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
436-438	0.07
438-439	0.06
439-441	0.04
441-442	0.05

DENSITY

Depth            Density  
Not determined.

Field number KIB-45

Date completed 5-9-88

MGS unique number 241845

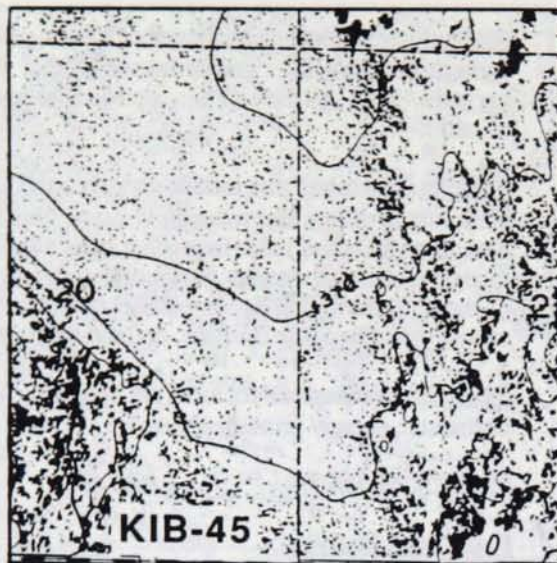
MGS lab number 2735

LOCATION (see map at right)

T-R-S 151-25-20 DCCD

County Koochiching

Quadrangle Wildwood NE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1323

Total depth 170

Elevation, top of  
Precambrian rock 1178

Core interval 159-170

Core recovered 11

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

QUATERNARY DEPOSITS

0-15	Sandy till, brownish-gray.
15-35	Gravelly till, brownish-gray, with carbonate pebbles.
35-115	Sandy till, greenish-gray.
115-145	Gravelly till, gray, pebbles of mafic rock and carbonate.

REGOLITH ON PRECAMBRIAN ROCK

145-159	Clay regolith, greenish-gray, with zones of hard biotite schist and granite.
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SOUND PRECAMBRIAN ROCK

159-170	Foliated quartz diorite.
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PETROGRAPHIC DESCRIPTION OF CORE: KIB-45

Principal rock type: Foliated quartz diorite

Mineralogy: Plagioclase (70%); hornblende (11%); quartz (10%); sericite (4%); sphene (1%); biotite (1%); chlorite (1%); epidote, opaque oxides, apatite, zircon (trace of each).

Texture: Coarse grained; strong igneous foliation defined by inequant plagioclase and hornblende. Feldspar is heavily sericitized adjacent to thin quartz veins.

Structure: Igneous foliation dips 60° from horizontal; thin brittle quartz veins are at a high angle to foliation. Subtle modal banding (hornblende enrichment) present.

CHEMICAL DATA

Rock Type Analyzed: Diorite, 167 ft.

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	59.2	Cl	50
Al <sub>2</sub> O <sub>3</sub>	18.4	Cr	25
CaO	6.50	Rb	25
MgO	2.41	Sr	1140
Na <sub>2</sub> O	5.96	Y	<10
K <sub>2</sub> O	0.89	Zr	67
(Fe <sub>2</sub> O <sub>3</sub> )	(1.82)	Nb	17
FeO	2.3	Ba	339
MnO	0.07		
TiO <sub>2</sub>	0.55		
P <sub>2</sub> O <sub>5</sub>	0.20		
H <sub>2</sub> O+	0.2		
CO <sub>2</sub>	0.24		
S	0.01		
LOI	0.77		
Total	99.5 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	4.38		

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
160	0.29	166	0.46
161	0.30	167	0.75
162	0.23	168	0.73
163	0.56	169	0.84
164	0.62	170	0.68
165	0.53		

DENSITY

Depth	Density
166.5	2.74

Field number KIB-46

Date completed 5-3-88

MGS unique number 241846

MGS lab number 2736

LOCATION (see map at right)

T-R-S 64-27-36 BB CAAD

County Koochiching

Quadrangle Effie NW 7.5'

HOLE PARAMETERS (feet)

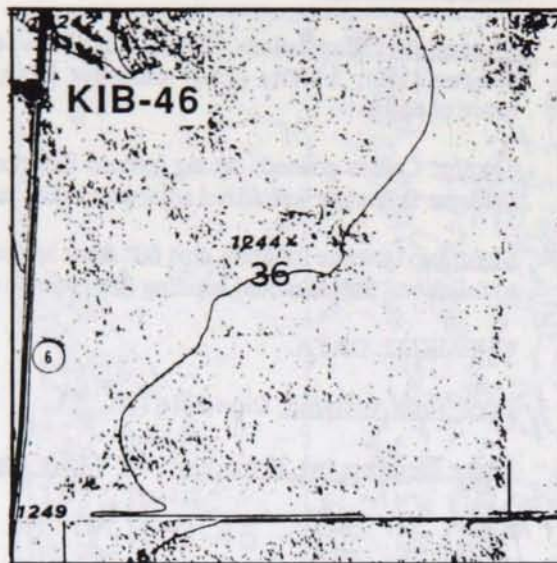
Surface elevation 1243

Total depth 191.5

Elevation, top of  
Precambrian rock 1073

Core interval 182-191.5

Core recovered 9.5



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-8	Sand, brown, medium- to fine-grained.
8-70	Sandy till, gray, with carbonate and granite clasts.
70-115	Silty clay, gray, possibly lacustrine.
115-140	Clay, brownish-gray, interlayered with cobbly gravel.
140-165	Silty and sandy clay, grey, possibly lacustrine.
165-170	Bouldery gravel.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
170-173	Regolith, contains chips of granite and quartz, with white kaolinitic clay.
<b>SOUND PRECAMBRIAN ROCK</b>	
173-191.5	Foliated quartz diorite, light gray.



PETROGRAPHIC DESCRIPTION OF CORE: KIB-46

Principal rock type: Quartz diorite

Mineralogy: Plagioclase (63%); quartz (17%); hornblende (8%); orthoclase (4%); epidote (3%); biotite (3%); opaque oxides (2%); chlorite, sphene, calcite (trace of each).

Texture: Medium to coarse grained, igneous foliation defined by blocky subhedral plagioclase and hornblende set in a fine-grained, anhedral mesostasis of quartz, plagioclase, and orthoclase.

Structure: Igneous foliation dips 70° from horizontal.

CHEMICAL DATA

Rock Type Analyzed: Quartz diorite, 187 ft.

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	64.0	Cl	100
Al <sub>2</sub> O <sub>3</sub>	17.6	Cr	21
CaO	5.52	Rb	47
MgO	1.72	Sr	1030
Na <sub>2</sub> O	5.32	Y	25
K <sub>2</sub> O	1.51	Zr	76
(Fe <sub>2</sub> O <sub>3</sub> )	(1.92)	Nb	13
FeO	1.3	Ba	440
MnO	0.06		
TiO <sub>2</sub>	0.41		
P <sub>2</sub> O <sub>5</sub>	0.16		
H <sub>2</sub> O+	0.5		
CO <sub>2</sub>	0.03		
S	NIL		
LOI	0.23		
Total	100.1 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	3.36		

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
182	0.65	187	0.66
183	0.39	188	0.87
184	0.61	189	0.53
185	0.57	190	0.79
186	0.69	191.5	0.35

DENSITY

Depth	Density
188	2.73

Field number KIB-47

Date completed 5-12-88

MGS unique number 241847

MGS lab number 2718

LOCATION (see map at right)

T-R-S 150-26-4 ADADDDD

County Itasca

Quadrangle Pomroy 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1376

Total depth 490

Elevation, top of  
Precambrian rock 1246.5

Core interval none

Core recovered none

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

QUATERNARY DEPOSITS

0-11 Clay till, light brown, contains clasts of carbonate, granite, schist and volcanic rocks.  
11-126 Clay till, gray.  
126-129.5 Sand.

REGOLITH ON PRECAMBRIAN ROCK

129.5-247 Regolith, light gray, sandy clay, upper 25 ft. may be reworked. Harder zones yield chips of hornblende and biotite schist.  
247-249 Regolith, gray, clayey, derived from mafic schist; interlayered with pink granitic rock.  
309-490 Regolith, brownish-red, mixed with granitic chips; zone of weathered granite.

SOUND PRECAMBRIAN ROCK

No sound bedrock obtained, but from cuttings rock is apparently a fine-grained hornblende-biotite schist interlayered with intrusive granitic sills or dikes.



Field number     KIB-48    

Date completed     5-20-88    

MGS unique number     241848    

MGS lab number     2719    

LOCATION (see map at right)

T-R-S     149-26-28 CBBB    

County     Itasca    

Quadrangle     Wirt 7.5'    

HOLE PARAMETERS (feet)

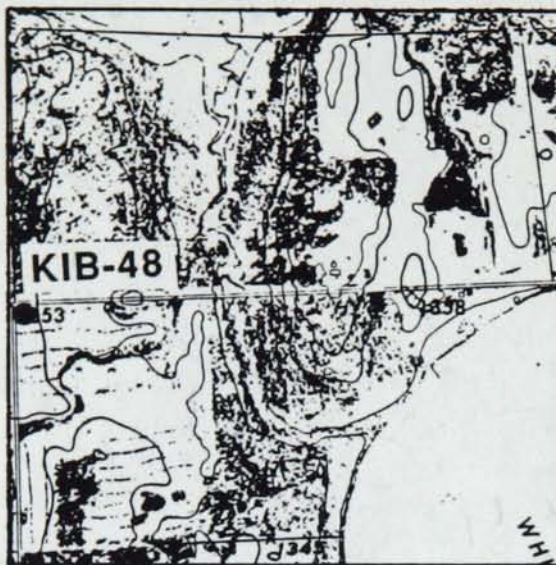
Surface elevation     1355    

Total depth     160    

Elevation, top of  
Precambrian rock     1230    

Core interval     none    

Core recovered     none    



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-22	Sandy till, brownish- tan. Sand is coarse-grained, includes lithologies of carbonate, mafic rocks, granite.
22-125	Sand, medium to coarse grained. Becomes gravelly below 80 ft., with random cobbles.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
See below.	
<b>SOUND PRECAMBRIAN ROCK</b>	
125-141	Bedrock(?), possibly boulders. Cuttings dominated by sharp angular pieces of intermediate to felsic plutonic rocks. No clays present.
141-150	Sandy-textured regolith (?) or layer of sand.
150-160	Bedrock(?), similar to 125-141 ft. Chips are mostly granitic in nature, with kaolinized feldspar. Possibly boulder lag in overburden material.



Field number KIB-49

Date completed 5-25-88

MGS unique number 241849

MGS lab number 2720

LOCATION (see map at right)

T-R-S 60-26-23 DDDDDA

County Itasca

Quadrangle Coon Lake 7.5'

HOLE PARAMETERS (feet)

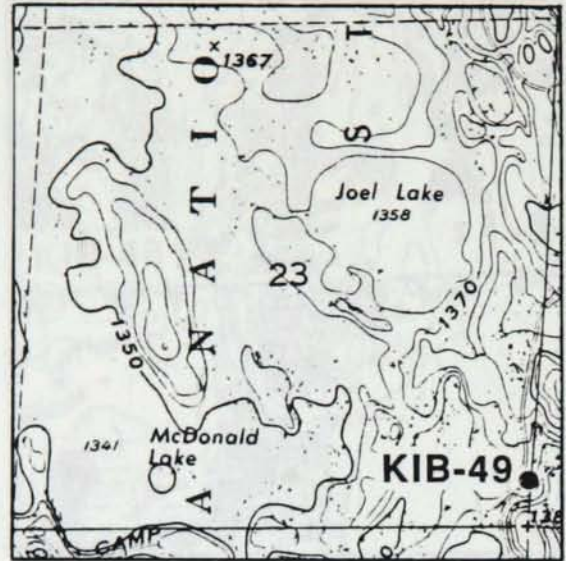
Surface elevation 1372

Total depth 68

Elevation, top of  
Precambrian rock 1330

Core interval 58-68

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-26	Sandy till, brown to grayish-brown, contains pebbles of carbonate and granite.
26-42	Gravel and coarse sand.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
42-47	Regolith, greenish-gray clay with chips of metagraywacke or mafic-intermediate volcanics.
<b>SOUND PRECAMBRIAN ROCK</b>	
47-68	Gray, medium grained, to weakly foliated metagraywacke or felsic crystal tuff.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-49

Principal rock type: Felsic to intermediate volcanoclastic rock.

Mineralogy: Matrix, quartz and feldspar, cherty texture, grades into rock fragments with increase in grain size (48%); plagioclase, crystal phenocrysts (10%) and matrix; quartz, crystal phenocrysts (10%) and matrix; felsic volcanic rock fragments (<10%); hornblende, as euhedral crystal phenocrysts (7%) and later prismatic metamorphic grains (10%); biotite (5%); chlorite, epidote, sericite, calcite, pyrite (trace of each).

Texture: Very weakly foliated, pristine. Brittle shear cleavage locally developed, along with minor quartz-carbonate or chlorite-epidote veining. Bedding is vaguely visible via crystal-lithic rich layers.

Structure: Foliation and bedding dip 65° from horizontal, quartz-carbonate veins are near horizontal, and thin chlorite-epidote veins are randomly oriented.

CHEMICAL DATA

Rock Type Analyzed: Felsic tuff, 59 ft. (whole rock); 66.5-66.8 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	62.4	Cl	50	Ag	0.122
Al <sub>2</sub> O <sub>3</sub>	15.5	Cr	265	As	2.09
CaO	4.78	Rb	57	Au	0.005
MgO	3.74	Sr	631	Cu	54.5
Na <sub>2</sub> O	4.56	Y	16	Hg	<0.095
K <sub>2</sub> O	1.33	Zr	60	Mo	1.31
(Fe <sub>2</sub> O <sub>3</sub> )	(0.91)	Nb	<10	Pb	4.25
FeO	4.4	Ba	473	Sb	<0.237
MnO	0.09			Tl	<0.474
TiO <sub>2</sub>	0.61			Zn	45.9
P <sub>2</sub> O <sub>5</sub>	0.16			Bi	<0.237
H <sub>2</sub> O+	1.2			Cd	<0.095
CO <sub>2</sub>	0.08			Ga	8.66
S	0.08			Pd	<0.474
LOI	0.85			Se	<0.949
Total	100.0 (normalized)			Te	<0.474
Total iron as Fe <sub>2</sub> O <sub>3</sub>	5.80				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
58	0.03	64	0.04
59	0.03	65	0.07
60	0.01	66	0.04
61	0.02	67	0.04
62	0.01	68	0.02
63	0.02		

DENSITY

Depth	Density
61	2.79
65.5	2.83

Field number KIB-50

Date completed 5-27-88

MGS unique number 241850

MGS lab number 2721

LOCATION (see map at right)

T-R-S 148-27-11 BADDD

County Itasca

Quadrangle Dora Lake 7.5'

HOLE PARAMETERS (feet)

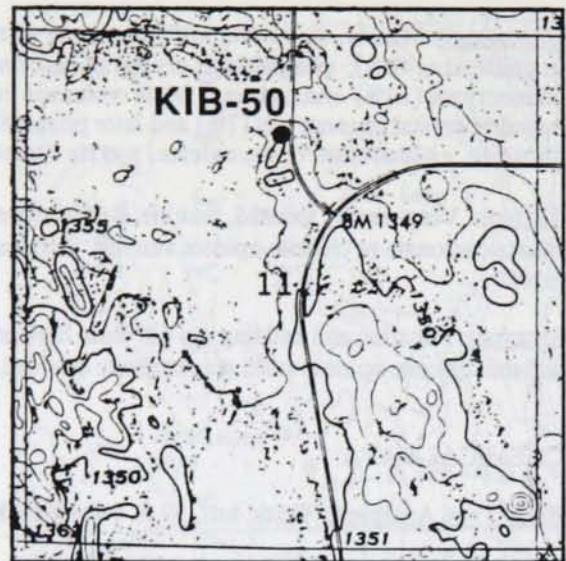
Surface elevation 1350

Total depth 301.5

Elevation, top of  
Precambrian rock 1313

Core interval 295-301.5

Core recovered 6.5



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-33	Sandy till, brownish-tan to gray, variegated. Contains clasts of carbonate, mafic and granitic rocks.
33-37	Sandy to gravelly till, gray.
37-140	Till, gray.
140-160	Sand and cobbly sand.

**REGOLITH ON PRECAMBRIAN ROCK**

160-245	Regolith, gray, gritty clay with chips of granite and mafic to intermediate igneous rocks.
245-291	Regolith, light greenish-gray, clayey.
291-295	Regolith, green, hard drilling, contains granitic chips.

**SOUND PRECAMBRIAN ROCK**

295-301.5	Quartz monzonite to quartz diorite, grayish-pink, medium grained, massive, weakly porphyritic.
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## PETROGRAPHIC DESCRIPTION OF CORE: KIB-50

Principal rock type: Quartz monzonite, quartz diorite, basalt inclusion.

Mineralogy:(Quartz monzonite) **Orthoclase**, perthite (48%); **plagioclase** (38%); **quartz** (9%); **hornblende** (2%); **chlorite** (1%); **opaque oxides** (2%); **biotite**, **epidote**, **sphene**, **apatite** (trace of each).

(Quartz diorite) **Plagioclase** (77%); **quartz** (10%); **hornblende** (5%); **opaque oxides** (5%); **biotite** (2%); **apatite** (1%); **epidote**, **chlorite**, **sphene**, **zircon** (trace of each).

Texture: Medium- to coarse-grained. The two rock types are distinct, relations indicate quartz diorite and the included basalt block were intruded by quartz monzonite. Quartz diorite shows good, shallow dipping, igneous foliation, quartz monzonite is very weakly lineated at a steeper angle.

Structure: Foliation in quartz diorite dips 23° from horizontal, lineation in quartz monzonite dips 70° from horizontal.

## CHEMICAL DATA

Rock Type Analyzed: Quartz diorite, 296.3 ft. depth

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	60.8	Cl	150
Al <sub>2</sub> O <sub>3</sub>	17.6	Cr	<10
CaO	4.85	Rb	55
MgO	1.35	Sr	394
Na <sub>2</sub> O	4.98	Y	10
K <sub>2</sub> O	1.21	Zr	141
(Fe <sub>2</sub> O <sub>3</sub> )	(3.97)	Nb	15
FeO	3.0	Ba	307
MnO	0.13		
TiO <sub>2</sub>	0.97		
P <sub>2</sub> O <sub>5</sub>	0.17		
H <sub>2</sub> O+	1.5		
CO <sub>2</sub>	0.07		
S	0.01		
LOI	0.77		
Total	100.2 (normalized)		
Total iron as Fe <sub>2</sub> O <sub>3</sub>	7.30		

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
295	0.05	299	0.21
296	4.6	300	0.39
297	0.56	301.5	0.46
298	0.61		

## DENSITY

Depth	Density
296.3	2.78
300.5	2.66

Field number KIB-51

Date completed 6-2-88

MGS unique number 241851

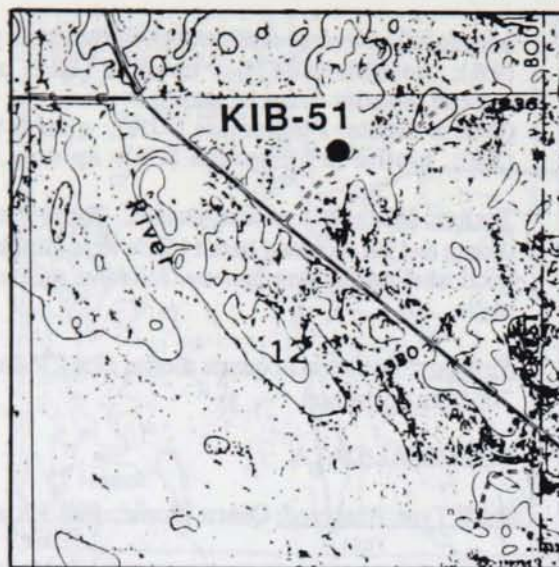
MGS lab number 2722

LOCATION (see map at right)

T-R-S 148-28-12 ABBDC

County Itasca

Quadrangle Squaw Lake 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1350

Total depth 283

Elevation, top of  
Precambrian rock 1266

Core interval 273-283

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-13	Sandy till, brown.
13-19	Sand, becomes gravelly below 16 ft.
19-46	Sandy till, gray; sand layer 23-24 ft. depth.
46-61	Sandy till, gray, more pebbly and cobbly than above.
61-67	Sand. Granite boulder at 66 ft. depth.
67-84	Cobbly till, gray. Cobbles of black biotite-hornblende schist, gneiss and carbonate.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
84-94	Regolith, medium greenish-gray, dense clay, minor black aphanitic rock chips.
94-96	Hard granite, foliated, leucocratic.
96-126	Regolith, greenish-gray, soft, sandy clay.
126-170	Regolith, medium greenish-gray, dense clay, locally sandy-textured.
170-184	Regolith, brownish-gray, dense clay.
184-196	Regolith, sandy textured.
196-266	Regolith, gray clay, increasing proportion of zones of hard, fine-grained aphanitic black metavolcanic rock with depth.
<b>SOUND PRECAMBRIAN ROCK</b>	
266-283	Meta-quartz diorite, greenish-gray, fine- to medium-grained.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-51

Principal rock type: Meta-quartz diorite.

Mineralogy: Plagioclase, altered (41%); hornblende (35%); quartz (10%); sericite (10%); chlorite (2%); epidote (1%); biotite, sphene, apatite, opaque oxides, calcite (trace of each).

Texture: Medium-grained, massive, decussate, relict igneous texture well preserved, but modified by metamorphism. Primary plagioclase is heavily altered to sericite, hornblende has a metamorphic habit. Rock is locally fine-grained, granoblastic, relatively unaltered, and with no relict igneous fabric.

Structure: Weak modal banding dips 50° from horizontal. Core is cut in upper portion by thin granitic intrusive.

CHEMICAL DATA

Rock Type Analyzed: Quartz diorite, 281.4 ft. (whole rock), 275-275.4 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	58.3	Cl	200	Ag	0.041
Al <sub>2</sub> O <sub>3</sub>	16.2	Cr	169	As	1.29
CaO	7.64	Rb	23	Au	0.006
MgO	4.96	Sr	273	Cu	28.6
Na <sub>2</sub> O	3.05	Y	<10	Hg	<0.096
K <sub>2</sub> O	0.95	Zr	64	Mo	1.63
(Fe <sub>2</sub> O <sub>3</sub> )	(1.75)	Nb	17	Pb	1.65
FeO	4.8	Ba	205	Sb	<0.239
MnO	0.12			Tl	<0.479
TiO <sub>2</sub>	0.58			Zn	26.6
P <sub>2</sub> O <sub>5</sub>	0.11			Bi	<0.239
H <sub>2</sub> O+	1.2			Cd	<0.096
CO <sub>2</sub>	0.06			Ga	2.64
S	0.01			Pd	<0.479
LOI	1.47			Se	<0.958
Total	100.6 (normalized)			Te	<0.479
Total iron as Fe <sub>2</sub> O <sub>3</sub>	7.08				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading (x 10 <sup>-3</sup> cgs units)	Depth	Reading (x 10 <sup>-3</sup> cgs units)
273	0.03	281	0.01
274	0.02	282	0.02
275-279	0.01	283	0.01
280	0.02		

DENSITY

Depth	Density
273.3	2.58
280.5	2.88

Field number KIB-52

Date completed 6-9-88

MGS unique number 241852

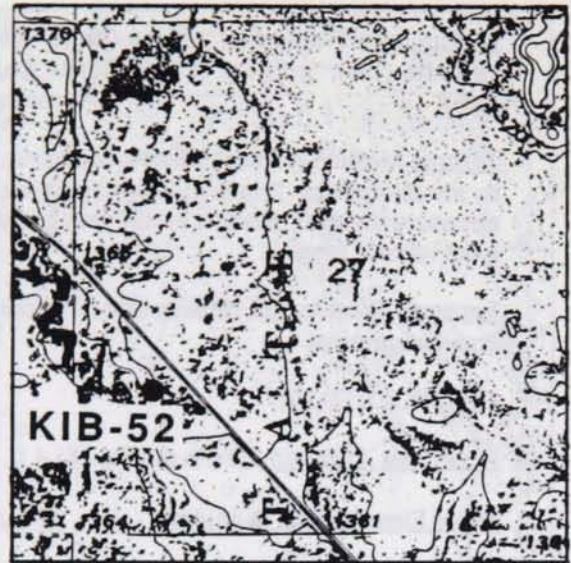
MGS lab number 2723

LOCATION (see map at right)

T-R-S 149-28-27 CCA

County Itasca

Quadrangle Squaw Lake 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1374

Total depth 263

Elevation, top of  
Precambrian rock 1319

Core interval 253-263

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-15	Sandy till, brown, coarse sand to gravel-sized clasts of granite, mafic rocks, and carbonate.
15-55	Sandy till, grey, same clast lithology as above.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
55-100	Regolith, dominantly light gray to green clay, with minor zones of harder drilling weathered granitic material.
100-253	Grus, crumbly weathered granite, with minor zones of greenish-gray clay.
<b>SOUND PRECAMBRIAN ROCK</b>	
253-263	Quartz diorite, medium- to coarse-grained.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-52

Principal rock type: Quartz diorite

Mineralogy: Plagioclase, heavily altered (53%); hornblende (26%); quartz (13%); chlorite (4%); epidote (1%); opaque oxides (1%); biotite (tr); apatite (tr).

Texture: Coarse-grained, equigranular, massive. Thin brittle fractures filled with quartz, epidote, calcite, and chlorite. Plagioclase is heavily altered to sericite and epidote.

Structure: Thin brittle fractures dip 15° and 70° from horizontal, otherwise massive igneous texture.

CHEMICAL DATA

Rock Type Analyzed: Quartz diorite, 257.7 ft. (whole rock), 253.8-254.3 (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	54.3	Cl	250	Ag	0.244
Al <sub>2</sub> O <sub>3</sub>	16.8	Cr	83	As	1.03
CaO	8.34	Rb	44	Au	0.004
MgO	4.31	Sr	230	Cu	125.
Na <sub>2</sub> O	2.75	Y	22	Hg	<0.097
K <sub>2</sub> O	1.17	Zr	41	Mo	1.76
(Fe <sub>2</sub> O <sub>3</sub> )	(3.06)	Nb	16	Pb	2.34
FeO	5.7	Ba	142	Sb	<0.244
MnO	0.15			Tl	<0.487
TiO <sub>2</sub>	0.87			Zn	49.4
P <sub>2</sub> O <sub>5</sub>	0.17			Bi	<0.244
H <sub>2</sub> O+	1.8			Cd	0.133
CO <sub>2</sub>	0.21			Ga	3.15
S	0.04			Pd	<0.487
LOI	1.93			Se	<0.975
Total	100.3 (normalized)			Te	<0.487
Total iron as Fe <sub>2</sub> O <sub>3</sub>	9.39				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
253	0.03	259	0.03
254	0.03	260	0.04
255	0.05	261	0.02
256	0.04	262	0.04
257	0.04	263	0.03
258	0.05		

DENSITY

Depth	Density
260	2.91

Field number KIB-53

Date completed 6-6-88

MGS unique number 241853

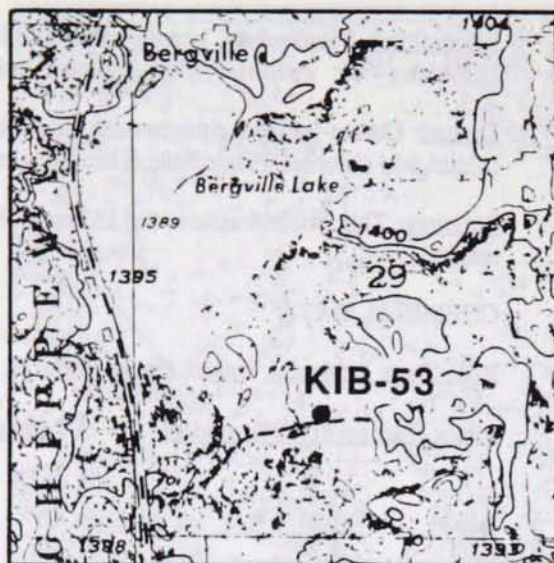
MGS lab number 2724

LOCATION (see map at right)

T-R-S 160-28-29 CDBAAAA

County Itasca

Quadrangle Northome South 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1395

Total depth 176

Elevation, top of  
Precambrian rock 1262

Core interval 166-176

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-13	Clay till, yellowish-brown, contains clasts of carbonate, quartz, granite, and black aphanitic rock.
13-50	Till, gray, similiar in texture and lithology to above. Also contains black slate, cobble of metabasalt at base.
50-61	Lacustrine silt and sand, gray.
61-111	Sandy till, gray, similiar to 13-50 ft. depth except for higher sand/gravel content. Clasts of black aphanitic rocks, gneiss, schist, carbonate, shale. Minor cobbles below 100 ft.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
111-133	Regolith, greenish-gray clay and fine sand-rich.
133-159	Regolith, greenish-gray sandy clay, interlayered with hard black biotite schist.
<b>SOUND PRECAMBRIAN ROCK</b>	
159-163	Biotite schist, dark grayish-black, possibly of volcanosedimentary protolith.
163-165	Mafic intrusive rock, dark colored, fine-grained.
165-166	Phyllite, gray, hard.
166-176	Tonalite, light greenish-gray, coarse-grained.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-53

Principal rock type: Tonalite

Mineralogy: Plagioclase (50%); hornblende (25%); quartz (16%); biotite (7%); apatite (1%); opaque oxides (1%); chlorite (tr); monazite (? tr).

Texture: Pristine, fresh, coarse-grained igneous texture shows weak foliation via aligned plagioclase crystals and elongate masses of hornblende and biotite.

Structure: Slight fracturing dips 70-80° from horizontal; igneous foliation dips 50° from horizontal.

CHEMICAL DATA

Rock Type Analyzed: Tonalite, 167.5 ft. (whole rock), 171.4-172 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	54.9	Cl	150	Ag	0.071
Al <sub>2</sub> O <sub>3</sub>	16.5	Cr	35	As	<0.971
CaO	8.02	Rb	23	Au	0.015
MgO	3.81	Sr	215	Cu	36.0
Na <sub>2</sub> O	3.38	Y	24	Hg	<0.097
K <sub>2</sub> O	0.67	Zr	141	Mo	3.43
(Fe <sub>2</sub> O <sub>3</sub> )	(2.83)	Nb	13	Pb	2.47
FeO	6.9	Ba	138	Sb	<0.243
MnO	0.18			Tl	<0.485
TiO <sub>2</sub>	1.17			Zn	24.6
P <sub>2</sub> O <sub>5</sub>	0.23			Bi	<0.243
H <sub>2</sub> O+	1.1			Cd	0.132
CO <sub>2</sub>	0.01			Ga	2.50
S	0.01			Pd	<0.485
LOI	0.85			Se	<0.971
Total	100.3 (normalized)			Te	<0.485
Total iron as Fe <sub>2</sub> O <sub>3</sub>	10.5				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
166	0.02	172	0.00
167	0.03	173	0.02
168	0.03	174	0.02
169	0.02	175	0.03
170	0.03	176	0.03
171	0.03		

DENSITY

Depth	Density
174	2.86

Field number KIB-54

Date completed 6-28-88

MGS unique number 241854

MGS lab number 2725

LOCATION (see map at right)

T-R-S 150-27-17 CAACDC

County Itasca

Quadrangle Elmwood Island 7.5'

HOLE PARAMETERS (feet)

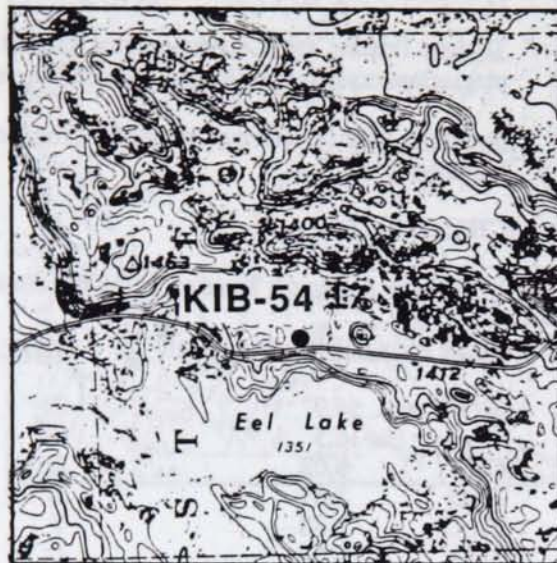
Surface elevation 1422

Total depth 243

Elevation, top of  
Precambrian rock 1252

Core interval 233-243

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

QUATERNARY DEPOSITS

0-2	Sandy till, dark brown, organic.
2-16	Sandy till, tan, coarse sand includes carbonate, granite, and mafic rock lithologies.
16-35	Coarse sand.
35-41	Sandy till, similiar to 2-16 ft. interval.
41-170	Sand, medium- to fine-grained, becomes finer with depth.

REGOLITH ON PRECAMBRIAN ROCK

170-175	Regolith, dark gray clay.
175-227	Regolith, greenish-gray clay, with cuttings of hard pink granitic rock included.
227-233	Schist, dark colored intermediate to mafic, hard, interlayered with decreasing proportions of gray clayey regolith.

SOUND PRECAMBRIAN ROCK

233-243	Metabasalt, green, schistose.
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PETROGRAPHIC DESCRIPTION OF CORE: KIB-54

Principal rock type: Amygdaloidal, weakly porphyritic metabasalt.

Mineralogy: Hornblende (50%); quartz (22%); plagioclase (22%); chlorite (2%); opaque oxides, leucoxene, rutile(?) (2% sum); epidote (tr).

Texture: Elliptical quartz amygdules and blocky phenocrysts of plagioclase (1%) and minor hornblende are in a fine-grained, strongly foliated groundmass of fibrous hornblende and granoblastic quartz plus feldspar. The foliation bends asymmetrically around the phenocrysts, giving an indication of shear component. Thin, discontinuous quartz veins are predeformation; later epidote veinlets are post-deformation.

Structure: Foliation dips 80-90° from horizontal, and weak to strong lineation plunges vertically in the foliation plane. Quartz-feldspar veins parallel foliation, are typically dismembered and deformed.

CHEMICAL DATA

Rock Type Analyzed: Metabasalt, 243 ft. (whole rock), garnetiferous basalt, 239-239.7 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	58.2	Cl	50	Ag	0.021
Al <sub>2</sub> O <sub>3</sub>	15.9	Cr	139	As	<0.954
CaO	5.93	Rb	17	Au	<0.048
MgO	6.14	Sr	189	Cu	18.6
Na <sub>2</sub> O	4.01	Y	11	Hg	<0.095
K <sub>2</sub> O	0.37	Zr	75	Mo	0.941
(Fe <sub>2</sub> O <sub>3</sub> )	1.51	Nb	<10	Pb	3.29
FeO	5.4	Ba	203	Sb	<0.239
MnO	0.16			Tl	<0.477
TiO <sub>2</sub>	0.50			Zn	52.4
P <sub>2</sub> O <sub>5</sub>	0.08			Bi	<0.239
H <sub>2</sub> O+	1.2			Cd	<0.095
CO <sub>2</sub>	0.01			Ga	2.15
S	nil			Pd	<0.477
LOI	1.39			Se	<0.954
Total	100.3 (normalized)			Te	<0.477
Total iron as Fe <sub>2</sub> O <sub>3</sub>	7.51				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading (x 10 <sup>-3</sup> cgs units)	Depth	Reading (x 10 <sup>-3</sup> cgs units)
233	0.02	239	0.02
234	0.02	240	0.01
235	0.01	241	0.01
236	0.01	242	0.03
237	0.02	243	0.01
238	0.01		

DENSITY

Depth	Density
234.4	2.85

Field number KIB-55

Date completed 6-30-88

MGS unique number 241855

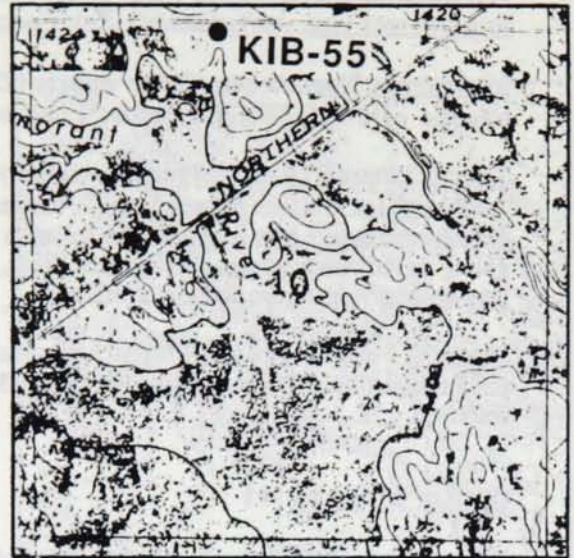
MGS lab number 2726

LOCATION (see map at right)

T-R-S 150-29-10 BABAAAA

County Itasca

Quadrangle Northome South 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1418

Total depth 441

Elevation, top of  
Precambrian rock 1315

Core interval None

Core recovered None

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-22	Sandy till, yellowish-brown, dark brown organic-rich in top foot. Clasts of carbonate and granite.
22-73	Sandy till, gray, lithologically and texturally similar to above.
73-103	Sand, medium-fine, layer of coarse gravel 77-78 ft., clay 78-80 ft.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
103-185	Possibly reworked regolith, alternating gray clay and sand, chunks of white kaolinite 150-160 ft.
185-210	Sand.
210-280	Regolith, medium gray, clay-rich.
280-421	Regolith, green clay with isolated chunks of white kaolin, possibly of granitic parent.
421-435	Regolith, yellowish-brown clay.
435-441	Regolith, grayish-brown clay.
<b>SOUND PRECAMBRIAN ROCK</b>	
No sound bedrock samples obtained.	



Field number KIB-56

Date completed 7-7-88

MGS unique number 241856

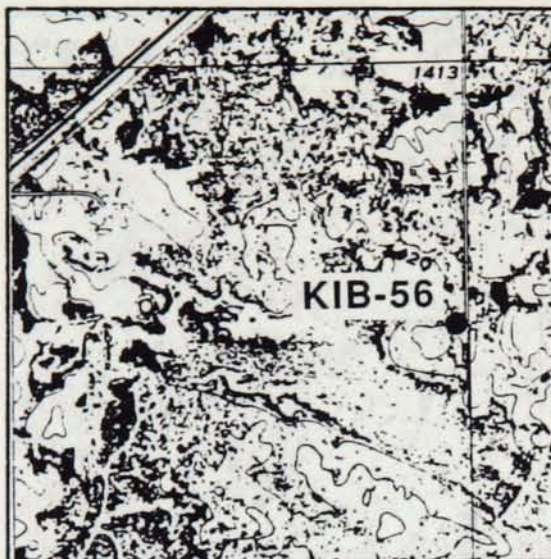
MGS lab number 2727

LOCATION (see map at right)

T-R-S 151-28-16 DAAAA

County Koochiching

Quadrangle Mizpah 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1422

Total depth 92.7

Elevation, top of  
Precambrian rock 1350

Core interval 84-92.7

Core recovered 8.7

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-13	Sandy till, yellowish-brown; contains coarse sand to gravel clasts, dominantly of carbonate.
13-32	Sandy till, olive-gray, texturally similiar to above.
32-72	Coarse sand and gravel, contains layers of silt below 41 ft., becomes cobbly near bottom.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
72-84	Regolith, greenish-gray clay with chips of fine-grained, dark green metavolcanic and gray metasedimentary rock.
<b>SOUND PRECAMBRIAN ROCK</b>	
84-92.7	Graywacke with strong intermediate volcaniclastic component.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-56

Principal rock type: Graywacke with intermediate volcanoclastic component.

Mineralogy: Hornblende (5-25%); quartz, plagioclase, orthoclase (25-75% combined, ratios of each indeterminate); biotite (tr-15%); epidote (tr-2%); pyrite, chalcopyrite (1-4%); sphene (0-1%); calcite (tr-2%); garnet (0-1%); apatite (tr); zircon (tr).

Texture: Foliated hornblende, biotite, and elongate epidote clots are in a fine-grained matrix of granoblastic quartz and feldspar. Thin-section from upper part of hole shows substantial (20%) orthoclase, with plagioclase and very little quartz; however sections from lower in the hole contain substantial quartz and plagioclase, no orthoclase. A weak second foliation transects main foliation at about 15°.

Macroscopic core examination shows textural attributes of a metasedimentary rock, however the high hornblende content indicates that a strong mafic volcanic component may be present. Locally the core shows conglomeratic tendencies, contains irregular, deformed, light-colored clasts of metasedimentary rock protolith. Garnet porphyroblasts are surrounded by asymmetric pressure shadows, indicative of shear deformation. Veins containing pyrite, chalcopyrite, calcite, and quartz have been seriously deformed and dismembered due to deformation.

Structure: Foliation dips 80-85° from horizontal; brittle fractures healed with pyrite, chlorite dip 45-55° from horizontal.

## CHEMICAL DATA

Rock Type Analyzed: Amphibolitic, intermediate composition metagraywacke, 87-87.1 ft. depth.

### Minor Elements (ppm)

Ag	0.681
As	<0.949
Au	<0.047
Cu	606.
Hg	<0.095
Mo	1.68
Pb	6.56
Sb	<0.237
Tl	<0.474
Zn	1564.
Bi	0.508
Cd	3.74
Ga	6.25
Pd	<0.474
Se	1.61
Te	1.65

### MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
84	0.16	89	0.33
85-87	0.02-0.05	90	0.25
88	0.42	91	0.14
		92	0.21

### DENSITY

Depth	Density
84.5	2.91
86.5	2.80
92.5	2.80

Field number KIB-57

Date completed 7-7-88

MGS unique number 241857

MGS lab number 2728

LOCATION (see map at right)

T-R-S 151-28-1 CBBCC

County Koochiching

Quadrangle Mizpah 7.5'

HOLE PARAMETERS (feet)

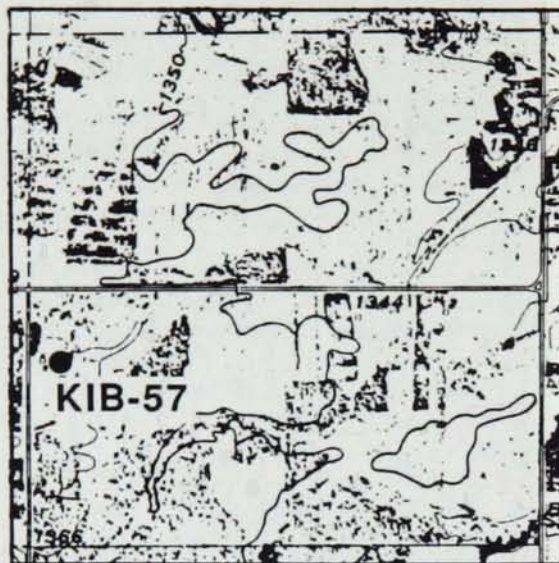
Surface elevation 1365

Total depth 78

Elevation, top of  
Precambrian rock 1305

Core interval 68-78

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-15	Till, tan to grayish-brown, contains coarse sand- to pebbled-sized clasts of carbonate, mafic rocks and granitics.
15-37	Till, medium to dark gray, clast lithologies and texture similiar to above.
37-50	Fine sand and silt interlayered with silty clay.
50-60	Coarse sand and gravel.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
60-64	Regolith, gray clay, possibly reworked.
<b>SOUND PRECAMBRIAN ROCK</b>	
64-78	Diabase, dark greenish-black, fine- to medium-grained, massive.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-57

Principal rock type: Massive metadiabase

Mineralogy: Hornblende (67%); plagioclase, pseudomorphed by dusty granular zoisite (23%); plagioclase, unaltered (5%); opaque oxides, rimmed by sphene (3%); quartz (2%).

Texture: Relict fine- to medium-grained, decussate to very weakly foliated igneous texture is well preserved via zoisite-altered white felty plagioclase in a groundmass of medium-fine decussate hornblende and granular oxides. Altered plagioclase is rimmed by clean, unaltered plagioclase and minor quartz.

Structure: Thin (1-6mm) zoisite/epidote-quartz veinlets occupy late brittle fractures which dip 40-80° from horizontal. Vague igneous foliation dips 80-85° from horizontal.

CHEMICAL DATA

Rock Type Analyzed: Diabase, 73.6-74 ft.

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	50.3	Cl	550	Ag	3.69
Al <sub>2</sub> O <sub>3</sub>	13.9	Cr	137	As	1.46
CaO	9.74	Rb	16	Au	0.707
MgO	5.68	Sr	103	Cu	5272.
Na <sub>2</sub> O	2.84	Y	34	Hg	<0.095
K <sub>2</sub> O	0.30	Zr	76	Mo	2.04
(Fe <sub>2</sub> O <sub>3</sub> )	2.81	Nb	24	Pb	6.61
FeO	10.7	Ba	88	Sb	<0.239
MnO	0.19			Tl	<0.477
TiO <sub>2</sub>	1.70			Zn	78.3
P <sub>2</sub> O <sub>5</sub>	0.14			Bi	<0.239
H <sub>2</sub> O+	1.1			Cd	0.784
CO <sub>2</sub>	0.08			Ga	1.71
S	0.03			Pd	<0.477
LOI	0.85			Se	0.971
Total	100.4 (normalized)			Te	0.969
Total iron as Fe <sub>2</sub> O <sub>3</sub>	14.7				

MAGNETIC SUSCEPTIBILITY (feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
68	0.03	74	0.06
69	0.04	75	0.04
70	0.03	76	0.05
71	0.04	77	0.03
72	0.03	78	0.03
73	0.04		

DENSITY

Depth	Density
77	3.07

Field number KIB-59

Date completed 7-13-88

MGS unique number 241859

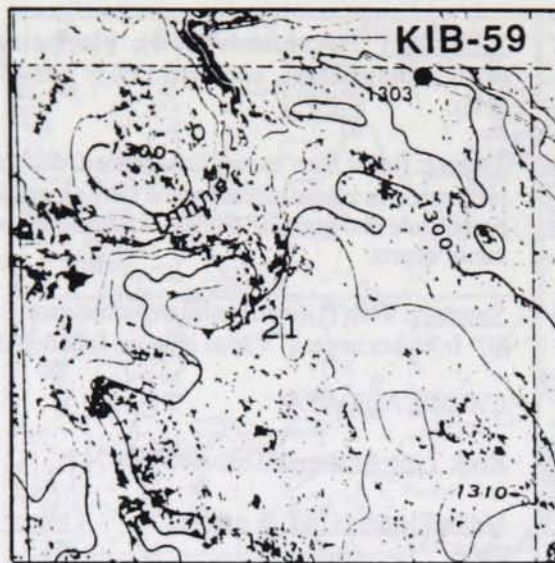
MGS lab number 2730

LOCATION (see map at right)

T-R-S 152-26-21 AAB

County Koochiching

Quadrangle Wildwood 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1303

Total depth 180

Elevation, top of  
Precambrian rock 1173

Core interval None

Core recovered none

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-6	Coarse sand, minor gravel.
6-13	Sandy till, yellowish-brown, contains clasts of granite and carbonate.
13-130	Sandy till, gray, gradational contact with above. Sand/silt lens 59-60 ft. depth. Clasts of carbonate, granite, mafic rock. Possibly some reworked regolith below 90 ft. depth.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
130-180	Regolith, gray clay alternating with zones of hard pink granite and dark green gabbro/diorite. Very rubbly and broken near 180 ft. depth, prevented further drilling progress.
<b>SOUND PRECAMBRIAN ROCK</b>	
180	Broken gabbroic or dioritic igneous rock (see above).





Field number     KIB-60    

Date completed     8-29-88    

MGS unique number     241860    

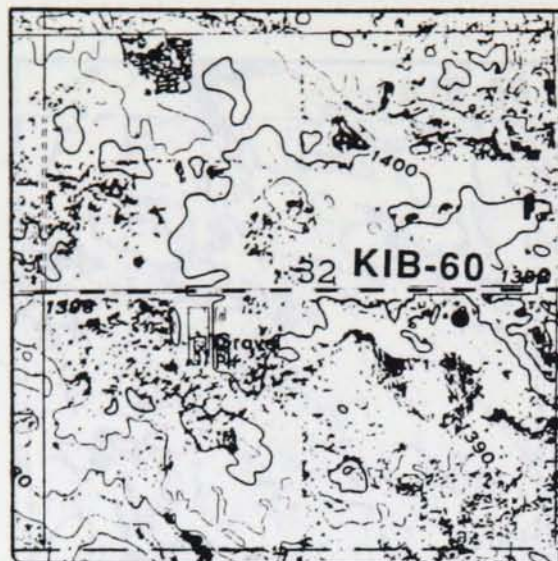
MGS lab number     2731    

LOCATION (see map at right)

T-R-S     152-29-32 DAB center AB    

County     Koochiching    

Quadrangle     Kelliher 7.5'    



HOLE PARAMETERS (feet)

Surface elevation     1400    

Total depth     341    

Elevation, top of  
Precambrian rock     1121    

Core interval     343.8-346.9    

Core recovered     3.1    

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-20	Loamy till, yellowish-brown, contains minor gritty carbonate and fine grained mafic rock clasts.
20-31	Granular sand and gravel, yellowish-brown, contains approximately 50% carbonate, 30% dark gray shale, remainder of Archean rocks.
31-35	Pebbly till, dark gray. Pebbles predominantly shale and limestone, with some granite, basalt, chert and other Archean rocks.
35-62	Till, dark gray, slightly sandy, with minor thin sand layers, foot-thick layer of granite and amphibolite cobbles at bottom of interval.
62-101	Fine sand.
101-112	Fine sand, layers of lacustrine clay 101-105 ft. and 107-112 ft. depths.
112-154	Sandy till, gray, with scattered cobbles.
154-159	Fine sand.
159-204	Bouldery, sandy till, gray, abundant cobbles of various Archean rocks, minor limestone.
204-230	Sandy till, gray, smooth drilling; possibly lacustrine in upper part.
230-258	Clay till, gray, smooth, sticky.
258-279	Coarse sand with a matrix of olive-gray clay and silt.
279-339	Clay till, gray, smooth, olive-gray below 259 ft., bouldery below 335 ft. depth.

**REGOLITH ON PRECAMBRIAN ROCK**

339-343      Regolith, dark greenish-gray to silvery gray and white clay.

**SOUND PRECAMBRIAN ROCK**

343-346.8      Tonalite, gray, medium grained.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-60

Principal rock type: Altered tonalite

Mineralogy: **Plagioclase** (45%); **quartz** (23%); **chlorite** (9%); **anthophyllite** (?-8%); **hornblende** (6%); **actinolite** (?-4%); **oxides**, altered to **sphene** (2%); **epidote** (2%); **apatite** (tr-1%); **zircon** (tr).

Texture: Original medium-grained igneous texture of blocky plagioclase and anhedral-interstitial quartz is well preserved but late deuteric or metamorphic retrograde alteration has given the rock an unusual amphibole and chlorite assemblage. Plagioclase is moderately altered to a fibrous bluish-green amphibole such as Mg-free anthophyllite. Stout prismatic apatite is concentrated with altered Fe-Ti oxide minerals as a late crystallization product, and zircon is a relatively abundant mineral. Rock had apparently crystallized from a rather evolved magma, given the mode of accessory minerals and the apparent high water content responsible for the deuteric alteration.

Structure: Massive.

## CHEMICAL DATA

Rock Type Analyzed: Not analyzed

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
343.8-344.8	0.04
344.8-345.8	0.03
345.8-346.10	0.04

## DENSITY

Depth	Density
Not determined.	

Field number KIB-61

Date completed 7-19-88

MGS unique number 241861

MGS lab number 2732

LOCATION (see map at right)

T-R-S 152-28-4 DCBCD

County Koochiching

Quadrangle Ridge SW 7.5'

HOLE PARAMETERS (feet)

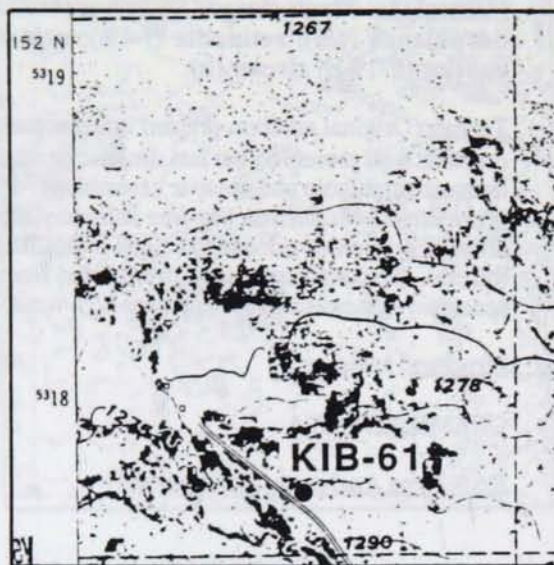
Surface elevation 1285

Total depth 80

Elevation, top of  
Precambrian rock unknown

Core interval none

Core recovered none



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

QUATERNARY DEPOSITS

- 0- 5 Sandy till, yellowish-brown, contains granular carbonate grains.
- 5-8 Gravel.
- 8-15 Cobbles, 6-8 inches in diameter.
- 15-23 Coarse gravel.
- 23-29.5 Cobbles.
- 39.5-32 Coarse sand.
- 32-36 Cobbles.
- 36-55 Coarse sand.
- 55-80 Gravel, coarse, well-sorted, well-rounded.

REGOLITH ON PRECAMBRIAN ROCK

No samples obtained.

SOUND PRECAMBRIAN ROCK

No samples obtained.



Field number KIB-62

Date completed 7-18-88

MGS unique number 241862

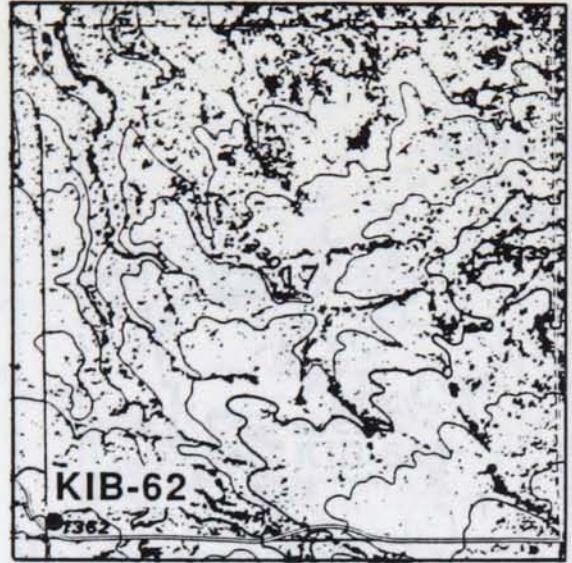
MGS lab number 2733

LOCATION (see map at right)

T-R-S 152-28-17 CCCC

County Koochiching

Quadrangle Northome North 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1362

Total depth 400

Elevation, top of  
Precambrian rock 1266

Core interval none

Core recovered none

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval

Description

#### QUATERNARY DEPOSITS

0-15	Sandy till, tan, contains clasts of granite, minor carbonate and mafic rock.
15-95	Sandy till, gray, gradational from with above. Lithologically similar to above.
95-96	Sand, medium- to coarse-grained.

#### REGOLITH ON PRECAMBRIAN ROCK

96-135	Regolith, gray, dry clay, with white kaolinitic clots and streaks.
135-140	Granite, moderately hard.
140-175	Regolith, gray clay.
175-181	Regolith, contains chips of hard gray, fine-grained meta- volcanic or sedimentary rock in with greenish-brown clay.
181-210	Regolith, greenish-gray clay.
210-223	Regolith, light epidote green to dark bluish-green, sandy clay.
223-260	Regolith, orangish-tan clay, minor amount of hard, dark green metavolcanic rock chips.
260-400	Regolith, reddish-brown clay with hard chips of light green sericitic and chloritic phyllite.

#### SOUND PRECAMBRIAN ROCK

No samples obtained.



Field number KIB-63

Date completed 7-19-88

MGS unique number 241863

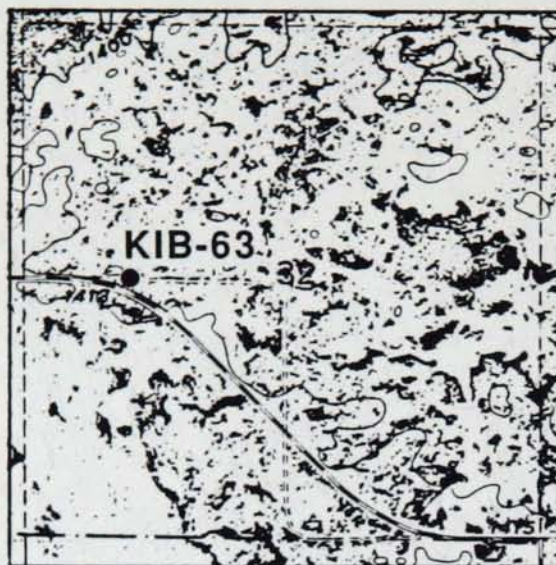
MGS lab number 2734

LOCATION (see map at right)

T-R-S 152-28-32 CBAAB

County Koochiching

Quadrangle Northome North 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1412

Total depth 216

Elevation, top of  
Precambrian rock 1209

Core interval cuttings only

Core recovered none

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-2	Organic till (topsoil), dark brown.
2-13	Clay till, yellowish-brown, slightly sandy.
13-35	Lacustrine silt and clay, dark gray.
35-39	Gravel, well-sorted, well-rounded, rich in carbonate component.
39-50	Fine sand.
50-55	Lacustrine clay, dark gray.
55-94	Silt and fine sand, gray.
94-107	Silt-rich till, gray, contains minor carbonate granules.
107-156	Moderately bouldery till, gray, boulders encountered every 3-4 ft. of drilling.
156-200	Calcareous till, gray, contains chunks of green and white reworked clay regolith.
200-203	Sand.

**REGOLITH ON PRECAMBRIAN ROCK**

Minor thickness encountered.

**SOUND PRECAMBRIAN ROCK**

203-216	Mafic schist and granodiorite gneiss. Bedrock encountered was very highly fractured, cuttings chips range in composition from black lineated amphibolite to gray biotite schist to light grayish-pink granodiorite, all fine- to medium-grained. As judged from cuttings rock is probably a granitic to granodioritic gneiss, possibly with mafic enclaves.
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Field number KIB-64

Date completed 9-13-88

MGS unique number 241864

MGS lab number 2782

LOCATION (see map at right)

T-R-S 152-30-11 BAAAA

County Beltrami

Quadrangle Norman Lake SW 7.5'

HOLE PARAMETERS (feet)

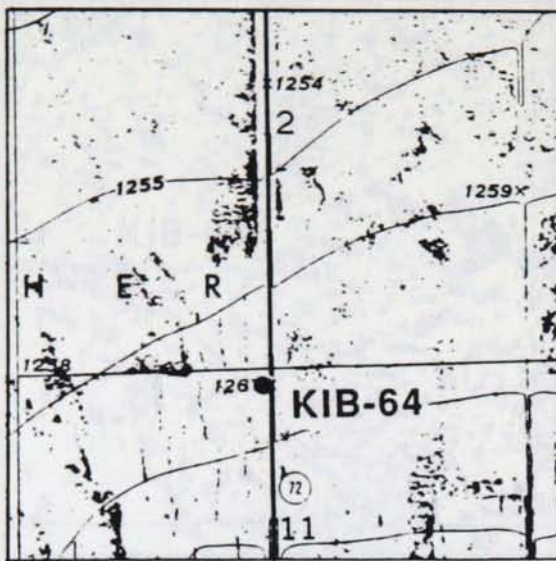
Surface elevation 1265

Total depth 450.9

Elevation, top of  
Precambrian rock 964

Core interval 447-450.9

Core recovered 3.9



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-13	Gravel, yellowish-brown, carbonate-rich.
13-18	Clay till, gray, contains moderate amount of carbonate, basalt, granite, and schist pebbles.
18-120	Sandy till, gray to olive-gray, gravelly at 80-90 ft. interval.
120-262	Clayey to sandy till, gray, drill rate proportional to sand content.
262-301	Bouldery till, gray, cobbles and boulders of gabbro, basalt, granite encountered every 3-4 ft. of drilling.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
301-342	Regolith, light greenish-gray. Begin to see soft, coherent rock chips of fine-grained phyllitic schist at 322 ft. Milky quartz vein 327 ft., also brown mottling of clay.
342-397	Regolith, brown, smooth clay, interlayered bluish- to greenish-gray clay. Brown intervals are thin, probably represent a pyrite- or carbonate-rich precursor.
397-400	Regolith, dark gray clay with abundant small chips of fine-grained black schist.
400-433.5	Regolith, epidote green to brownish-green clay.
433.5-446	Regolith, gray soft clay, mixed with chips of hard schist.
<b>SOUND PRECAMBRIAN ROCK</b>	
446-450.8	Felsic tuff or felsic volcanogenic graywacke, green, bedded.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-64

Principal rock type: Volcaniclastic crystal tuff and argillite.

Mineralogy: Sandy-textured beds contain a total of 10-20% quartz and plagioclase crystals and felsic rock fragments in a fine-grained groundmass of sericite, quartz, and feldspar. Argillite beds contain silt-sized quartz and feldspar in a groundmass of sericite, chlorite, aphanitic quartz plus feldspar. Also traces of tourmaline, zoned green to brown, apatite, pyrite, zircon, rutile and up to 1% leucoxene after sphene.

Texture: Bedding is well defined, and foliation is defined by sericite and chlorite. Crystals and rock fragments are flattened parallel to foliation. Thin quartz ± calcite veins are variably oriented and deformed by shearing. Larger crystals or phenocrysts typically have asymmetric pressure shadows which provide shear stress indicators.

Structure: Bedding is near vertical, at a slight (5°) angle to foliation. Quartz-carbonate veins tend to pinch and swell, form a crude subvertical conjugate set. Thin, ladder-shaped pyrite veins are subhorizontal.

Comments: Downhole geophysical logs on file in the Minnesota Geological Survey downhole geophysical log file.

## CHEMICAL DATA

Rock Type Analyzed: Sheared phyllitic felsic volcanic, 448.5 ft. depth.

### Minor Elements (ppm)

Ag	0.406
As	20.0
Au	<0.048
Cu	481.
Hg	<0.096
Mo	0.848
Pb	12.4
Sb	0.308
Tl	<0.481
Zn	68.8
Bi	<0.24
Cd	0.115
Ga	6.53
Pd	<0.481
Se	<0.962
Te	<0.481

### MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
447-450.5	0.02

### DENSITY

Depth	Density
Not determined.	

Field number KIB-65

Date completed 9-18-88

MGS unique number 241865

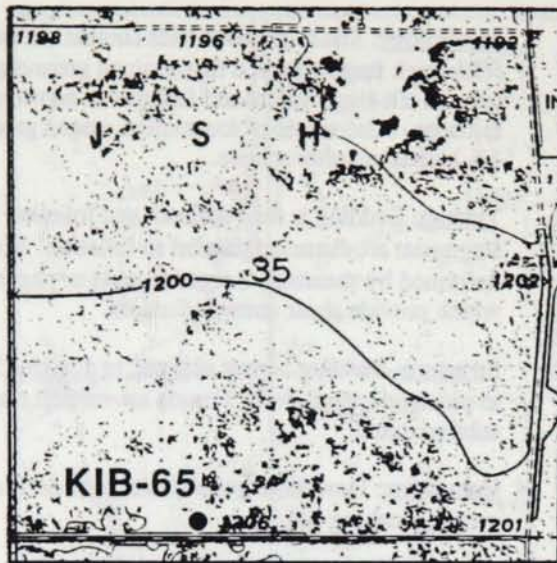
MGS lab number 2822

LOCATION (see map at right)

T-R-S 154-30-35 CDCDD

County Beltrami

Quadrangle Norman Lake SW 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1205

Total depth 143.5

Elevation, top of  
Precambrian rock 1078

Core interval 133-143.5

Core recovered 10.5

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-39	Sand, brown, fine-grained. Layer of smooth green clay 17-18.5 ft., becomes slightly pebbly near bottom.
39-55	Gravel, coarse, well-sorted, well-rounded. Black and white color due to abundant black shale and limestone. Separated from above by a layer of watery gray clay 39-40 ft. interval.
55-88	Till, dark gray, moderately sandy. Contains clasts of carbonate, granite, felsic fragmental volcanic rocks, shale, fine-grained basalt. Sand layer 71.5-73 ft., till below is slightly lighter in color and more clay-rich.
88-96	Gravel, possibly watery gray clay in top 2 ft.
96-127	Boulders and cobbles, tightly packed, variable Archean rock lithologies. Clayey sand in with cobbles 98-102 ft. interval.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
Minor gray clay regolith, but transition to sound bedrock is very abrupt.	
<b>SOUND PRECAMBRIAN ROCK</b>	
127-143.5	Metagraywacke (foliated hornblende-garnet-biotite schist), dark grayish-black.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-65

Principal rock type: Metagraywacke (hornblende-garnet-biotite schist)

Mineralogy: Quartz (30-40%); plagioclase (30-40%); biotite (10-30%); hornblende (1-10%); garnet (1-3%); apatite (tr-1%); oxides and pyrite (1% total); chlorite (tr-2%); sphene, zircon, tourmaline (trace of each).

Texture: Fine-to medium-grained, well-foliated (defined by biotite and hornblende in a granoblastic matrix of quartz and plagioclase). Layering is defined by variable hornblende to biotite ratios, possibly from compositional variations of primary bedding.

Structure: Bedding/layering dips 70-75° from horizontal.

CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
233-234	0.00	238-239	0.02
234-235	0.01	239-240	0.03
235-236	0.03	240-242	0.02
236-237	0.02	242-243	0.03
237-238	0.03		

DENSITY

Sample Density  
Not determined.

Field number KIB-66

Date completed 9-20-88

MGS unique number 241866

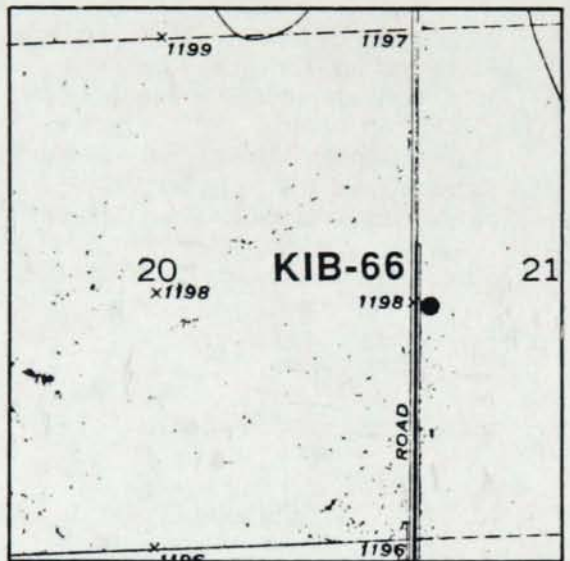
MGS lab number 2823

LOCATION (see map at right)

T-R-S 155-29-21 CBBB

County Koochiching

Quadrangle Norman Lake 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1196

Total depth 86

Elevation, top of  
Precambrian rock 1124

Core interval 77-86

Core recovered 9

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-4	Road fill.
4-6	Peat, changes color from brown to dark brownish-black with depth.
6-8	Clay till, greenish-gray, contains small clasts of carbonate.
8-11	Clay till(?), yellowish-brown to olive
11-72	Sandy till, gray, contains clasts of carbonate, shale, granite, felsic and mafic volcanic rocks. Foot-thick sand layers at 49, 70 ft.
REGOLITH ON PRECAMBRIAN ROCK	
72	Regolith, greenish-gray clay.
SOUND PRECAMBRIAN ROCK	
72-86	Granitic gneiss, grayish-pink, medium-grained.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-66

Principal rock type: Granitic gneiss

Mineralogy: Plagioclase (40%); quartz (29%); orthoclase, perthite (25%); biotite (3%); chlorite (2%); muscovite (1%); zircon, apatite, rutile, pyrite, oxides, sphene (trace of each).

Texture: Medium-grained, weakly foliated. Foliation defined by poorly aligned biotite, in an allotriomorphic-granular (anhedral) matrix of feldspar and quartz. Plagioclase is weakly sericitized. Zircon is abundant relative to typical crystalline rocks. Irregular pink pegmatitic granite stringers range from 0.5 to 10 cm thick. Quartz commonly contains long prismatic rutile crystals.

Structure: Foliation dips 45-50° from horizontal, pink granite stringers dip variably, from 45° to vertical. Late brittle fractures form roughly conjugate sets which dip at 60°.

CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
76-78	0.01
78-79	0.00
79-80	0.01
80-81	0.02
81-82	0.01
82-85	0.00

DENSITY

Depth            Density  
Not determined.

Field number KIB-67

Date completed 9-23-88

MGS unique number 241867

MGS lab number 2820

LOCATION (see map at right)

T-R-S 156-29-35 ACACAA

County Koochiching

Quadrangle Wayland SE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1215

Total depth 350

Elevation, top of  
Precambrian rock 1048

Core interval 340-350

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0- 8	Gravel, yellowish-brown, very rich in carbonate component.
8-32	Silty sand, fine grained.
32-36	Sandy clay, dark greenish-black, rich in chlorite flakes.
36-49	Sand, fine-grained.
49-58	Gravel, carbonate-rich, contains minor green (chloritic), yellow, gray, and brown clay.
58-164	Lacustrine silty sand and clayey silt. Contains abundant black lignite chips and chlorite. 58-80 ft. interval contains abundant chips of black lignitic wood.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
167-184	Regolith, gray and minor greenish-white clay, very smooth.
184-337	Regolith, gray to greenish-gray clay, sandy-textured. Hard zones (granitic) 193-195, 201-214 ft. Minor zones of smooth, bluish-green clay from a mafic precursor scattered throughout interval. Abundant biotite and pink orthoclase below 214 ft., quartz veins every 1-2 ft. from 225-229 ft. depth. Regolith becomes gradationally harder overall with depth to 337 ft.
<b>SOUND PRECAMBRIAN ROCK</b>	
337-350	Quartz diorite gneiss, grayish-pink.



## PETROGRAPHIC DESCRIPTION OF CORE: KIB-67

Principal rock type: Quartz diorite to tonalite gneiss.

Mineralogy: Plagioclase, weakly saussuritized (70%); quartz (15-20%); orthoclase (0-5%); chlorite (1-10%); apatite, zircon, sphene, zoisite, adularia, pyrite, chalcopyrite, oxides (trace of each)./

Texture: Medium-grained; quartz and feldspar are anhedral, equigranular to foliated, chlorite is secondary after biotite, foliated. Core consists of approximately 80% grayish-pink, weakly foliated tonalite (neosome) and 20% biotite schist (paleosome). Irregular fractures have various orientations.

Structure: Foliation is subvertical.

## CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
340-349.5	0.00

## DENSITY

Depth	Density
Not determined	

Field number KIB-68

Date completed 10-7-88

MGS unique number 241868

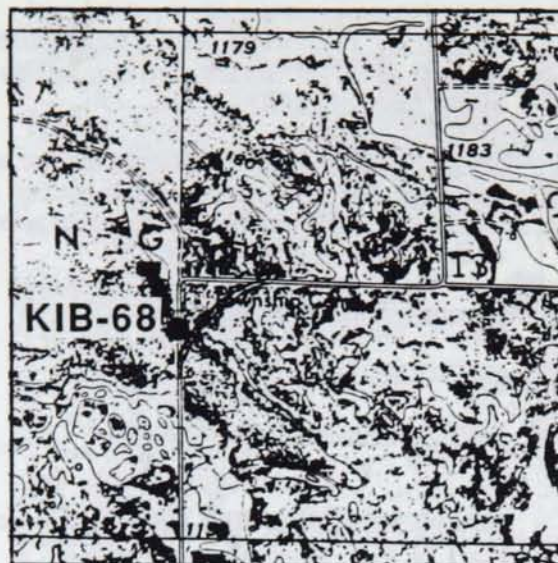
MGS lab number 2739

LOCATION (see map at right)

T-R-S 151-32-13 CBBCCB

County Beltrami

Quadrangle Saum 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1185

Total depth 342

Elevation, top of  
Precambrian rock 876

Core interval 332-342

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-3	Fine sand.
3-5	Peat, dark brownish-black.
5-9	Silty clay and fine sand, gray.
9-44	Lacustrine clay, gray, smooth, soft and watery.
44-55	Clay till, light gray, clasts dominantly of carbonate.
55-82	Sand and clay, gray, interlayered. Becomes more clay-rich with depth, probably lacustrine.
82-98	Clay till, gray, dense, boulders encountered evry 3-4 ft. of drilling.
98-135	Sandy till, gray. Zone of boulders 115-118 ft. interval.
135-145	Clay till, dark gray, abrupt contact with above.
145-152	Sand, fine to coarse, cobbles in last foot of interval.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
152-207	Regolith, light greenish-gray clay.
207-221	Regolith, clay as above but with dark green chlorite and rare feldspar.
221-309	Regolith, clay as above but begin to note much hard green, altered granitic rock.
<b>SOUND PRECAMBRIAN ROCK</b>	
309-332	Granitic cuttings, moderately hard to very hard and fresh.
332-342	Quartz diorite, grayish-to pinkish-green, medium-grained (core).

PETROGRAPHIC DESCRIPTION OF CORE: KIB-68

Principal rock type: Lineated quartz diorite

Mineralogy: Plagioclase (76%); quartz (9%); alkali feldspar (4%); amphibole, hornblende and actinolite (4%); chlorite (2%); epidote (2%); sphene (1%); pyrite, flourite, apatite, (trace of each).

Texture: Medium- to coarse-grained; strong igneous foliation/lineation defined by tabular plagioclase and hornblende crystals. Plagioclase crystals show strong cyclic zonation, are moderately saussuritized in the more calcic zones. Hornblende is moderately to heavily altered to chlorite and epidote. Minor blue flourite is present as an intersitial phase.

Structure: Foliation/lineation plane is near horizontal. Tight quartz, pyrite, and red clay-lined brittle fractures are subvertical.

CHEMICAL DATA

Rock Type Analyzed: Quartz diorite, 339-339.5 ft. (whole rock), 335-336 ft. (assay)

<u>Major Elements (wt. % oxides)</u>		<u>Minor Elements (ppm)</u>		<u>Minor Elements (ppm)</u>	
SiO <sub>2</sub>	64.2	Cl	100	Ag	0.144
Al <sub>2</sub> O <sub>3</sub>	16.3	Cr	127	As	<0.94
CaO	4.10	Rb	97	Au	<0.047
MgO	1.61	Sr	1600	Cu	31.5
Na <sub>2</sub> O	5.77	Y	<10	Hg	<0.094
K <sub>2</sub> O	2.58	Zr	88	Mo	1.57
(Fe <sub>2</sub> O <sub>3</sub> )	2.03	Nb	<10	Pb	3.73
FeO	0.9	Ba	1080	Sb	0.417
MnO	0.08			Tl	<0.47
TiO <sub>2</sub>	0.36			Zn	45.7
P <sub>2</sub> O <sub>5</sub>	0.15			Bi	<0.235
H <sub>2</sub> O+	1.1			Cd	<0.094
CO <sub>2</sub>	0.31			Ga	2.42
S	0.03			Pd	<0.47
LOI	1.70			Se	<0.94
Total	100.2 (normalized)			Te	<0.47
Total iron as Fe <sub>2</sub> O <sub>3</sub>	3.03				

MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
332-336	0.00
336-338	0.01
338-340	0.00

DENSITY

Depth	Density
Not Determined	

Field number KIB-69.B

Date completed 10-3-88

MGS unique number 241869B

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 153-30-19 CCCC

County Beltrami

Quadrangle Shotley Brook 7.5'

HOLE PARAMETERS (feet)

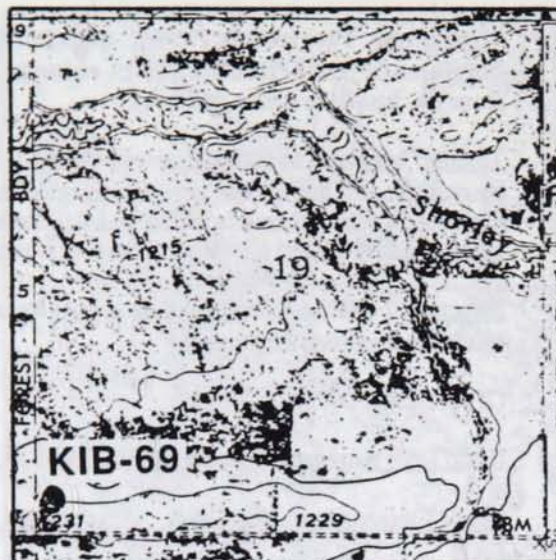
Surface elevation 1231

Total depth 185.5

Elevation, top of  
Precambrian rock 1060

Core interval 175.5-185.5

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-6	Sand, light brown, fine- to medium-grained.
6-157.5	Sandy till, gray, contains clasts of carbonate, granite, mafic volcanic rock. Cobbly zone 10 to 12 ft. depth, large boulder 20 ft. depth.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
157.5-175	Regolith, greenish-gray sandy clay, becomes bluish-green at 160-165 ft. Contains cuttings of dark, fine-grained schist. Hardens consistently with depth.
<b>SOUND PRECAMBRIAN ROCK</b>	
175-185.5	Metagraywacke (biotite schist), dark gray, fine-grained, bedded.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-69.B

Principal rock type: Metagraywacke (garnet-biotite schist).

Mineralogy: Feldspar (40%); quartz (35%); biotite (5-20%); chlorite (3%); garnet (1%); muscovite (1-2%); clinozoisite (5-10%); apatite (up to 1%); pyrite (up to 1%); oxides, calcite (trace of each).

Texture: Fine-grained, well foliated (defined by biotite) schist with well preserved bedding, defined by variations in color and grain size. Coarser-grained beds contain plagioclase and recrystallized quartz grains up to 0.5 mm across in a fine-grained recrystallized-granoblastic matrix. Garnet prophyroblasts are subhedral, poikilitic, have only vague, symmetric pressure shadows. Quartz-carbonate veins 1 - 3mm thick are deformed and clotted, at a low angle to bedding; thin greenish-bleached zones follow late, tight brittle fractures; mm-wide chloritized shear zones parallel bedding, and cross-cut quartz-carbonate veins.

Structure: Bedding dips 65° from horizontal, bleached fractures dip 50° from horizontal.

CHEMICAL DATA

Rock Type Analyzed: Tuffaceous metagraywacke, 179 ft. depth

Minor Elements (ppm)

Ag	0.098
As	<0.931
Au	<0.047
Cu	44.8
Hg	<0.093
Mo	1.42
Pb	10.8
Sb	<0.233
Tl	<0.466
Zn	124.
Bi	<0.233
Cd	0.139
Ga	8.55
Pd	<0.466
Se	<0.931
Te	<0.466

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
175.5-176.5	0.08	180.5-181.5	0.07
176.5-177.5	0.03	181.5-182.5	0.09
177.5-178.5	0.04	182.5-183.5	0.12
178.5-180.5	0.03	183.5-184.5	0.13
		184.5-185.5	0.17

DENSITY

Depth	Density
Not determined	

Field number KIB-70

Date completed 10-23-88

MGS unique number 241870

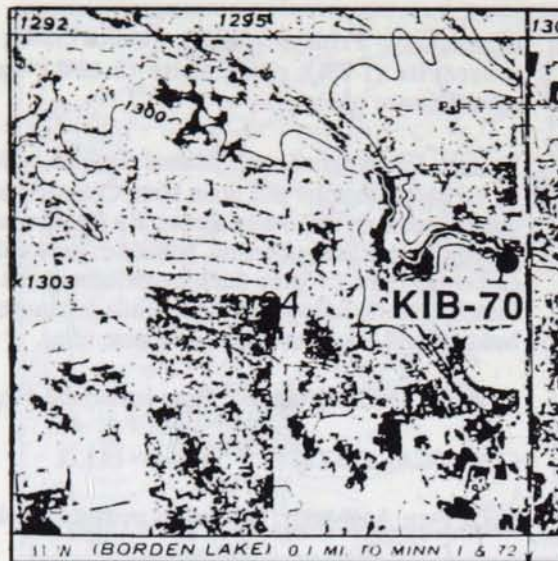
MGS lab number 2738

LOCATION (see map at right)

T-R-S 151-31-24 DAA

County Beltrami

Quadrangle Saum NE 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1300

Total depth 233

Elevation, top of  
Precambrian rock 1108

Core interval 223-233

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-11	Clay till, grayish-brown, contains rare clasts of carbonate and granite. Top foot is organic, dark-brown topsoil.
11-16	Clay, gray, smooth, possibly lacustrine.
16-25	Sandy till, gray, contains low volume of carbonate, granite, and shale clasts.
25-46	Fine silty sand, gray, contains lignite chips. Cobbles of granite and limestone at very bottom of interval.
46-57	Silty till, gray. Boulder at 53.5 ft. depth.
57-63	Lacustrine clay or clay till, dark gray, becomes sandy near 60 ft.
63-76	Cobbly gravel, abrupt transition from above, with interlayered beds of sand and clay (a lacustrine sequence).
76-192	Sandy till, gray, dry. Carbonate is dominant clast lithology. Minor thin layers of sand.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
192-217	Regolith, green to bluish-green sandy clay with chips of greenish-black aphanitic metasedimentary rock.
<b>SOUND PRECAMBRIAN ROCK</b>	
217-233	Volcaniclastic argillite and siltstone, green, fine-grained (sericite-chlorite schist).

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-70

Principal rock type: Meta-argillite and siltstone (sericite-chlorite schist).

Mineralogy: Chlorite (30%); sericite (20%); quartz, crystals and groundmass; feldspar, crystals and groundmass (30% total); calcite (5-10%); opaque oxides, leucoxene, sphene (5-10% total); pyrite, epidote (1% total).

Texture: Well-foliated, kinked, phyllitic schist has low to moderate volume of unit quartz and blocky plagioclase crystals in a fine-grained matrix of chlorite, biotite, quartz, feldspar, opaque oxides and their alteration products. Carbonate-quartz veins are recrystallized and deformed, tend to be best preserved if foliation-parallel. Kink bands are late, affect both foliation and veining, locally contain brittle calcite- and quartz-filled tension gashes. Asymmetric pygmatic folds in quartz veins give evidence of shearing. Bedding is visible via variations in grain size and crystal content.

Structure: Bedding and foliation dip near vertical, fractures tend to dip 45° from horizontal.

## CHEMICAL DATA

Rock Type Analyzed: Sheared felsic argillite, 229-229.5 ft. depth

### Minor Elements (ppm)

Ag	0.069
As	7.65
Au	<0.046
Cu	125.
Hg	<0.092
Mo	0.739
Pb	2.82
Sb	0.360
Tl	<0.458
Zn	110.
Bi	<0.229
Cd	0.174
Ga	8.87
Pd	<0.458
Se	<0.916
Te	<0.458

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)	Depth	Reading( x 10 <sup>-3</sup> cgs units)
223-224	0.41	227-228	0.09
224-225	0.75	228-229	0.13
225-226	0.61	229-230	0.12
226-227	0.11	230-231	0.03

## DENSITY

Depth	Density
Not determined	

Field number KIB-71

Date completed 10-6-88

MGS unique number 241871

MGS lab number 2783

LOCATION (see map at right)

T-R-S 152-32-25 DDAABA

County Beltrami

Quadrangle Saum 7.5'

HOLE PARAMETERS (feet)

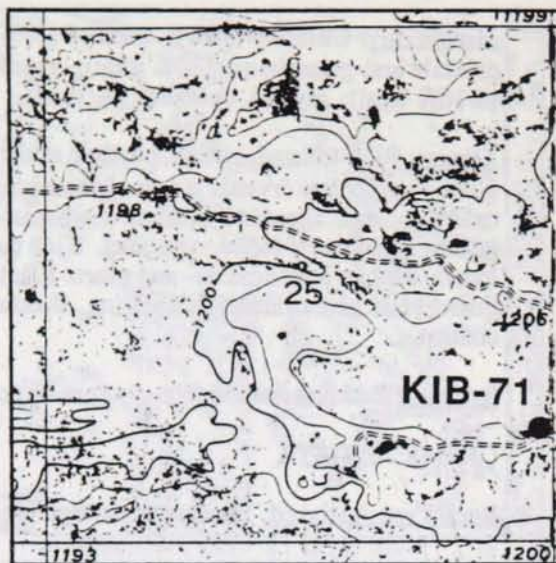
Surface elevation 1207

Total depth 244.25

Elevation, top of  
Precambrian rock 977

Core interval 234.25 - 244.25

Core recovered 10



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-4	Sand, yellowish-brown, fine grained.
4-10	Sandy till, yellowish-brown.
10-25	Sandy till, gray, locally becomes gravelly.
25-51	Sand, yellowish-brown, fine-grained.
51-62	Clayey till, gray, with clasts of carbonate and various Archean rock types.
62-230	Sandy till, gray, locally more clay-rich. Cobbles are minor, clasts of similiar lithologies to above, also black shale and lignite.
REGOLITH ON PRECAMBRIAN ROCK	
230-232	Regolith, green and white clay, with chips of dark, aphanitic metavolcanic rock.
SOUND PRECAMBRIAN ROCK	
232-244.3	Sheared metagabbro, greenish-black, medium-grained.



## PETROGRAPHIC DESCRIPTION OF CORE: KIB-71

Principal rock type: Sheared metagabbro

Mineralogy: Hornblende and actinolite (50-70%); clinozoisite and epidote (15-25%); chlorite (1-15%); quartz (1-5%); plagioclase (0-5%); oxides and sphene (1%); pyrite (trace).

Texture: Foliated shear fabric defined by fibrous amphiboles and chlorite. Shear deformation varies from moderate to strong, with corresponding moderately preserved to nonexistent medium-grained relict gabbroic texture. Primary shear fabric cut at 35-40° by a second, reverse-motion (with regard to uphole direction) shear with corresponding epidote veining, which in turn is cut by thin, late quartz-chlorite veins. The second shear may be a conjugate to the primary shear.

Structure: Foliation dips 60° from horizontal.

## CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

## MAGNETIC SUSCEPTIBILITY (depths in feet)

Depth	Reading( x 10 <sup>-3</sup> cgs units)
234.25-238.25	0.02
238.25-239.25	0.03
239.25-240.25	0.02
240.25-242.25	0.03
242.25-244.25	0.02

## DENSITY

Depth	Density
Not determined	

Field number KIB-73

Date completed 5-23-89

MGS unique number 241873

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 151-30-27 DDD BAAA

County Beltrami

Quadrangle Funkley 7.5'

HOLE PARAMETERS (feet)

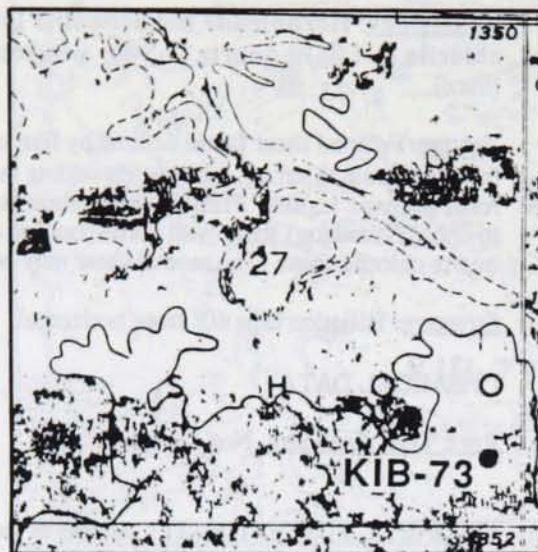
Surface elevation 1353

Total depth 253

Elevation, top of  
Precambrian rock 1115

Core interval 242-253

Core recovered 11



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-7.5	Brown sandy soil and sand.
7.5-32	Lacustrine clay, gray, smooth, weakly varved or laminated.
32-41	Clayey till, gray, contains pebble-sized clasts of carbonate, black slate, minor granite.
41-74	Sandy till, gray, rich in sand, pebbles, cobbles and boulders. Clast lithologies similar to above.
74-107	Sand interlayered with minor silt.
107-238	Mixed sandy and clayey tills with layers of sand and gravel. Contains clasts of carbonate, shale, granite, and volcanic rocks, minor cobbles present.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
	None encountered.
<b>SOUND PRECAMBRIAN ROCK</b>	
238-253	Black, fine-grained microlitic diabase, in contact with mafic schist.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-73

Principal rock type: Diabase, mafic schist.

Mineralogy: (Diabase) Contains up to 5% variably saussuritized microlitic feldspar in a mafic groundmass. Rock is strongly magnetic. (Mafic schist) Rock is carbonate-altered, consists of green chlorite ( $\pm$  epidote), carbonate, quartz, feldspar, disseminated magnetite, and pyrite (up to 3-5%). Clots of dark chlorite may be relict Fe-Mg minerals. Protolith appears to be of basaltic to intermediate-composition volcanic.

Texture: (Diabase) Massive and fine-grained to aphanitic. Grain size decreases in proximity to the contact with the mafic schist, suggesting core may be taken from the edge of a coarser-grained diabase dike. (Mafic schist) Strongly foliated, veined, and metamorphosed.

Structure: (Diabase) Early irregular veinlets with bleached walls and pyrite are random, second set of calcite-filled tension gashes are nearly horizontal, third vein set is nearly vertical and offsets the first two, is of shear origin. Contact of diabase with underlying schist dips at  $45^\circ$  from horizontal. (Mafic schist) Foliation dips at  $75-85^\circ$  from horizontal. Fabric indicates moderate to strong shearing. Three vein sets: 1.) early, pre-foliation calcite veins, parallel to foliation; 2.) post-foliation calcite veins parallel fabric but are only weakly deformed; 3.) late calcite-filled tension gashes dip steeply but are normal to foliation.

## CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

## MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x $10^{-3}$ cgs units)
Not determined	

## DENSITY

Depth	Density
Not determined	

Field number KIB-74

Date completed 6-4-89

MGS unique number 241874

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 150-30-8 DDDDA

County Beltrami

Quadrangle Borden Lake 7.5'

HOLE PARAMETERS (feet)

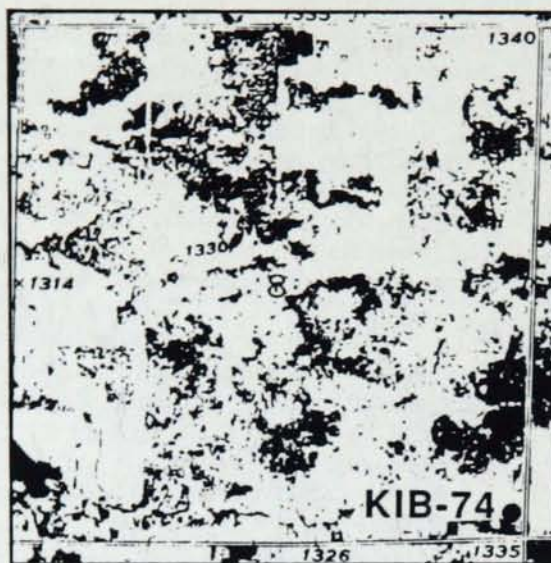
Surface elevation 1334

Total depth 264

Elevation, top of  
Precambrian rock 1116

Core interval 253-264

Core recovered 11



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-5	Clayey soil, dark brownish-black.
5-11	Clay till, yellowish-brown, contains small clasts of carbonate.
11-52	Lacustrine clay, silt, and sand, gray. Contains a 2 foot layer of coarse carbonate-rich sand.
52-106	Sandy till, gray, rich in sand, pebbles, cobbles and boulders. Clast lithologies similar to above.
106-126	Gravel, coarse, rich in carbonate, also contains abundant Keeweenaw-age pebbles.
126-204	Clay till (?-possibly lacustrine), gray. Similar to that above gravel but less sandy.
204-208	Gravel.
208-218	Sandy till, gray, with boulders of weathered granite, fine-grained gabbro and/or amphibolite.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
218-238	Regolith, dark green smooth clay, from a mafic protolith.
238-240	Regolith, light greenish-white clay with quartz and feldspar, from a granitic protolith.
240-250	Regolith, dark green clay, from a mafic protolith.
<b>SOUND PRECAMBRIAN ROCK</b>	
250-264	Foliated granitic rock, dark red, cut by mafic dike, possibly lamprophyric.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-74

Principal rock type: Granite, lamprohyric mafic dike.

Mineralogy: (Hand sample estimation) Granite-feldspar 67%; quartz 20%; hornblende 8%; epidote 3%; biotite 1%; sphene up to 1%; chlorite and oxides, trace. Hornblende is partially altered to epidote, oxides are small, blocky, probably hematite. Mafic dike contains 3-5% small phenocrysts of chlorite (probably pseudomorphic after biotite) in a fine-grained matrix of feldspar, chlorite, and epidote. Late brittle fractures are lined by chlorite, minor calcite, and rare pyrite.

Texture: Granite is moderately foliated/lineated (primary), medium-coarse-grained; mafic intrusive is strongly foliated, fine-grained.

Structure: Granite lineation dips 45° from horizontal, at a right angle to the contact and the foliation in the mafic intrusive rock. Mafic intrusive has undergone slight preferential shear. Both rock types are cut by abundant late brittle fractures, most of which dip 60-80° from horizontal, some are also flat-lying.

CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
Not determined	

DENSITY

Depth	Density
Not determined	

Field number KIB-76

Date completed 6-7-89

MGS unique number 241876

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 149-31-30 DCCDC

County Beltrami

Quadrangle Tenstrike 7.5'

HOLE PARAMETERS (feet)

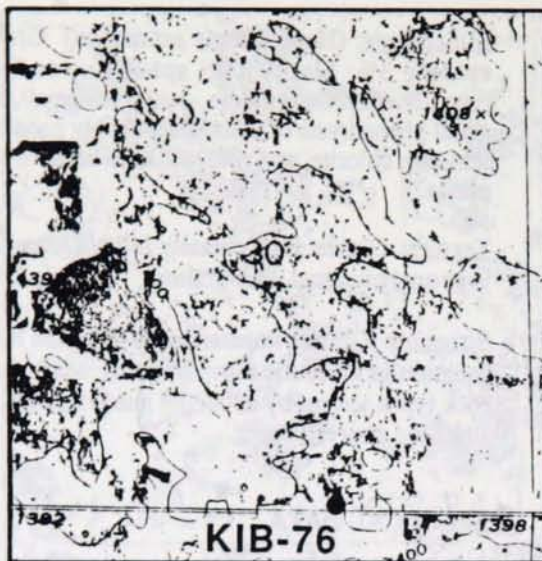
Surface elevation 1398

Total depth 427

Elevation, top of  
Precambrian rock 1029

Core interval 417-427

Core recovered 11



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-7	Slightly sandy clayey till, light olive-brown.
7-18	Till, yellowish-brown, possibly sandy lacustrine clay. Contains sand-sized clasts of carbonate and Archean rocks, few pebbles. Gravelly 17-18 ft.
18-38	Clayey till, dark grayish-brown to gray, locally silty, texturally similar to above. Carbonate-rich gravel 26-27 ft., underlain by 1 ft. of gray silt, then back to till.
38-118	Lacustrine clay, gray, slightly sandy and silty. Layer of brownish-gray silty sand 43-63 ft., boulder of granite near 68 ft., gravel 79-81 ft., cobbly near 83 ft. Other gravel layers near 93, 101, 110 ft.
118-153	Coarse gravel mixed with sandy silt. Very coarse, angular pebbles consist of Archean schist, metabasalt, felsic volcanics, granitoids, also carbonate. Sandy 145-148 ft.
153-273	Sandy clay till(?), gray, with minor gravel. Boulders 179-181 ft.
273-303	Sand and silt underlain by gravel.
303-369	Slightly gravelly sandy till, gray. Becomes bouldery below 351 ft.

**REGOLITH ON PRECAMBRIAN ROCK**

369-413 Regolith, grayish-green, smooth clay.

**SOUND PRECAMBRIAN ROCK**

413-427 Fine-grained, foliated, dark grayish-green pyritic metabasalt and volcanic conglomerate.

## PETROGRAPHIC DESCRIPTION OF CORE: KIB-76

Principal rock type: Meta-basalt and volcanic conglomerate.

Mineralogy: Chloritic ( $\pm$  sericitic) schist has been heavily carbonate-altered, contains abundant very fine-grained pyrite and pyrrhotite throughout as linings along cleavage planes and in veins with calcite and marcasite.

Texture: Upper part of core shows dark and light green, mm-scale layering which is due to shearing and recrystallization of the primary basaltic protolith. Lower half of core (in transitional contact) shows a definite clastic texture of flattened clasts which are dark to light green in color, generally very carbonate altered, in a fine-grained chloritic matrix. Rock has been moderately sheared.

Structure: Foliation dips 70-80° from horizontal. Early, deformed calcite-pyrite-marcasite veins dip 70-80° from horizontal, but are not coplanar with foliation. Later thin, straight, continuous to en-echelon carbonate-pyrite-marcasite veins range in orientation from near vertical (perpendicular to foliation) to  $\pm 45^\circ$  from horizontal (oblique to foliation), to flat-lying. Veining is limited to upper half of core, in the basaltic protolith portion.

## CHEMICAL DATA

Rock Type Analyzed: Pyritic basalt, 415-416 ft.

### Minor Elements (ppm)

Ag	0.037
As	4.34
Au	0.002
Cu	52.1
Hg	<0.092
Mo	0.725
Pb	0.721
Sb	0.471
Tl	<0.46
Zn	106.
Bi	<0.23
Cd	0.130
Ga	5.89
Pd	<0.46
Se	<0.921
Te	<0.46

## MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
Not detrmined	

## DENSITY

Depth	Density
Not determined	

Field number KIB-77

Date completed 6-3-89

MGS unique number 241877

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 149-30-23 ADADCD

County Beltrami

Quadrangle Decker Lake 7.5'

HOLE PARAMETERS (feet)

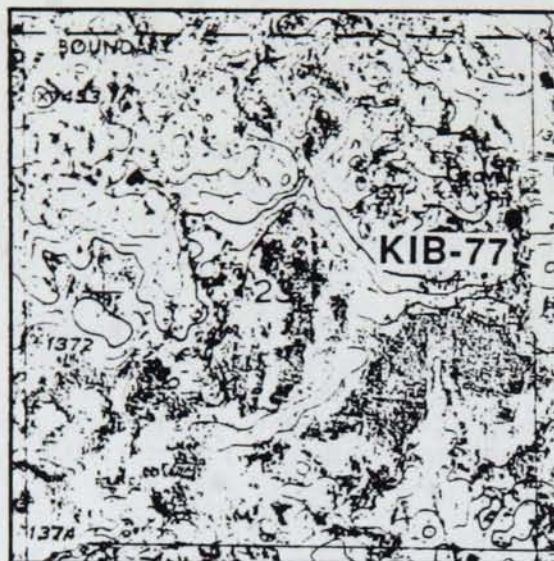
Surface elevation 1395

Total depth 512

Elevation, top of  
Precambrian rock 901

Core interval 501-512

Core recovered 11



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-4	Silty sand, yellowish-brown, dark organic rich in top 6 inches.
4-17	Clay till, yellowish-brown with gray and reddish-brown mottling, smooth, contains sand-sized clasts of carbonate.
17-77	Coarse carbonate-rich sand, cobbles, gravel, interlayered; also contains minor silty sand.
77-150	Gravelly till, gray, contains a high proportion of coarse granular sand and pebbles, lithologies of carbonate (50%), granite, gneiss. Locally very sandy.
150-178	Lacustrine clay, dark gray to greenish-gray to brownish-gray.
178-255	Sandy till, gray, contains cobbles and boulders of fine-grained gneiss and amphibolite.
255-318	Coarse sand, gravel with cobbles, also minor layers of dark gray silt and sandy clay.
318-355	Silty clay, gray, with thin layers of gravel and boulders.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
355-491	Regolith, white to light gray clay, contains abundant gray quartz sand and white kaolinitized feldspar; also biotite below 470 ft. Protolith of granitic rock.
491-494	Regolith, dark grayish-green clay from a mafic protolith.
<b>SOUND PRECAMBRIAN ROCK</b>	
494-512	Pink, massive granite to granodiorite.



PETROGRAPHIC DESCRIPTION OF CORE: KIB-77

Principal rock type: Coarse-grained, pink granite/granodiorite.

Mineralogy (Hand sample estimation) **Plagioclase**, blocky, zoned (40%); **quartz**, equant, 2 - 3mm in size (35%); **orthoclase**, poikilitic in groundmass (21%); **hornblende**, blocky (3%); **biotite**, **epidote**, trace of each. Brittle fractures lined with chlorite, one is lined with gray quartz (1cm thick).

Texture: Coarse-grained, massive, blocky plagioclase and hornblende crystals and quartz are poikilitically enclosed in orthoclase feldspar (albite?)

Structure: Late brittle fractures are widely spaced, subhorizontal.

CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
Not determined	

DENSITY

Depth	Density
Not determined	

Field number KIB-79

Date completed 5-31--89

MGS unique number 241879

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 149-30-29 ADAAD

County Beltrami

Quadrangle Blackduck 7.5'

HOLE PARAMETERS (feet)

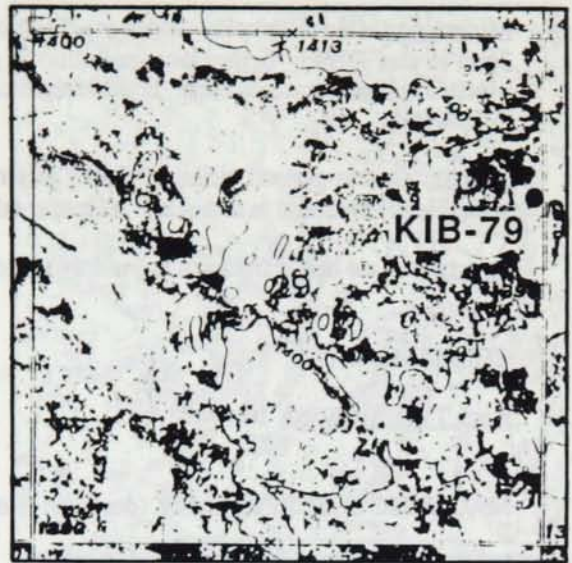
Surface elevation 1405

Total depth 353

Elevation, top of  
Precambrian rock 1065

Core interval 346-357

Core recovered 11



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-14	Clayey till, yellowish-brown, contains small clasts of carbonate, shale, various Archean rocks.
14-79	Clayey till, gray, texturally similar to above. Slightly sandy near 45, 70-75 ft.
79-90	Sandy till, gray, boulders of granite, gabbro 85-86 ft.
90-335	Lacustrine sequence consisting of gray clay, silt, sand, minor gravel and cobbles. Various lithologies are interlayered and bedded.

**REGOLITH ON PRECAMBRIAN ROCK**

335-340	Regolith, grayish-green clay with abundant fine-grained white kaolinized feldspar, biotite, quartz.
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**SOUND PRECAMBRIAN ROCK**

340-352	Granodiorite, medium to coarse grained, greenish-pink, weakly foliated.
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PETROGRAPHIC DESCRIPTION OF CORE: KIB-79

Principal rock type: Weakly foliated granodiorite.

Mineralogy: (Hand sample examination) Quartz 15-20%; plagioclase, white, blocky 30%; K-feldspar, pink 40%; hornblende, partially altered to chlorite 10%; pyrite, pyrrhotite, and minor chalcopyrite 1% total; epidote, sphene, blocky oxides, trace of each. Thin pegmatitic granitic segregations are present; lower 1.5 ft. of core is dk. green, more hornblende-rich version of granodiorite hornblende (20-40%), less quartz and orthoclase.

Texture: Medium- to coarse-grained, weakly foliated. Sulfides are present along flat fracture coatings and as very fine disseminations along cleavage planes.

Structure: Foliation dips 45° from horizontal, late brittle fractures are complex, of varying orientations.

CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
Not determined	

DENSITY

Depth	Density
NOt determined	

Field number KIB-81

Date completed 5-26--89

MGS unique number 241881

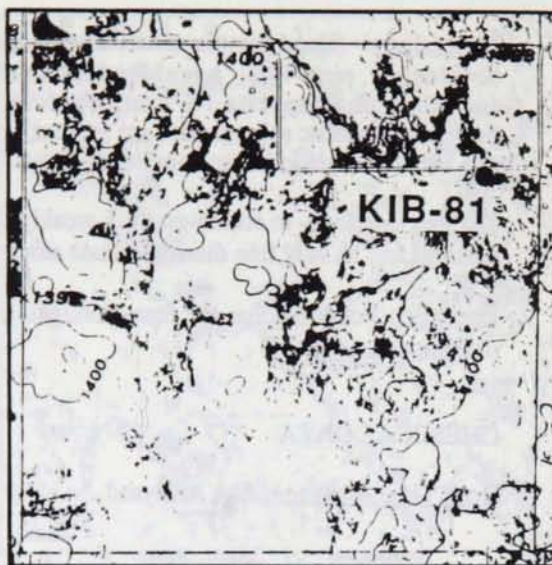
MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 149-30-34 ADABBB

County Beltrami

Quadrangle Blackduck 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1425

Total depth 399

Elevation, top of  
Precambrian rock 1063

Core interval 389-399

Core recovered 10

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
<b>QUATERNARY DEPOSITS</b>	
0-5	Rocky clay, reddish-brown.
5-11	Sand, coarse, rich in carbonate and shale.
11-108	Till gray, with layers of sand. Clasts of carbonate, shale, granite, black metavolcanics. Cobbly 68.5-72.5 ft.
108-283	Sand, gravel, cobbles, layers of silt. Pebbles of Keweenawan-age rocks in sand/gravel.
283-310	Clayey and sandy till, gray. Contains clasts of carbonate, shale, dark fine-grained rock.
310-356	Sand and gravel.
356-362	Sandy till, gray.
<b>REGOLITH ON PRECAMBRIAN ROCK</b>	
362-386	Regolith, light grayish-green clay, broken and weathered rock below 368 ft.
<b>SOUND PRECAMBRIAN ROCK</b>	
386-399	Metabasalt cut by adamellite intrusion.

PETROGRAPHIC DESCRIPTION OF CORE: KIB-81

Principal rock type: Metabasalt, adamellite.

Mineralogy: (Hand sample examination) Metabasalt - Chloritic, locally silicified, veins of quartz, possibly carbonate. Adamellite - **quartz**, 2-6mm sub-euhedral (20%); **hornblende**, acicular to tabular (10%) **K-feldspar**, white to pink (40%); **plagioclase**, white, interstitial (30%); **magnetite**, **sphene**, **pyrite**, trace of each; **chlorite**, native Cu along shear veins and brittle fractures.

Texture: Metabasalt - pillowed and fragmental. Adamellite - medium-grained, cut by thin, irregular quartz veins, locally sheared.

Structure: Metabasalt - massive, undeformed; bedding as judged from contacts dips 45 - 60°. Adamellite - shows weak brittle shear fabric.

CHEMICAL DATA

Rock Type Analyzed: Not Analyzed.

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
Not determined	

DENSITY

Depth	Density
Not determined	

Field number KDH-1

Date completed 1-18-89

MGS unique number 241891

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 64-24-24 BABB

County Koochiching

Quadrangle Nett Lake River SE 7.5'

HOLE PARAMETERS (feet)

Surface elevation 1280

Total depth 501

HOLE ORIENTATION (degrees)

Azimuth N 10 E

Inclination -60

Elevation, top of  
Precambrian rock 979

Core interval 310-501

Percent recovery 100



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-15	Clay, gray to greenish-gray.
15-31	Sandy clay, gravelly 31-33 ft. interval
40-44	Lacustrine clay.
44-60	Sand, clay, gravel.
60-96	Sandy clay (till?).
96-167	Clay, silt, sand, gravel, scattered boulders.
167-181	Gravelly clay (till).
181-232	Sand, silt, clay.
232-269	Coarse sand, gravel, cobbles.
REGOLITH ON PRECAMBRIAN ROCK	
269-310	Regolith, green and minor light brown clay; relatively hard by 301 ft.
SOUND PRECAMBRIAN ROCK	
310-494	Metagraywacke.

## PETROGRAPHIC DESCRIPTION OF CORE: KDH-1

Principal rock type: Metagraywacke.

Core Description: Gray, fine- to medium-grained, plagioclase-biotite-quartz schist of graywacke protolith with thin argillaceous biotite schist lenses and beds. Relict bedding is well preserved, as are local graded beds. Grading indicates top is up-hole to south. Foliation dips about 45° to core axis, dip is approximately 60-70° south. Three vein sets exist, but generally are widely spaced. Earliest veins are folded into schistosity and contain feldspar and biotite. A second set, typically parallel to schistosity, contains quartz, feldspar, and chlorite. The latest set is straight walled, post-dates foliation, and contains various amounts of carbonate, quartz, and minor pyrite. Minor, late chlorite-filled fractures are subparallel to core axis and offset early veins, indicating north side down. Minor disseminated pyrite is present in argillaceous units. No thin sections made from this core.

## CHEMICAL DATA

Rock Type Analyzed: Not Analyzed

## MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
310-501	0.00-0.02

## DENSITY

Depth	Density
Not determined	

Field number KDH-2

Date completed 1-26-89

MGS unique number 241892

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 60-25-36 BAAABBB

County Itasca

Quadrangle Anderson Lake 7.5'

HOLE PARAMETERS (feet)

Surface elevation 1425

Total depth 494

HOLE ORIENTATION (degrees)

Azimuth Due North

Inclination -60 (top), -68 (bottom)

Elevation, top of  
Precambrian rock 1297

Core interval 140-494

Percent recovery 95



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-5	Clay till.
5-17	Sand, fine-medium grained, yellowish-brown.
17-46	Cobbly gravel.
46-71	Sand, fine to coarse, light brown.
71-105	Sand interlayered with minor cobbly gravel.
105-128	Silty sand, reddish-brown to light gray in color.
REGOLITH ON PRECAMBRIAN ROCK	
128-140	Regolith, gray to greenish-gray clay. (Drilled interval).
140-141	Regolith, green clay with broken rock. (Cored interval).
SOUND PRECAMBRIAN ROCK	
141-494	Metabasalt, magnetic.



## PETROGRAPHIC DESCRIPTION OF CORE: KDH-2

Principal rock type: Metabasalt

Core Description: Rock consists mainly of magnetic, locally altered and veined metabasalt with ubiquitous oxides and pyrite. Upper part and many zones below are weathered to clays. Schistosity is locally well developed; foliation is nearly parallel to core axis and is variable, in part because hole inclination steepened from 60° at top to 68° at bottom. Bedding dips about 60° to the north. Metamorphic and vein minerals include pyrite, magnetite (and hematite?), epidote, amphibole, garnet, feldspar and quartz. Most appear to have been crystallized during or before the fabric-forming event. Calcite, pyrite, quartz occur in later, post-foliation veins. Very late bull-quartz veins do not contain pyrite. Some veins contain minor chalcopyrite and pyrrhotite.

- 140-154 Metabasalt; green, fine- to very fine-grained and amygdaloidal. Core is moderately fresh, except for oxidation of disseminated magnetite and pyrite.
- 154-159 No recovery.
- 159-160 Banded chert and phyllite, contains weathered oxides and pyrite. Thin section shows laminae to be defined by variations in grain size of blocky pyrite and recrystallized chert matrix. A conformable vein of recrystallized quartz with minor brown garnet is also present in thin section. Approximate mode of 20% pyrite, 15% hydrous Fe-oxide, 65% quartz, trace garnet.
- 160-207.8 Metabasalt, schistose, weathered and altered. Black to brown relict magnetite and pyrite occur as disseminated grains in weathered, folded veins.
- 207.8-356 Metabasalt, schistose, very weathered in upper part and local zones below. Freshest parts appear to be pillowed and amygdaloidal. Strongly veined with secondary minerals in interpillow and in cross-cutting but folded veins. Ubiquitous fine disseminated pyrite and magnetite are locally fresh (unoxidized). Becomes progressively more massive, less weathered and veined downward. Thin section at 258 ft. shows a metamorphic mineral assemblage suggestive of pyroxene granofels-grade thermal metamorphism of an iron-rich pillow basalt, followed by slight retrograde metamorphism. Rind material consists of massive epidote and chlorite; primary crystalline portion of rock now consists of hornblende, actinolite, subpoikiloblastic diopsidic pyroxene, antiperthitic plagioclase, magnetite, epidote, sphene, and calcite. Section is cut by a cm-wide vein of plagioclase, antiperthite, magnetite, pyrite, diopside, calcite, epidote, garnet. Section overall contains 15-20% magnetite and 10% pyrite, which are complexly intergrown. (216.5-220.0) Hornblende porphyry (lamprophyre) dike with 2-5mm hornblende lineated parallel to intrusive contacts. Aphanitic dark gray to pink groundmass. Thin section of this porphyry shows euhedral hornblende crystals in a fine-grained matrix of flow-lineated acicular actinolitic hornblende and equant feldspar. Secondary epidote is common, and blocky oxides approach phenocryst size. Approximate mode of 17% hornblende, 17% actinolitic hornblende, 53% groundmass of feldspar plus possible feldspathoids, 8% epidote, 4% sphene/leucoxene, 1% oxides, trace apatite.
- 356-385.5 Metabasalt, schistose, medium to dark greenish-gray, aphanitic to fine-grained. Contains amygdules and strongly lineated hornblende crystals. Unit is bounded by sharp (depositional) contacts.
- 385.5-414.3 Metabasalt, medium greenish-gray, aphanitic to fine-grained and pyritic.
- 414.3-488.2 Metabasalt, fine- to medium- grained, amphibolitic, very epidotized. Locally contains as much as 30% lineated amphibole. Thin sections at 454, 467 ft. show amphibolitic, lineated, ferruginous metabasalt with abundant oxides and pyrite, relict amygdules. Three generations of veining exist, consisting (earliest to latest) of pygmatic veins of coarse, blocky plagioclase, sphene, and abundant pyrite in the vein and wall rock; straight, brittle fractures along which amphibole has been leached from wall rock; and late veins of epidote ± plagioclase which occupy brittle veins. Approximate mode of 45-60% felty hornblende, 5-20% plagioclase, 7-12% opaques, 10-40% epidote, trace sphene and calcite.
- 488.2-494 No Recovery.

CHEMICAL DATA

Rock Type Analyzed: Metabasalt

Sample Depth:	<u>454</u>	<u>182</u>	<u>210</u>	<u>258</u>	<u>454</u>	<u>467</u>		
<u>Major Elements</u> (wt. % oxides)		<u>Minor Elements</u> (ppm)	<u>Minor Elements (ppm)</u>					
SiO <sub>2</sub>	48.5	Cl <50	Ag	0.096	<0.015	0.113	0.124	0.086
Al <sub>2</sub> O <sub>3</sub>	13.1	Cr 64	As	<0.984	1.63	<0.926	2.43	0.951
CaO	9.83	Rb 39	Au	<0.049	<0.049	<0.046	<0.046	<0.047
MgO	5.14	Sr 293	Cu	110.	277.	239.	95.7	47.6
Na <sub>2</sub> O	2.61	Y 30	Hg	<0.098	<0.099	<0.093	<0.092	<0.094
K <sub>2</sub> O	0.35	Zr 75	Mo	0.595	0.395	0.637	2.08	1.54
(Fe <sub>2</sub> O <sub>3</sub> )	(6.31)	Nb 14	Pb	11.9	22.7	21.2	21.8	10.6
FeO	9.8	Ba 99	Sb	<0.246	<0.247	0.391	0.499	<0.236
MnO	0.28		Tl	<0.492	1.81	0.624	<0.46	<0.472
TiO <sub>2</sub>	1.50		Zn	84.4	262.	128.	66.7	46.9
P <sub>2</sub> O <sub>5</sub>	0.13		Bi	<0.246	<0.247	<0.231	<0.23	<0.236
H <sub>2</sub> O <sup>+</sup>	1.3		Cd	<0.098	<0.099	0.152	0.124	0.190
CO <sub>2</sub>	0.03		Ga	2.88	18.0	5.51	3.54	2.01
S	0.27		Pd	<0.492	<0.493	<0.463	<0.46	<0.472
LOI	1.54		Se	<0.984	<0.986	<0.926	<0.919	<0.943
Total	100.3		Te	<0.492	<0.493	<0.463	<0.46	<0.472
Total iron as Fe <sub>2</sub> O <sub>3</sub>	17.2							

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
140-190	0.1-0.6 (chert/phyllite 0.002-0.05)
190-207.8	2.0-5.5
207.8-240	0.1-1.0 (porphyry at 216.5-221 = 0.1)
240-274	1.0-11.1, variable
274-290	0.1-0.2 (epidote ± sericite zone)
290-356	1.5-9.5, variable
356-385.5	2.5-0.4, decreases downward
385.5-414.3	1.5-0.2, decreases downward
414.3-440-	variable 0.8-3.5
440-455	0.1-0.3
455-470	1.4-6.5, increases downward
470-488	1.9-2.7, increases downward

DENSITY

Depth	Density
Not determined	



Field number KDH-4

Date completed 2-12-89

MGS unique number 241893

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 26 148-27-11 DDCCB

County Itasca

Quadrangle Wirt 7.5'

HOLE PARAMETERS (feet)

Surface elevation 1430

Total depth 558

HOLE ORIENTATION (degrees)

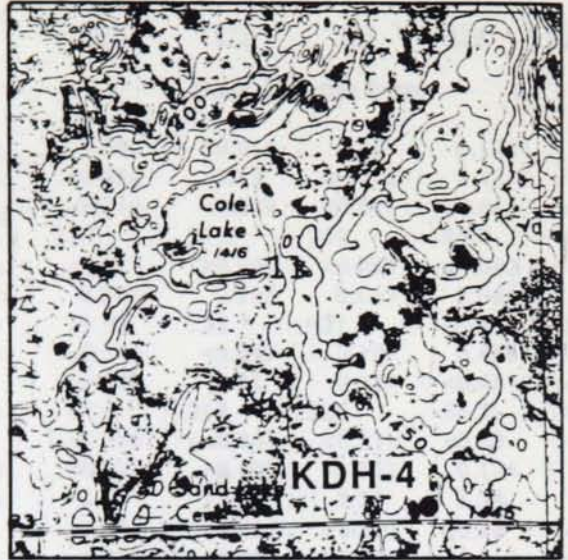
Azimuth S 45 E

Inclination -60

Elevation, top of  
Precambrian rock 1123

Core interval 307-558

Percent recovery 100



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-4	Clay
4-8	Sand
8-11	Clay
11-80	Sandy till, gray, contains clasts of carbonate, mafic, and granitic rocks. Boulders at 60-65, 67-70 ft.
80-307	Sand and cobbles, random thin layers of gray silt and clay. Silty sand, reddish-brown to light gray in color.
REGOLITH ON PRECAMBRIAN ROCK	
No regolith noted.	
SOUND PRECAMBRIAN ROCK	
307-558	Metagraywacke

## PETROGRAPHIC DESCRIPTION OF CORE: KDH-4

Principal rock type: Metagraywacke

Mineralogy: Core is dominantly gray to slightly greenish-gray, fine-grained, schistose meta-graywacke and argillite (biotite ± sericite in a vitreous quartzofeldspathic matrix) which is locally sheared and brecciated and intruded by thin intervals of pinkish-gray, fine-grained intermediate to mafic igneous rock. The graywacke/argillite is very massive and contains no obvious bedding contacts. Foliation and shear fabric are 0-5° to core axis, therefore dip about 60° from horizontal (strike is assumed NE-SW from aeromagnetic maps). Bedding is apparently foliation-parallel. The graywacke/argillite is cut by a myriad of variously oriented tight brittle chlorite-lined fractures which have a mm-wide zone of bleached and sericitized rock on either side. Red feldspar alteration is locally developed in a similiar fashion, culminating at 423-424 ft., where quartz - K-feldspar - carbonate - tourmaline veins occur in brecciated rock. Sulfides, consisting of minor pyrite, chalcopyrite, and pyrrhotite are sparsely disseminated throughout rock and concentrated slightly into brittle chloritized shear zones and late fractures. Thin, late quartz-carbonate veins are generally parallel to core axis but oblique to foliation. The intrusive units are foliated and sheared along contacts, which are steeply dipping and presumably parallel to bedding. Sieve-textured staurolite is abundant near the bottom of the core, also possible garnet and cordierite which are pseudomorphed by sericite and chlorite.

## CHEMICAL DATA

Rock Type Analyzed: Metagraywacke with pyrite, chalcopyrite, 419 ft.; metagraywacke with quartz-carbonate-tourmaline veins, 423 ft.; gray siliceous metagraywacke with 1% or more pyrite and chalcopyrite, 481 ft.

<u>Sample Depth</u>	<u>419</u>	<u>423</u>	<u>481</u>
<u>Minor Elements (ppm)</u>			
Ag	0.161	0.043	0.340
As	<0.954	<0.992	2.28
Au	0.007	0.003	0.007
Cu	158.	7.28	159.
Hg	<0.095	<0.099	<0.095
Mo	0.653	0.960	2.41
Pb	1.69	3.01	2.08
Sb	<0.239	<0.248	0.350
Tl	<0.477	<0.496	<0.475
Zn	190.	78.8	400.
Bi	0.521	<0.248	0.528
Cd	0.266	0.260	1.13
Ga	7.04	3.27	5.18
Pd	<0.477	<0.496	<0.475
Se	<0.954	<0.992	<0.951
Te	<0.477	<0.496	<0.475

## MAGNETIC SUSCEPTIBILITY (depths in feet).

Generally 0.1-0.3, except in local intervals of magnetite concentration along shear planes, as at 386 ft., where susceptibility is as high as 3.10.

## DENSITY

Depth            Density  
Not determined

Field number KDH-5

Date completed 2-16-89

MGS unique number 241894

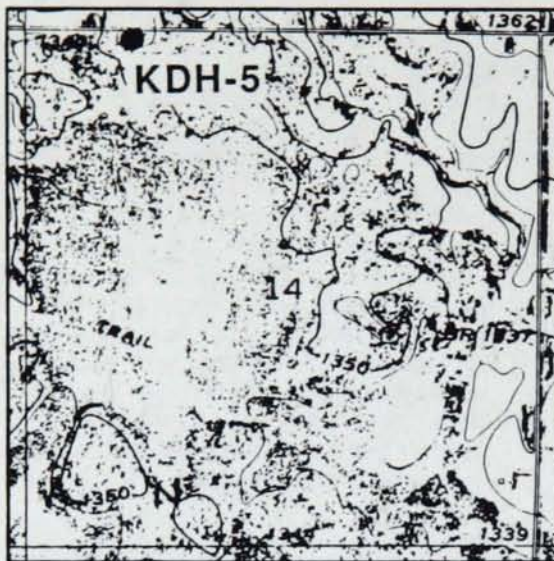
MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 150-27-14 BBABAD

County Itasca

Quadrangle Coddington Lake 7.5'



HOLE PARAMETERS (feet)

Surface elevation 1355

Total depth 614

HOLE ORIENTATION (degrees)

Azimuth Due North

Inclination -60

Elevation, top of  
Precambrian rock 1074

Core interval 281-614

Percent recovery 95

ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-28	Clay
28-50	Silty sand, gray, gravel in top 2 ft.
50-272	Till, gray, contains clasts of carbonate, scattered cobbles and boulders. Sand and cobbles, random thin layers of gray silt and clay.
REGOLITH ON PRECAMBRIAN ROCK	
272-281	Regolith, consists of bluish-green clay with chunks of crumbly feldspar; possibly reworked into overlying till.
SOUND PRECAMBRIAN ROCK	
281-614	Mylonite, of granitic protolith.

PETROGRAPHIC DESCRIPTION OF CORE: KDH-5

Principal rock type: Mylonite

Mineralogy: Rock consists of mylonite to ultramylonite (phyllonite) which is developed from granitoid and possibly gabbroic to ultramafic rock protoliths. Foliation is generally 10° to 15° to core axis. The most intensely deformed portion of the core is essentially a quartz-sericite-Mg chlorite schist, but it can be proven by tracing through progressive deformation that the protolith is a plutonic rock type. Sulfides consist of relatively sparse disseminated pyrite, also rare native Cu along some shear planes. Foliation dips approximately 60° north, and shear lineation plunges approximately 60° east. Upper portion of core is saprolitic, gradually grades into fresh rock. Calcite, epidote, and minor pyrite occur in thin, late veins of varying orientation (upper portion), lower portion contains very deformed veins and pods of quartz and tremolite and layers of phlogopite.

- 281-341 Mottled, streaky pink - yellowish-brown - white clay-rich saprolite. Lower portion contains blue quartz, macroscopically shows texture of strongly sheared gabbro or granodiorite. Thin section at 337 ft. consists dominantly of quartz, chlorite, sericite, and tremolite, the last of which forms neoblastic prisms in chlorite.
- 341-371 Ribbon-textured mylonite with much blue quartz, local zones of pseudotachylite and thin zones of ultramylonite. Minor native Cu present near 351 ft.
- 371-385 Mylonite with abundant oxides, no visible quartz. Contains pyrite, relict feldspar, 6-8% blocky hematite after magnetite, and actinolite. Quartz and lesser pyrite occur in deformed veins. Local relict igneous texture present. Thin section at 372 ft. is predominantly fibrous actinolite, granular epidote, chlorite, pods of deformed vein quartz.
- 385-400 Ultramylonite with abundant quartz and sphene or leucosene. Contains abundant fine-grained disseminated pyrite, has local relict medium-grained igneous texture, and local pseudotachylite.
- 400-409 Possible mylonitized quartz porphyry (?), with blocky pyrite along brittle shear-like fractures. Includes a fine-grained rock of basaltic appearance 404-406 ft.
- 409-424 Phyllonite to mylonite containing actinolite, sphene, blue quartz, orange streaks from oxidized pyrite, and elliptical pods of deformed vein quartz.
- 424-464 Light greenish-gray to tan, crenulated, uniform phyllonite/ultramylonite. Minor blue quartz visible in upper portion, sphene is also abundant where blue quartz is visible. Weakly banded in appearance below 440 ft. Fine-grained relict quartz and sphene are visible in the coarser-grained bands. Contains abundant cm-sized elliptical pods of deformed vein quartz, and local deformed pods of felty tremolite. Thin sections from this interval show colorless Mg-chlorite and quartz to be dominant; sericite and feldspar are locally abundant. At 552 ft. is a 6-inch interval of phlogopite schist which contains plagioclase clots and minor rutile; this is perhaps a more K-rich variant of the Mg-chlorite schist.

CHEMICAL DATA

Rock Type Analyzed: Mylonitized gabbro, 372 ft.; mylonite; 463 ft.

Sample Depth      372                      463

Minor Elements (ppm)

Ag	0.436	0.03
As	<0.998	<0.952
Au	0.004	0.001
Cu	641.	6.26
Hg	<0.1	<0.095
Mo	0.851	0.267
Pb	0.538	0.369
Sb	<0.25	<0.238
Tl	<0.499	<0.476
Zn	7.85	5.41
Bi	<0.25	>0.238
Cd	<0.1	<0.095
Ga	2.22	1.44
Pd	<0.499	<0.476
Se	<0.998	<0.952
Te	<0.499	<0.476

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
371-385	0.19-0.76 (probable gabbroic protolith)
385-400	0.00-0.17 (probable granitic protolith)
No other intervals tested.	

DENSITY

Depth	Density
Not determined	





Field number KDH-6

Date completed 2-24-89

MGS unique number 241895

MGS lab number

LOCATION (see map at right)

T-R-S 152-28-17 CCDCDD

County Koochiching

Quadrangle Northome North 7.5'

HOLE PARAMETERS (feet)

Surface elevation 1352

Total depth 520

HOLE ORIENTATION (degrees)

Azimuth S 17 E

Inclination -60

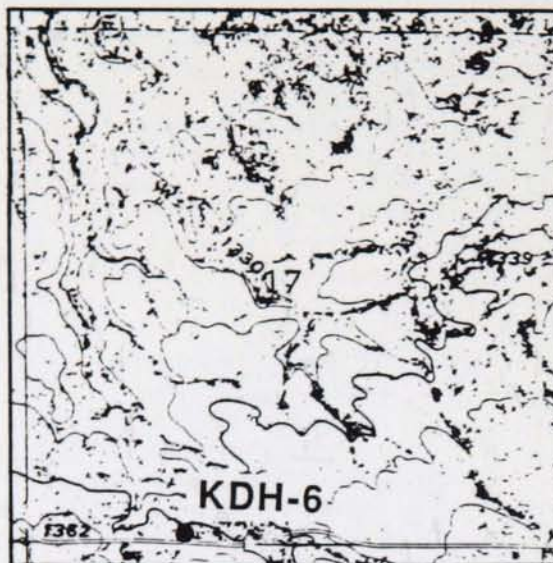
Elevation, top of  
Precambrian rock 1140

Core interval 212-274

Percent recovery 70

Core interval 274-520

Percent recovery 100



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-26	Sandy till, yellowish-brown, contains clasts of carbonate, granite, mafic rocks.
26-212	Sandy till, gray, lithologically equivalent to above.
REGOLITH ON PRECAMBRIAN ROCK	
None encountered.	
SOUND PRECAMBRIAN ROCK	
212-520	Mylonitized to massive and undeformed ferrodiorite.

## PETROGRAPHIC DESCRIPTION OF CORE: KDH-6

Principal rock type: Mylonitized to massive and undeformed ferrodiorite.

Mineralogy: Rock consists of a coarse, decussate, prismatic, melanocratic ferrodiorite at the base which becomes progressively more sheared uphole to an ultramylonite, then back into sheared diorite. The ultramylonite zone is partially banded by layers rich in quartz and feldspar, sulfides, and fine-grained micaceous schist. Just above this is a thick quartz-feldspar vein, suggestive that flood veining preceded shearing and those parts of the vein caught in shearing resulted in the striped green-red-white appearance of the mylonite.

- 210-320 Phyllitic (mylonite) schist. Contains chlorite, sericite, local weathered-out pyrite, carbonate clots. Upper part is saprolitic.
- 320-358 Similar to above, but begin to see pygmatically folded quartz-carbonate veins at a high angle to foliation. Rock contains very fine, blocky, disseminated Cu-sulfides (?). Abundant sphene near 350 ft. Massive quartz and feldspar veining near bottom of interval.
- 358-407 Green, red, and white banded ultramylonite. Contains cm-thick layers of pyrite zones, as at 357 ft. Fine-grained sphene or leucoxene is visible, most abundant in darker layers. Also contains disseminated pyrite, pyrrhotite, chalcopyrite near 407 ft. Thin section at 373 ft. contains approximately 43% sericite, 35% carbonate, 20% quartz, 2% sphene, leucoxene, or hematite. Carbonate in this interval varies from fine-grained groundmass to rhombohedrons which are overprinted onto preexisting mylonite. Oxides occur as granular elongate masses which commonly retain some hint of their pre-shear skeletal nature.
- 407-446 Mylonitized (upper) ferrodiorite, deformation decreases with depth. Skeletal oxide pseudomorphs (see below) provide good indicators of shear, ranging from broken and flat to only slightly squeezed. Carbonate veins and pervasive orange ankerite alteration abundant in upper part of interval; quartz occupies larger veins with carbonate. Veins are pre- to syndeformation.
- 446-492.5 Massive ferrodiorite, medium-coarse grained, dark green, prismatic, decussate. Plagioclase forms laths up to 1 cm long, is heavily saussuritized and rimmed by myrmekitic quartz/feldspar. Primary hornblende occurs as prismatic crystals up to 2 cm long and is moderately altered to chlorite. Black skeletal magnetic oxides (magnetite plus ilmenite) up to 1cm across are variably altered to gray sphene/leucoxene. Rounded glassy quartz is macroscopically visible only on fresh face. Undeformed veins of carbonate-quartz ± epidote are dominantly at 45° to 90° to core axis. Approximate thin section mode of 44% plagioclase, 36% chlorite, 8% hornblende, 8% quartz, 2% Fe-Ti oxides (primary and secondary), 1% apatite, 1% epidote not as feldspar alteration.
- 492.5-503 Diabase, medium-grained, massive, darker than above, but otherwise similar.
- 503-520 Sheared ferrodiorite.

CHEMICAL DATA

Rock Type Analyzed: Banded red and green fault rock, 375 and 382 ft., the former with a 3mm-thick layer of massive pyrite, the latter with disseminated pyrite and chalcopyrite..

Sample Depth      375                      382

Minor Elements (ppm)

Ag	0.267	0.193
As	41.6	187.
Au	0.002	0.001
Cu	140.	1180
Hg	<0.095	<0.094
Mo	0.687	0.597
Pb	3.04	0.718
Sb	1.19	0.932
Tl	<0.474	<0.471
Zn	57.4	81.1
Bi	<0.237	<0.235
Cd	<0.095	0.105
Ga	1.33	4.42
Pd	<0.474	<0.471
Se	2.36	2.08
Te	<0.474	<0.471

MAGNETIC SUSCEPTIBILITY (depths in feet).

Depth	Reading( x 10 <sup>-3</sup> cgs units)
462-492	2.1-3.5 (undeformed ferrodiorite)

DENSITY

Depth	Density
Not determined	



Field number KDH-7

Date completed 2-28-89

MGS unique number 241896

MGS lab number \_\_\_\_\_

LOCATION (see map at right)

T-R-S 148-30-10 BABAAA

County Beltrami

Quadrangle Decker Lake 7.5'

HOLE PARAMETERS (feet)

Surface elevation 1367

Total depth 460

HOLE ORIENTATION (degrees)

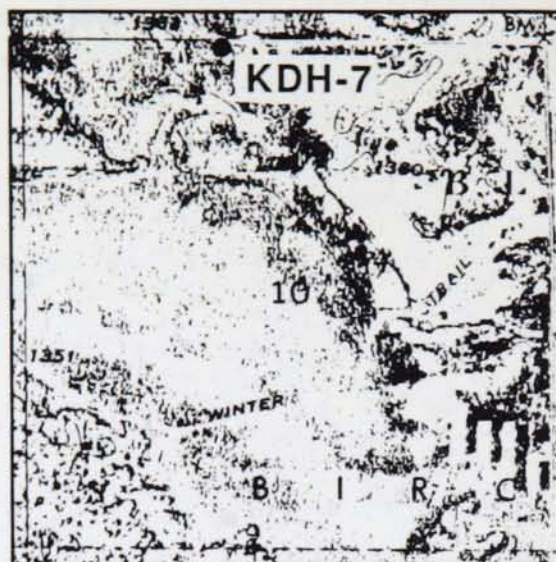
Azimuth Due North

Inclination - 60

Elevation, top of  
Precambrian rock S 45 E

Core interval 268-460

Percent recovery 100



ABBREVIATED LITHOLOGIC LOG (intervals recorded are depths in feet)

Interval	Description
QUATERNARY DEPOSITS	
0-33	Loamy sand, brownish-gray.
33-36	Gravel.
36-40	Clay
40-60	Clay and sand mixed with gravel.
60-92	Sand and gravel.
92-117	Hard clay.
117-268	Sand and gravel with minor interlayered clay.

REGOLITH ON PRECAMBRIAN ROCK

None encountered.

SOUND PRECAMBRIAN ROCK

268-460 Fine-grained to aphanitic diabase.

## PETROGRAPHIC DESCRIPTION OF CORE: KDH-7

Principal rock type: Diabase, fine-grained to aphanitic.

Mineralogy: Rock is dark greenish-black, fine-grained to aphanitic diabase, locally porphyritic. Portions of core appear siliceous, in one case silicified, in the other quartz-phyric and probably a more quartz-rich variant of the diabase. Pervasively veined by thin quartz-carbonate, minor epidote veins which commonly have a silicified rim. These veins are 1-2mm thick, occupy late brittle fractures at 45° to 90° to core axis.

- 268-351 Dark green, fine-grained metadiabase, veined, weakly porphyritic. Approximate mode of 40-60% hornblende, 40-60% plagioclase, trace quartz, pyrite, chalcopyrite, galena.
- 351-352 Rubbly or brecciated intrusive contact; 4 - 6cm rounded blocks of diabase porphyry as below in a matrix of fine-grained quartz, chlorite, and "saussurite."
- 352-372 Porphyritic diabase, aphanitic diabase, and thin chilled dikelets of diabase intermixed. This section at 357 ft. in shows decussate, ragged green hornblende and scattered plagioclase phenocrysts in a groundmass of fine-grained, anhedral, sericitized plagioclase. A trace of euhedral apatite is present. Approximate mode of 55% plagioclase, 43% hornblende, 2% oxides, trace of quartz, apatite, calcite, epidote.
- 372-383 Silicified(?) fine-grained diabase. Thin section at 376 ft. suggests this interval is a chilled dike rock of tonalitic-andesitic composition which has been retrograde-metamorphosed but still shows fine-grained, primary decussate texture. Feldspar is heavily sericitized. Approximate mode of 75% plagioclase (including alteration products), 8% quartz, 7% epidote, 5% hornblende, 3% chlorite, 2% biotite, trace opaques.
- 383-399 Fine-grained phaneritic diabase, increases in grain size with depth.
- 399-405 Diabase with chilled top and bottom.
- 405-423 Fine-grained diabase with felty plagioclase, non-porphyritic. Thin section at 411 ft. shows rock to be very similar to that at 357 ft.
- 423-432 Porphyritic diabase or diorite. Contains xenocrysts(?) of blue quartz. Chilled upper contact, lower 2 ft. is chilled dikelet.
- 432-437 Possible basaltic xenolith.
- 437-450 Fine-grained diabase with felty plagioclase.
- 450-460 Fine-grained diabase with chilled upper contact.

## CHEMICAL DATA

Rock Type Analyzed: Brecciated diabase, 419.5 ft.

### Minor Elements (ppm)

Ag	0.057
As	3.50
Au	0.003
Cu	62.7
Hg	<0.1
Mo	0.658
Pb	0.661
Sb	0.570
Tl	<0.499
Zn	47.0
Bi	<0.25
Cd	<0.1
Ga	4.54
Pd	<0.499
Se	<0.998
Te	<0.499

Magnetic susceptibility and density not determined.

APPENDIX A. PRINCIPAL FACTS FOR SCIENTIFIC TEST HOLES DRILLED IN PARTS OF KOOCHICHING, ITASCA, AND BELTRAMI COUNTIES BY THE MINNESOTA GEOLOGICAL SURVEY, 1987-1989.

BELTRAMI COUNTY

Hole No.	Township-Range-Sec. <sup>(1)</sup>	Az <sup>(2)</sup>	Drift <sup>(3)</sup> thickness	Regolith thickness	Sound rock drilled	Sound rock cored	Total depth	Rock types <sup>(4)</sup>
KDH-7	148-30-10 BABAAA	S45E	268	0	0	192	460	Fine-grained diabase, locally quartz-bearing.
KIB-77	149-30-23 ADADCD	V	355	139	7	11	512	Massive hornblende granodiorite.
KIB-79	149-30-29 ADAAD	V	335	5	1	11	352	Weakly foliated hornblende granodiorite.
KIB-76	149-31-30 DCCDC	V	369	44	3	11	427	Sheared volcanic conglomerate.
KIB-81	149-31-34 ADABBB	V	362	24	3	10	399	Metabasalt cut by felsic intrusion.
KIB-74	150-30-8 DDDDA	V	218	32	3	11	264	Foliated granitic rock cut by mafic dike.
KIB-73	151-30-27 DDDBAAA	V	238	0	4	11	253	•Diabase in contact with mafic schist.
KIB-70	151-31-24 DAA	V	192	25	6	10	233	Meta-volcaniclastic argillite and siltstone.
KIB-68	151-32-13 CBBCCB	V	152	157	23	10	342	Lineated quartz diorite.
KIB-64	152-30-11 BAAAA	V	301	145	1	3.9	450.9	Felsic tuff/volcanogenic graywacke.
KIB-71	152-32-25 DDAABA	V	230	2	2.3	10	244.3	Sheared metagabbro.
KIB-69	153-30-19 CCCC	V	157.5	17.5	0.5	10	185.5	Metagraywacke (biotite schist).
KIB-65	154-30-35 CDCDD	V	127	0	6	10.5	143.5	Metagraywacke (hornblende-garnet-biotite schist).

ITASCA COUNTY

KIB-4	60-23-3 DAADD	V	78	87	8	10	183	Mafic to intermediate volcanic breccia.
KIB-5B	60-24-36 ADBcenter	V	127	20	7	10	164	Trondhjemite.
KDH-2	60-25-36 BAAABB	N0W	128	12	1	353	494	Metabasalt, hornblende porphyry intrusions.
KIB-7	60-26-20 BABAA	V	198	12	4.9	10	224.9	Granite.
KIB-49	60-26-23 DDDDDA	V	42	5	11	10	68	Volcaniclastic metagraywacke.



## APPENDIX A, CONTINUED

## ITASCA COUNTY, CONTINUED

Hole No.	Township-Range-Sec. <sup>(1)</sup>	Az <sup>(2)</sup>	Drift <sup>(3)</sup> thickness	Regolith thickness	Sound rock drilled	Sound rock cored	Total depth	Rock types <sup>(4)</sup>
KIB-2	61-22-15 AABBBB	V	49	0	14	10	73	Tuffaceous metagraywacke.
KIB-1	61-22-36 DABACC	V	106	0	8	8	122	Garnet, biotite schist (meta-crystal tuff)
KIB-6	61-25-36 ABCC	V	15	0	18.3	10	43.3	Garnet-bearing syenite.
KIB-11	61-26-10 AADDD	V	50	10	11	10	81	Meta-basalt/andesite.
KIB-8	61-26-13 CCB BB	V	57	0	9	6.5	72.5	Leucotonalite.
KIB-9	61-26-28 AAACAA	V	119	154 <sup>+</sup>	0	0	273	Felsic-intermediate schist (metavolcanic).
KIB-10	61-26-29 BBAAA	V	81	3	5	10	99	Quartz-bearing diabase.
KIB-3B	62-23-14 DDDD	V	181	6	9	23	219	Graywacke, minor argillite and conglomerate.
KIB-18	62-24-35 DBBB	V	168	191	0	16	375	Altered felsic-intermediate crystal tuff.
KIB-13	62-25-33 CBBBBB	V	69	0	0	56	125	Meta-andesite and felsic breccia.
KIB-12	62-26-24 AADDDD	V	145	15	7	10	177	Leucogranodiorite.
KIB-39	148-25-9 BBCBBB	V	149	0	16	4	169	Pyroxene monzonite.
KIB-40	148-25-15 CCCA	V	243	37	17	8	305	Hornblende monzonite/monzodiorite.
KDH-4	148-26-11 DDCCB	S45E	307	0	0	251	558	Metagraywacke, argillite, intermediate sills.
KIB-41	148-26-11 DDCCC	V	153	115	7	6	281	Phyllitic schist (meta-intermediate volcanic).
KIB-50	148-27-11 BADDD	V	160	135	0	6.5	301.5	Quartz monzonite, quartz diorite.
KIB-51	148-28-12 ABBDC	V	84	182	7	10	283	Meta-quartz diorite.

## FOOTNOTES:

(1) All township numbers are north, ranges are west. See introduction for explanation of ABCD quartering system

(2) Azimuth; KIB holes are all drilled vertically (noted as V); KDH holes are drilled at about 60° in the direction given.

(3) Measurements given in feet.

(4) See Table A-2 geochemical analyses. Rock type determined from cuttings if core length is reported as 0 feet.

APPENDIX A, CONTINUED.

ITASCA COUNTY, CONTINUED

Hole No.	Township-Range-Sec. <sup>(1)</sup>	Az <sup>(2)</sup>	Drift <sup>(3)</sup> thickness	Regolith thickness	Sound rock drilled	Sound rock cored	Total depth	Rock types <sup>(4)</sup>
KIB-35	149-25-3 ABBBB	V	193	147	20	0	360	Pink granite.
KIB-38	149-25-31 AAAA	V	197	68	3	0	268	Hornblende granite.
KIB-37	149-26-23 BDA	V	110	110	0	2.5	225.5	Meta-(quartz)diorite.
KIB-48	149-26-28 CBBB	V	125	35 (?)	0	0	160	Granite (?).
KIB-52	149-28-27 CCA	V	55	198	0	10	263	Quartz diorite.
KIB-47	150-26-4 ADADDDD	V	129.5	360.5	0	0	490	Hornblende-biotite schist, granitic stringers.
KDH-5	150-27-14 BBABAD	N	272	9	39	294	614	Mylonitized granodiorite, gabbro (?).
KIB-54	150-27-17 CAACDC	V	170	63	0	10	243	Metabasalt.
KIB-55	150-29-10 BABAAA	V	103	338	0		441	UNKNOWN
KIB-53	160-28-29 CDBAAA	V	111	48	7	10	176	Biotite schist, tonalite, diabase, phyllite.

KOOCHICHING COUNTY

KIB-16	63-24-16 BABD	V	226	56	6	0	288	Tonalite.	
KIB-14	63-24-29 ABDD	V	186	110	24	0	320	Granitic rock (?).	
KIB-26	63-25-7 ABCCC	V	90	10	0	10	110	Syenite.	
KIB-23	63-25-14 DBcenter	V	120+	-----UNKNOWN-----					
KIB-24	63-25-15 CDA	V	134	206	20	0	360	Tonalite/granodiorite.	
KIB-32	63-27-26 BDCDDD	V	67	38	0	2.5	107.5	Biotite schist (metagraywacke).	
KIB-21	64-24-24 BABB	V	223	77	15	0	315	Volcanogenic metagraywacke.	

Table A-1, continued.

## KOOCHICHING COUNTY, CONTINUED

Hole No.	Township-Range-Sec. <sup>(1)</sup>	Az <sup>(2)</sup>	Drift <sup>(3)</sup> thickness	Regolith thickness	Sound rock drilled	Sound rock cored	Total depth	Rock types <sup>(4)</sup>
KDH-1	64-24-24 BABB	N10E	269	41	10	181	501	Metagraywacke (biotite schist).
KIB-20	64-24-24 DADB	V	191	29	16	10	246	Metaarkose cut by granite stringers.
KIB-19	64-24-25 DDA	V	68	0	3	10	81	Meta-mafic tuff or flow.
KIB-17	64-24-36 DACB	V	22	0	1.3	8.7	31	Sheared metabasalt.
KIB-17	64-24-36 DACB	V	22	0	1.3	8.7	31	Sheared metabasalt.
KIB-46	64-27-36 BBCAAD	V	170	3	9	9.5	191.5	Foliated quartz diorite.
KIB-30	65-26-21 DCCABB	V	216	4	11	10	241	Brecciated metagraywacke.
KIB-45	151-25-20 DCCD	V	145	14	0	11	170	Foliated quartz diorite.
KIB-57	151-28-1 CBBCC	V	60	4	4	10	78	Massive metadiabase.
KIB-56	151-28-16 DAAAA	V	72	12	0	8.7	92.7	Volcaniclastic metagraywacke.
KIB-59	152-26-21 AABB	V	130	50	0	0	180	Gabbro or diorite.
KIB-61	152-28-4 DCBCD	V	80	?	0	0	80	UNKNOWN
KIB-62	152-28-17 CCCC	V	96	304+	0	0	400	UNKNOWN
KDH-6	152-28-17 CCDCDD	S17E	212	0	6	302	520	Massive to mylonitized ferrodiorite.
KIB-63	152-28-32 CBAAB	V	203	0	13	0	216	Mafic schist, granodiorite gneiss.
KIB-60	152-29-32 DAB	V	339	4	0.8	3	346.8	Tonalite.
KIB-43B	153-27-31 DBCA	V	38	396	2	6	442	Felsic lithic-crystal tuff.
KIB-66	155-29-21 CBBB	V	72	0.5	4.5	9	86	Granitic gneiss.
KIB-67	156-29-35 ACACAA	V	164	173	3	10	350	Quartz diorite gneiss.

## FOOTNOTES:

(1) All township numbers are north, ranges are west. See introduction for explanation of ABCD quartering system

(2) Azimuth; KIB holes are all drilled vertically (noted as V); KDH holes are drilled at about 60° in the direction given.

(3) Measurements given in feet.

(4) See Table A-2 geochemical analyses. Rock type determined from cuttings if core length is reported as 0 feet.

APPENDIX B. MAJOR-ELEMENT AND SELECTED MINOR-ELEMENT GEOCHEMICAL DATA FOR BEDROCK DRILL-CORE SAMPLES.

Sample Number	Sample Depth	Rock type	Major Elements (Wt % oxides)														Minor Elements (ppm)										
			SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	MgO	Na <sub>2</sub> O	K <sub>2</sub> O	Fe <sub>2</sub> O <sub>3</sub> C	FeO	MnO	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	H <sub>2</sub> O+	CO <sub>2</sub>	S	LOI	Sum	Fe <sub>2</sub> O <sub>3</sub> T	Cl	Cr	Rb	Sr	Y	Zr	Nb	Ba
KIB-4	176.4-176.7	Andesite Agglomerate	62.5	14.7	3.87	3.84	4.26	0.32	1.11	5.0	0.11	0.58	0.11	2.2	0.52	0.02	2.62	99.7	6.67	50	106	<10	201	33	107	22	120
KIB-5B	158-158.3	Trondhjemite	72.8	15.5	2.57	0.37	6.41	0.98	0.31	0.5	0.03	0.13	0.05	0.3	0.01	0	0.54	100.4	0.87	30	19	28	539	<10	31	10	479
KIB-6	34.6-35	Syenite	57.7	17.8	5.45	0.42	5.75	5.80	2.38	0.3	0.07	0.26	0.11	1.4	0.59	0	2.77	99.6	2.71	150	<10	100	3700	81	64	15	2530
KIB-7	218.6-218.8	Granite	69.7	15.7	1.87	0.51	5.67	3.51	1.39	0.4	0.04	0.20	0.09	0.7	0.01	0	0.70	100.2	1.84	50	22	165	1210	<10	90	<10	1340
KIB-11	71-71.4	Altered Basalt	56.0	15.6	7.70	3.84	3.24	0.70	1.88	7.1	0.16	0.92	0.15	1.2	0.20	0	1.08	99.2	9.77	50	49	27	215	19	78	15	124
KIB-12	174.7-175	Leucogranodiorite	71.4	14.8	2.13	0.39	4.62	3.51	0.74	0.4	0.04	0.13	0.05	0.5	0.02	0	0.70	99.1	1.18	<50	14	101	588	<10	25	17	494
KIB-13	84-84.4	Basalt	50.5	16.1	5.61	8.15	3.75	0.74	2.48	7.4	0.19	0.71	0.32	3.3	0.22	0.01	3.47	100.3	10.7	50	177	28	92	21	73	<10	302
KIB-13	120	Felsic volcanic clast	81.7	7.22	5.96	0.34	0.38	0.33	2.26	0.2	0.04	0.28	0.05	0.3	0.31	0.05	1.08	99.9	2.48	160	32	31	175	26	216	13	135
KIB-17	30.3-30.7	Metabasalt	47.6	13.2	11.6	4.13	1.82	0.27	2.61	11.6	0.31	1.35	0.13	0.7	2.59	0.09	2.31	98.3	15.5	150	106	17	70	31	74	12	61
KIB-19	71.2-71.4	Metabasalt	51.4	14.5	9.56	6.32	2.92	1.17	3.49	7.3	0.33	0.96	0.10	0.9	0.03	0	0.77	99.8	11.6	100	519	66	126	23	48	12	204
KIB-26	100.6	Quartz Monzonite	59.8	17.7	6.34	2.58	4.96	1.58	3.25	2.1	0.10	0.56	0.27	1.0	0.02	0.04	0.54	100.2	5.58	100	17	45	1260	<10	66	19	626
KIB-30	237	Metagraywacke	64.8	14.3	1.56	3.00	1.37	3.57	1.77	4.8	0.11	0.63	0.16	1.9	<0.01	0.27	2.77	99.6	7.10	<50	213	154	313	13	130	16	904
KIB-37	221.5	Meta-(quartz)diorite	53.5	17.2	8.35	5.20	2.79	0.59	2.87	4.7	0.12	0.55	0.07	2.3	0.07	0.03	2.54	99.1	8.09	50	72	32	252	12	24	<10	148
KIB-39	168-168.3	Pyroxene Monzonite	60.2	17.2	3.55	1.85	6.30	4.40	2.83	1.0	0.08	0.42	0.32	0.5	0.02	0	1.00	99.8	3.94	50	36	129	2180	17	253	14	1970
KIB-40	299.3-299.6	Monzonite	63.9	17.4	2.16	1.28	6.13	4.47	2.21	1.0	0.07	0.35	0.18	0.4	0.01	0	0.77	100.4	3.32	<50	26	135	1340	41	303	14	1470
KIB-45	167	Diorite	59.2	18.4	6.50	2.41	5.96	0.89	1.82	2.3	0.07	0.55	0.20	0.2	0.24	0.01	0.77	99.5	4.38	50	25	25	1140	<10	67	17	339
KIB-46	187	Quartz Diorite	64.0	17.6	5.52	1.72	5.32	1.51	1.92	1.3	0.06	0.41	0.16	0.5	0.03	0	0.23	100.1	3.36	100	21	47	1030	25	76	13	44
KIB-49	59	Felsic Tuff	62.4	15.5	4.78	3.74	4.56	1.33	0.91	4.4	0.09	0.61	0.16	1.2	0.08	0.08	0.85	100.0	5.80	50	265	57	631	16	60	<10	473
KIB-50	296.3	Quartz Diorite	60.8	17.6	4.85	1.35	4.98	1.21	3.97	3.0	0.13	0.97	0.17	1.5	0.07	0.01	0.77	100.2	7.3	150	<10	55	394	10	141	15	307
KIB-51	281.4	Quartz Diorite	58.3	16.2	7.64	4.96	3.05	0.95	1.75	4.8	0.12	0.58	0.11	1.2	0.06	0.01	1.47	100.6	7.08	200	169	23	273	<10	64	17	205
KIB-52	257.7	Quartz Diorite	54.3	16.8	8.34	4.31	2.75	1.17	3.06	5.7	0.15	0.87	0.17	1.8	0.21	0.04	1.93	100.3	9.39	250	83	44	230	22	41	16	142
KIB-53	167.5	Tonalite	54.9	16.5	8.02	3.81	3.38	0.67	2.83	6.9	0.18	1.17	0.23	1.1	0.01	0.01	0.85	100.3	10.5	150	35	23	215	24	141	13	138
KIB-54	243	Metabasalt	58.2	15.9	5.93	6.14	4.01	0.37	1.51	5.4	0.16	0.50	0.08	1.2	0.01	0	1.39	100.3	7.51	50	139	17	189	11	75	<10	203
KIB-57	68-68.7	Metadiabase	50.3	13.9	9.74	5.68	2.84	0.30	2.81	10.7	0.19	1.70	0.14	1.1	0.08	0.03	0.85	100.4	14.7	550	137	16	103	34	76	24	88
KIB-68	339-339.5	Quartz Diorite	64.2	16.3	4.10	1.61	5.77	2.58	2.03	0.9	0.08	0.36	0.15	1.1	0.31	0.03	1.70	100.2	3.03	100	127	97	1600	<10	88	<10	1080
KDI1-2	454	Metabasalt	48.5	13.1	9.83	5.14	2.61	0.35	6.31	9.8	0.28	1.50	0.13	1.3	0.03	0.27	1.54	100.3	17.2	9.8	64	39	293	30	75	14	99

Notes: Fe<sub>2</sub>O<sub>3</sub>T = total iron as Fe<sub>2</sub>O<sub>3</sub>

Fe<sub>2</sub>O<sub>3</sub>C = Fe<sub>2</sub>O<sub>3</sub> calculated by subtracting analyzed FeO as equivalent Fe<sub>2</sub>O<sub>3</sub> from Fe<sub>2</sub>O<sub>3</sub>T

APPENDIX C. MINOR-ELEMENT GEOCHEMICAL DATA FOR BEDROCK DRILL-CORE SAMPLES (ppm)

Number	Sample Depth	Rock Type	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
KJB-1	118.5	Biotite Schist	0.185	2.85	0.004	69.3	<0.096	1.29	5.34	<0.24	1.26	41.9	0.251	0.192	5.48	<0.481	<0.962	<0.481
KJB-2	72-73	Mgraywke/siltstone	0.133	1.06	0.003	95.1	<0.096	0.191	1.28	<0.24	1.17	46.6	<0.24	<0.096	6.02	<0.48	<0.96	<0.48
KJB-3B	207-208	Argillite	0.116	7.32	0.003	64.1	<0.097	1.10	9.25	<0.242	1.13	69.9	<0.242	<0.097	5.69	<0.484	<0.696	<0.484
KJB-4	179-180	Andesite Agglomerate	0.079	1.96	0.003	47.4	<0.097	0.178	1.28	<0.241	0.890	48.8	<0.241	<0.097	5.89	<0.483	<0.965	<0.483
KJB-6	36.5-37.5	Syenite	0.049	1.69	0.002	11.2	<0.092	1.77	5.56	<0.231	0.909	8.18	<0.231	<0.092	1.58	<0.461	<0.923	<0.461
KJB-8	67.2-67.9	Trondhjemite	0.02	1.01	0.002	7.54	<0.092	0.792	0.725	<0.23	0.706	21.1	0.240	<0.092	1.71	<0.46	<0.919	<0.46
KJB-9	200-270	Andesite/dacite chips	0.092	<0.942	0.005	29.2	<0.094	0.719	0.861	<0.235	0.868	48.8	<0.235	<0.094	4.56	<0.471	<0.942	<0.471
KIB-10	89.3-39.8	Altered Qtz. Diorite	0.67	<0.988	0.002	34.6	<0.099	0.558	1.54	0.331	1.33	64.0	<0.247	<0.099	8.31	<0.494	<0.988	<0.494
KIB-10	96.5-97	Altered Qtz. Diorite	0.68	1.11	0.003	56.3	<0.095	0.365	0.942	<0.236	1.13	69.1	<0.236	<0.095	5.73	<0.473	<0.945	<0.473
KIB-11	79-79.7	Altered Basalt	0.05	<0.963	0.003	40.7	<0.096	0.326	0.701	<0.241	1.13	28.4	<0.241	<0.096	2.41	<0.482	<0.963	<0.482
KIB-13	71.8-72.5	Metabasalt	0.364	1.95	<0.046	94.8	<0.091	1.07	7.79	0.288	<0.455	100.	0.302	0.175	8.02	<0.455	<0.911	<0.455
KIB-13	100-101	Metabasalt	0.149	4.35	<0.046	122.	<0.093	1.16	5.49	0.462	<0.465	94.8	<0.232	0.097	6.59	<0.465	<0.929	<0.465
KIB-13	123-124	Metabasalt	0.05	1.98	<0.048	9.02	<0.096	3.62	4.19	0.239	<0.478	19.63	<0.239	<0.096	1.04	<0.478	<0.956	<0.478
KIB-17	27.2-28	Metabasalt	0.08	<0.969	0.004	105.	<0.097	0.213	0.647	<0.242	0.908	30	<0.242	<0.097	3.39	<0.484	<0.969	<0.484
KIB-18	363-364	Carb. Altered Tuff	0.038	2.42	0.002	9.06	<0.094	0.520	1.38	0.339	1.23	27.0	<0.235	<0.094	<0.469	<0.469	<0.938	<0.469
KIB-18	373-374	Carb. Altered Tuff	0.023	<0.926	0.001	17.3	<0.093	0.100	0.976	0.362	1.25	40.8	<0.231	<0.093	<0.463	<0.463	<0.926	<0.463
KIB-19	73.5-74.5	Metabasalt	0.127	<0.967	0.002	169.	<0.097	<0.097	1.31	<0.242	0.961	47.2	<0.242	<0.097	4.17	<0.484	<0.967	<0.484
KIB-20	241.3	Dacitic Tuff	0.046	0.975	0.002	43.1	<0.095	0.149	3.87	<0.237	1.13	75.2	<0.237	<0.095	8.30	<0.474	<0.949	<0.474
KIB-20	245.2	Quartz Monzonite	0.042	<0.954	0.002	24.4	<0.095	0.857	2.80	<0.239	1.11	31.9	0.267	<0.095	3.40	<0.477	<0.954	<0.477
KIB-21	300-315	Volcanogenic Grwke	0.07	4.72	0.002	43.1	<0.095	0.235	5.19	<0.238	0.937	74.1	<0.238	<0.095	11.8	<0.476	<0.952	<0.476
KIB-30	237.5-238	Metagraywacke	0.202	1.10	0.007	96.6	<0.095	1.83	9.15	<0.238	<0.476	88.3	0.811	0.098	10.8	<0.476	1.64	<0.476
KIB-32	107-107.5	Biotite Schist	0.113	0.998	0.006	60.2	<0.098	2.03	7.31	0.245	<0.49	74.7	<0.245	0.117	8.03	<0.49	<0.98	<0.49
KIB-39	168.6-169	Pyroxene Monzonite	0.289	3.22	0.005	190.	<0.095	0.283	27.9	<0.238	0.988	55.0	0.248	<0.095	2.76	<0.475	<0.951	<0.475
KIB-41	277-277.5	Felsic Metavolcanic	0.183	1.42	0.004	147.	<0.093	0.228	6.42	<0.231	1.02	114.	<0.231	<0.093	6.61	<0.463	<0.926	<0.463
KIB-49	66.5-66.8	Felsic Tuff	0.122	2.09	0.005	54.5	<0.095	1.31	4.25	<0.237	<0.474	45.9	<0.237	<0.095	8.66	<0.474	<0.949	<0.474
KIB-51	275-275.4	Quartz Diorite	0.041	1.29	0.006	28.6	<0.096	1.63	1.65	<0.239	<0.479	26.6	<0.239	<0.096	2.64	<0.479	<0.958	<0.479
KIB-52	253.8-254.3	Quartz Diorite	0.244	1.03	0.004	125.	<0.097	1.76	2.34	<0.244	<0.487	49.4	<0.244	0.133	3.15	<0.487	<0.975	<0.487
KIB-53	171.4-172	Tonalite	0.071	<0.971	0.015	36	<0.097	3.43	2.47	<0.243	<0.485	24.6	<0.243	0.132	2.50	<0.485	<0.971	<0.485
KIB-54	239-239.7	Metabasalt	0.021	<0.954	<0.048	18.6	<0.095	0.941	3.29	<0.239	<0.477	52.4	<0.239	<0.095	2.15	<0.477	<0.954	<0.477
KIB-56	87-87.1	Metagraywacke	0.681	<0.949	<0.047	606.	<0.095	1.68	6.56	<0.237	<0.474	1564	0.508	3.74	6.25	<0.474	1.61	1.65
KIB-57	68-68.7	Metadiabase	3.69	1.46	0.707	5272	<0.095	2.04	6.61	<0.239	<0.477	78.3	<0.239	0.784	1.71	<0.477	0.971	0.969
KIB-64	448.5	Sheared tuff-wacke	0.406	20.0	<0.048	481	<0.096	0.848	12.4	0.308	<0.481	68.8	<0.24	0.115	6.53	<0.481	<0.962	<0.481
KIB-68	335-336	Quartz Diorite	0.144	<0.94	<0.047	31.5	<0.094	1.57	3.73	0.417	<0.47	45.7	<0.235	<0.094	2.42	<0.47	<0.94	<0.47
KIB-69	179	Biotite Schist/mgwke	0.098	<0.931	<0.047	44.8	<0.093	1.42	10.8	<0.233	<0.466	124.	<0.233	0.139	8.55	<0.466	<0.931	<0.466
KIB-70	229-229.5	Sheared volc. argillite	0.069	7.65	<0.046	125.	<0.092	0.739	2.82	0.360	<0.458	110.	<0.229	0.174	8.87	<0.458	<0.916	<0.458
KIB-76	415-416	Metabasalt	0.037	4.34	0.002	52.1	<0.092	0.725	0.721	0.471	<0.46	106.	<0.23	0.130	5.89	<0.46	<0.921	<0.46
KDH-2	182	Metabasalt	0.096	<0.984	<0.049	110.	<0.098	0.595	11.9	<0.246	<0.492	84.4	<0.246	<0.098	2.88	<0.492	<0.984	<0.492
KDH-2	210	Metabasalt	<0.015	1.63	<0.049	277.	<0.099	0.395	22.7	<0.247	1.81	262.	<0.247	<0.099	18.0	<0.493	<0.986	<0.493
KDH-2	258	Metabasalt	0.113	<0.926	<0.046	239.	<0.093	0.637	21.2	0.391	0.624	128.	<0.231	0.152	5.51	<0.463	<0.926	<0.463
KDH-2	454	Metabasalt	0.124	2.43	<0.046	95.7	<0.092	2.08	21.8	0.499	<0.46	66.7	<0.23	0.124	3.54	<0.46	<0.919	<0.46
KDH-2	467	Metabasalt	0.086	0.951	<0.047	47.6	<0.094	1.54	10.6	<0.236	<0.472	46.9	<0.236	0.190	2.01	<0.472	<0.943	<0.472
KDH-4	418.5-419.5	Metagraywacke	0.161	<0.954	0.007	158.	<0.095	0.653	1.69	<0.239	<0.477	190.	0.521	0.266	7.04	<0.477	<0.954	<0.477
KDH-4	422.5-423	Veined metagraywacke	0.043	<0.992	0.003	7.28	<0.099	0.960	3.01	<0.248	<0.496	78.8	<0.248	0.260	3.27	<0.496	<0.992	<0.496
KDH-4	481-481.5	Silic. metagraywacke	0.340	2.28	0.007	159.	<0.095	2.41	2.08	0.350	<0.475	400.	0.528	1.13	5.18	<0.475	<0.951	<0.475
KDH-5	371.5-372	Mylonitized gabbro	0.436	<0.998	0.004	641.	<.1	0.851	0.538	<0.25	<0.499	7.85	<0.25	<0.1	2.22	<0.499	<0.998	<0.499
KDH-5	463-464	Mylonite	0.03	<0.952	0.001	6.26	<0.095	0.267	0.369	<0.238	<0.476	5.41	<0.238	<0.095	1.44	<0.476	<0.952	<0.476
KDH-6	375-375.5	Mylonite	0.267	41.6	0.002	140.	<0.095	0.687	3.04	1.19	<0.474	57.4	<0.237	<0.095	1.33	<0.474	2.36	<0.474
KDH-6	382-382.5	Mylonite	0.193	187.	0.001	1180	<0.094	0.597	0.718	0.932	<0.471	81.1	<0.235	0.105	4.42	<0.471	2.08	<0.471
KDH-7	419.2-419.7	Metadiabase	0.057	3.50	0.003	62.7	<0.1	0.658	0.661	0.570	<0.499	47.0	<0.25	<0.1	4.54	<0.499	<0.998	<0.499



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