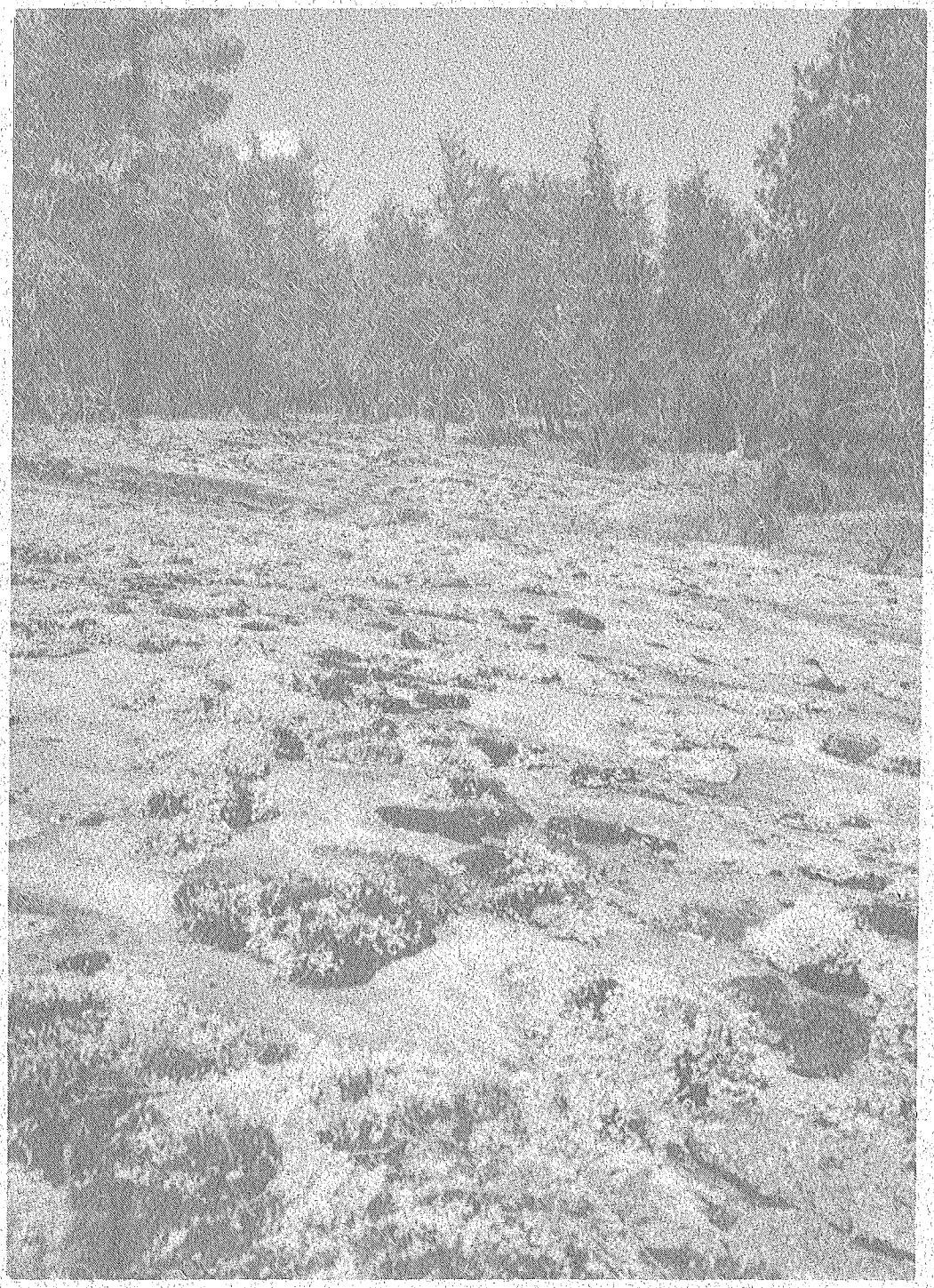
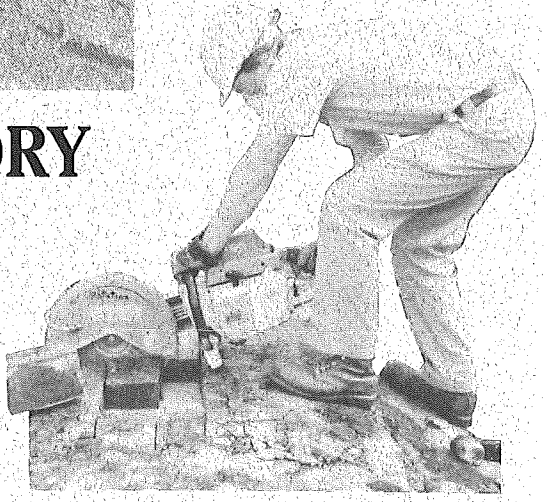
Report 289



DIMENSION STONE INVENTORY OF NORTHERN MINNESOTA

1991



Minnesota Department of Natural Resources
Division of Minerals

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Dimension Stone Inventory of Northern Minnesota

By Matt Oberhelman
1991

Report 289

Minnesota Department of Natural Resources
Division of Minerals
William C. Brice, Director

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Abstract

A reconnaissance-level dimension stone inventory of crystalline rocks was conducted on government-owned and administrated lands in six northern Minnesota counties. Approximately 250 Middle Proterozoic (Keweenawan) and Archean outcroppings were evaluated with respect to joint spacing, color, texture, deleterious minerals, and size of extractable blocks.

Based on industry criteria, field investigations identified eight prospects and two inactive quarries that have potential for dimension stone development. These sites contain rock of a variety of color and texture, some of which is remarkably different from what is currently quarried or available domestically.

Polished tiles from the prospects and past producing quarries can be examined at offices of the Minnesota Department of Natural Resources in St. Paul and Hibbing, and the Superior National Forest office in Duluth. Photographs of these tiles are contained in a companion brochure, also available from the mentioned offices.

During the 1991 field season, the division will expand the evaluation of outcrops to include selected outcrops previously not evaluated within the original survey area.

Introduction

This report presents the results of the first two years of the Minnesota Department of Natural Resources' (MDNR) dimension stone inventory. The inventory is one of several projects initiated by the Division of Minerals to encourage the diversification and expansion of the state's industrial minerals industry.

The purpose of this inventory is to identify areas of crystalline rock in northern Minnesota that have potential for dimension stone development, thereby encouraging the stone industry to evaluate these sites further. The ultimate goal of the project is to increase the utilization of the state's dimension stone resources and create additional economic opportunities within the state.

During the first two years of the inventory, the Industrial Minerals staff conducted investigations of crystalline rocks on government lands in portions of Cook, Itasca, Koochiching, Lake, Lake of the Woods, and St. Louis counties (Fig. 1). Field investigations were conducted during the fall of 1989 and spring through fall of 1990 by one field crew, which consisted of a geologist and a field technician.

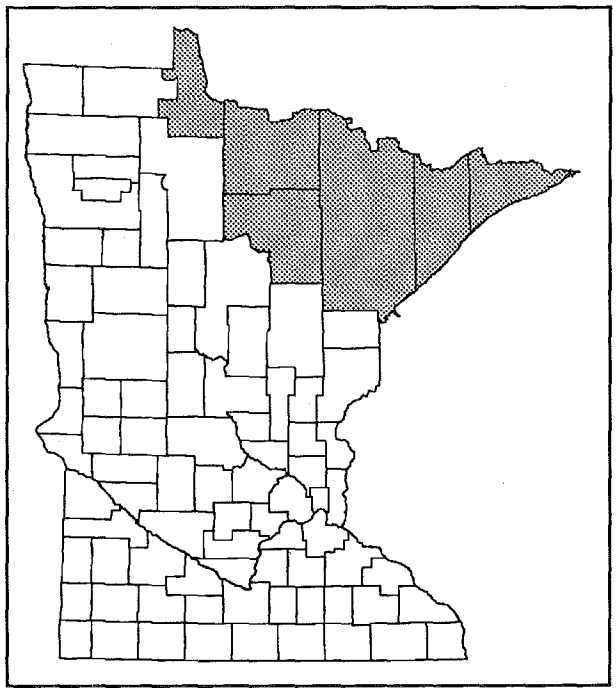

Figure 1. Dimension stone inventory study area.

Regional Geologic Setting

The survey area is underlain by Middle Proterozoic (Keweenawan) rocks (ca. 1100 m.y.) and Archean (>2700 m.y.) rocks of the Wabigoon, Quetico, and Wawa-Shebandowan subprovinces of the Superior Province. Within Minnesota, the Middle Proterozoic rocks consist mainly of lava flows, gabbroic intrusions, sandstones, and other sediments. (Ojakangas and Matsch, 1982). Archean rocks of the Superior Province consist mainly of belts of metavolcanic and metasedimentary rocks (greenstone belts) and of enclosing granitic and, locally, gneissic rocks (Sims, 1972).

The inventory of dimension stone resources encompassed the following rock units: (Fig. 2):

Middle Proterozoic (Keweenawan) rocks:

Logan Intrusions, diabase and gabbro in dikes and sills (Morey and others, 1982).

Duluth Complex, which includes anorthositic, troctolitic, gabbroic, granodioritic, and granitic rocks (Phinney, 1972a).

Beaver Bay Complex, composed of rocks ranging from troctolite to granite; ophitic olivine gabbro is the dominant rock type (Green, 1972).

Archean rocks:

Granodiorite gneiss, composed chiefly of medium-grained hornblende biotite granodiorite gneiss (Day and Klein, 1990).

Granitoid rocks, including moderately to well-foliated tonalite, granodiorite, granite, and minor monzodiorite (Day and Klein, 1990).

Linden Pluton, composed of syenitic rocks displaying a pronounced foliation and lineation (Sims, Sinclair and Mudrey, 1972).

Giants Range Granite, composed chiefly of granitic rocks, ranging in composition from tonalite to granite (Sims and Viswanathan, 1972).

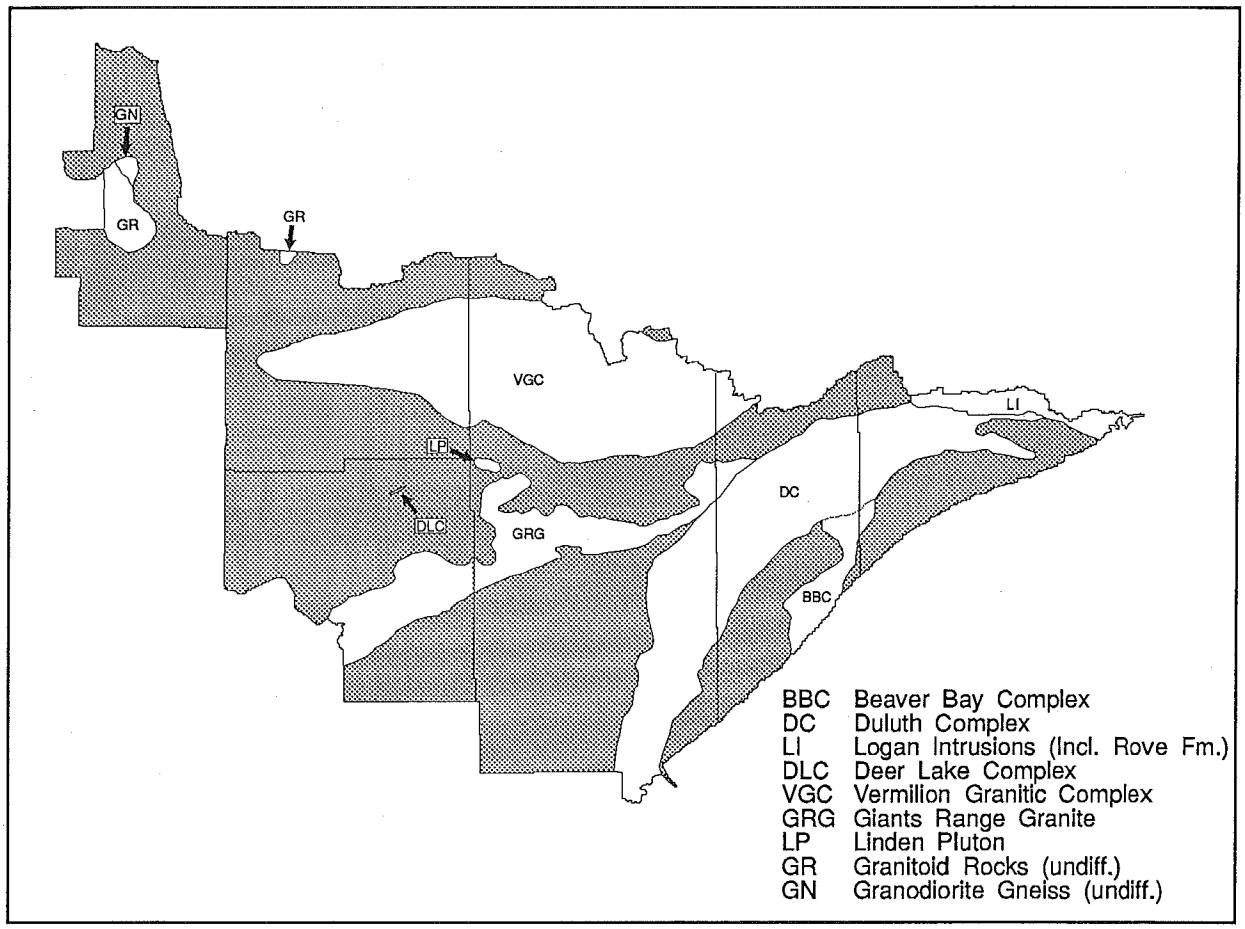

Figure 2. Generalized map of rock units investigated within the study area. Adapted from Morey and others, 1982; Sims and others, 1970; Day and Klein, 1990; and Phinney, 1972a.

Vermilion Granitic Complex, composed chiefly of granitic rocks, granite-rich migmatites, and schist-rich migmatites (Southwick, 1972).

Deer Lake Complex, composed of peridotite, pyroxenite, diorite, and gabbro (Berkley and Himmelberg, 1978).

Methodology

In the course of this investigation the various stages of work included site selection, field work, and analysis of field data.

Site Selection

The site selection phase consisted of a review of available geologic maps and pertinent literature — in addition to discussions with geologists familiar with the region — to identify areas that contain rocks with potential for dimension stone development. The next step consisted of an examination of color aerial photographs (1:15,840 scale) and U.S. Geological Survey 7.5 minute series topographic maps to locate specific outcrops for evaluation.

Field Work

A roadside reconnaissance survey was then conducted to examine as many outcrops in the survey area as possible. Due to time and budgetary restraints and the extent of the survey area, the evaluation of outcrops was restricted to near-road locations. Off-road traverses were generally limited to areas within a mile from roads.

The evaluation of outcrops was based primarily on surface observations. *The criteria used to assess quarry potential of specific outcrops are as follows:*

1. A minimum spacing for vertical joints of approximately 6 ft (2 m), and a minimum spacing for horizontal joints (sheeting) of approximately 3 ft (1 m). The spacing and distribution of joints controls the size of blocks that can be quarried.

2. A sufficient volume of stone to allow quarrying for a minimum of twenty years. The deposit size should be approximately 500 x 500 ft (150 x 150 m), although some companies may require a larger deposit with a depth of at least 100 feet of homogeneous rock. The determination of the actual volume of specific deposits is outside the scope of this inventory. It was often difficult to estimate the areal extent of a rock type because of the presence of glacial overburden. The uniformity of rock at depth can only be determined by drilling, which was not a component of this survey.

3. The color and texture (size, shape, and arrangement of crystals) of the stone should be relatively consistent and the deposit should have an absence of dikes, veins, and inclusions, which are usually considered to be imperfections because they tend to interrupt the continuity of the stone.

4. An absence of deleterious minerals. These minerals tend to weather easily and are usually considered undesirable in a building stone. For example, some sulfide minerals, such as pyrite, may cause rust staining upon weathering.

5. The deposit should be accessible and located in an area without land-use constraints. The Boundary Waters Canoe Area Wilderness, BWCAW Mineral Management Corridor, and federal and state parks were not included in the survey area.

Analysis of Field Data

After the field work was completed, the outcrops were classified into the following three groups: (1) **Prospects** (areas of potential), (2) **Inactive quarries**, and (3) **Occurrences** (sites of little or no potential).

Additional steps were completed to assess the outcrops and inactive quarries thought to have potential for development. They included the preparation of polished tiles and petrographic analysis (mineralogy and geologic rock names).

Rock samples were extracted from outcrops using a 14 inch dry diamond blade "chop saw." They were then cut into 4 x 6 inch tiles and polished by a vendor. The tiles are available for inspection at the MDNR Minerals offices in Hibbing and St. Paul, and the Superior National Forest office in Duluth.

Petrographic analysis (mineralogy and geologic rock names) was determined by thin section study at the MDNR office in Hibbing. Geologic rock names were assigned using Phinney's (1972) classification for the mafic rocks and Streckeisen's (1973) rock classification for the granitic rocks, illustrated in figures 3 and 4, respectively. One should note that the stone industries use of the term "granite" is much broader than that used by petrologists. The commercial stone term "granite" includes most crystalline igneous rocks and some metamorphic rocks, whereas the petrologist's definition of granite is very specific (see Fig. 4).

A complete evaluation of the prospect and inactive quarries requires further analysis to determine if the rock is of suitable quality and quantity for quarrying. Further investigative methods may include: the extraction of large test blocks, which are used to test physical properties and to evaluate the consistency of color and texture in large finished pieces; and the removal of overburden adjacent to outcrops and drilling to gain a better understanding of the rocks continuity and jointing characteristics both laterally and at depth. It is intended that this next phase of assessment be carried out by the stone industry.

Results

Outcrops were examined along approximately 1200 miles (1900 km) of roads within the survey area, including highways, secondary, and primitive roads. Based on this work, 244 rock outcrops were described in detail. The evaluation of outcrops was restricted to near-road locations during this phase of the inventory, and the potential of outcrops further from the road was not determined.

From this initial evaluation, the inventory identified eight prospects and two inactive quarries. These sites have potential for the extraction of moderate to

large quarry blocks (5ft x 5ft x 8ft [1.5m x 1.5m x 2.5m] minimum). The size of quarry blocks was estimated from the joint intensity and joint patterns observed on the outcrop surface. Horizontal jointing (sheeting) is often not evident from outcrop exposures; drilling would aid in understanding the horizontal jointing characteristics. The actual size of quarry blocks cannot be definitely determined until stone has been removed.

The sites classified as occurrences have little or no potential for dimension stone development based on the criteria established for this inventory. The outcrops at these sites have one or more unfavorable characteristic, such as closely spaced joints, nonuniform color or texture, or an abundance of veins, dikes, or inclusions. In these cases, the site description is limited to the location, a brief geologic description, and comments on the reason for the marginal rating. In many cases where the potential was obviously poor, site descriptions were not recorded.

Summary of Prospect and Inactive Quarry Sites

The following sites, consisting of rock of a variety of color and texture, exhibit potential for dimension stone development (see Fig. 5).

Site No.: Koochiching - 3. This pinkish-gray gneissic granite displays wide joint spacings, up to 65 ft (20 m). Black elongate segregations of biotite and amphibole, up to 12 in. (30 cm) in length, are scattered throughout the exposure. This site has the potential for very large quarry blocks.

Site No.: Koochiching - 8. This pinkish-gray gneissic granite displays wide joint spacings, up to 60 ft (18 m). Black elongate segregations of biotite, up to 12 in. (30 cm) in length, are scattered throughout the exposure. This site has the potential for very large quarry blocks.

Site No.: Lake - 7. Exposures of this black granite commonly display joint spacings greater than 10 ft (3m).

Site No.: Lake - 49. This black granite, although only observed in small exposures, displays joint spacings of up to 16 ft (5 m).

Site No.: Lake - 53. This stone displays a unique greenish-gray hue and porphyritic texture. Stone of this cast and texture is currently not available in the marketplace. The joint spacings appear adequate for the removal of large quarry blocks.

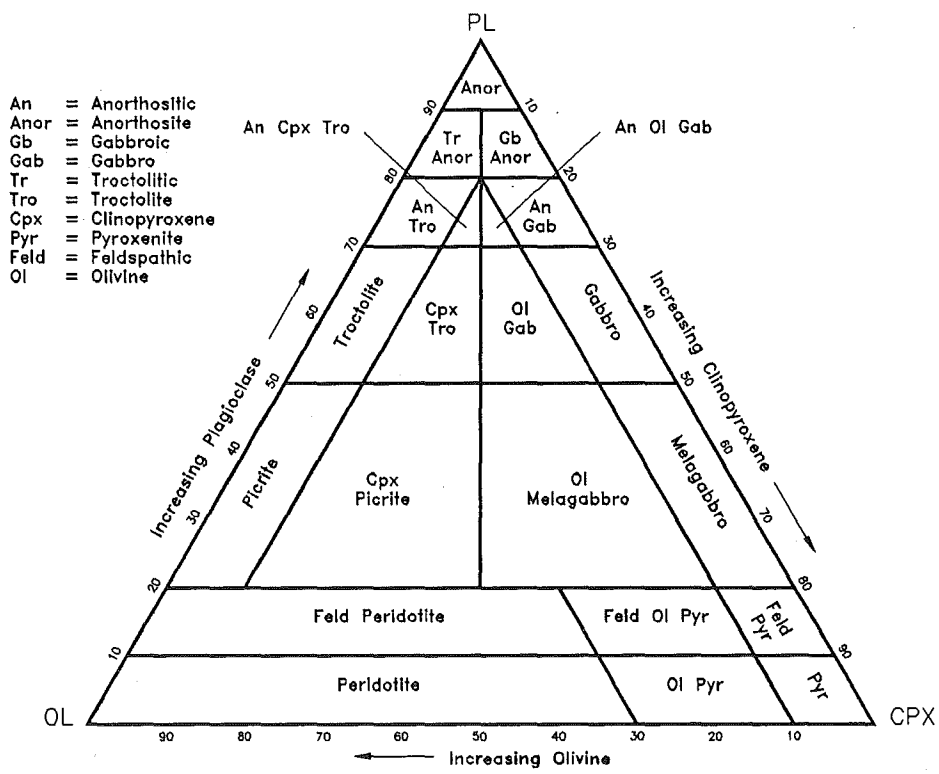

Figure 3. Classification for mafic rocks (from Phinney, 1972). PL+OL+CPX=100

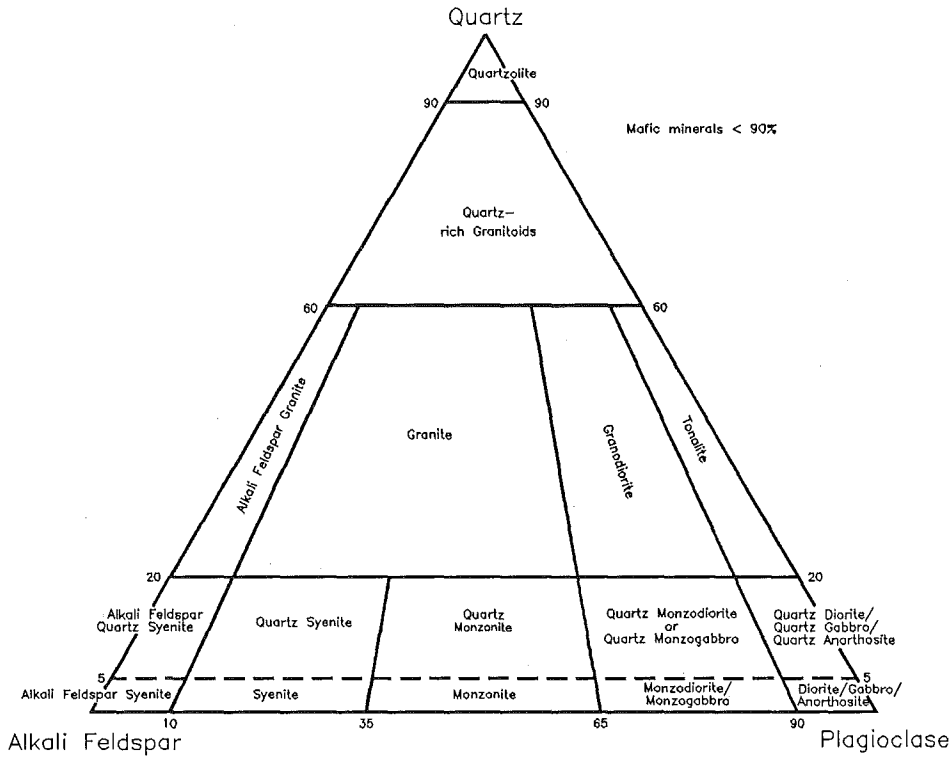

Figure 4. Classification for granitic rocks (from Streckeisen, 1973). Qtz+Ksp+Plag=100.

Site No.: Lake - 54. In this 50 x 30 ft (16 x 10 m) exposure of black granite, only two joints are observed. Plagioclase, the predominant mineral, is distributed in an interesting arrangement of long tabular crystals with varying orientations. When polished these gray-white to brown crystals give the stone a distinctive quality.

Site No.: Lake - 65. The arrangement of the plagioclase and pyroxene crystals give polished pieces of this black granite a unique richness and depth. The joint spacings appear adequate for the removal of large quarry blocks.

Site No.: St. Louis - 95. Two colors of granite are present at this site, a grayish-pink and a brownish-gray. The joints are widely spaced, up to 50 ft (16 m). This site has the potential for very large quarry blocks.

Site No.: Lake - 11 and Lake - 13. Both past producing black granite quarries exhibit variable joint spacings and regular and irregular joint patterns. Lake - 11 displays wider joint spacings than Lake - 13.

Detailed descriptions of these sites are presented in the following section. The format and explanations of the data are listed below.

Classification: Prospect (area of potential), Inactive quarry

Site No:

Commodity:

Geologic Rock Name:

Location Information: includes County, Township (T), range (R), section (Sec) and section locators, UTM coordinates, and USGS quadrangle map name

Access:

Color of Fresh and Weathered Surfaces: the determination of color is strongly affected by the perception of the person viewing the stone

Texture: shape and arrangement of crystals

Grain Size:
fine-grained = less than 1 mm
medium-grained = 1-5 mm
coarse-grained = more than 5 mm

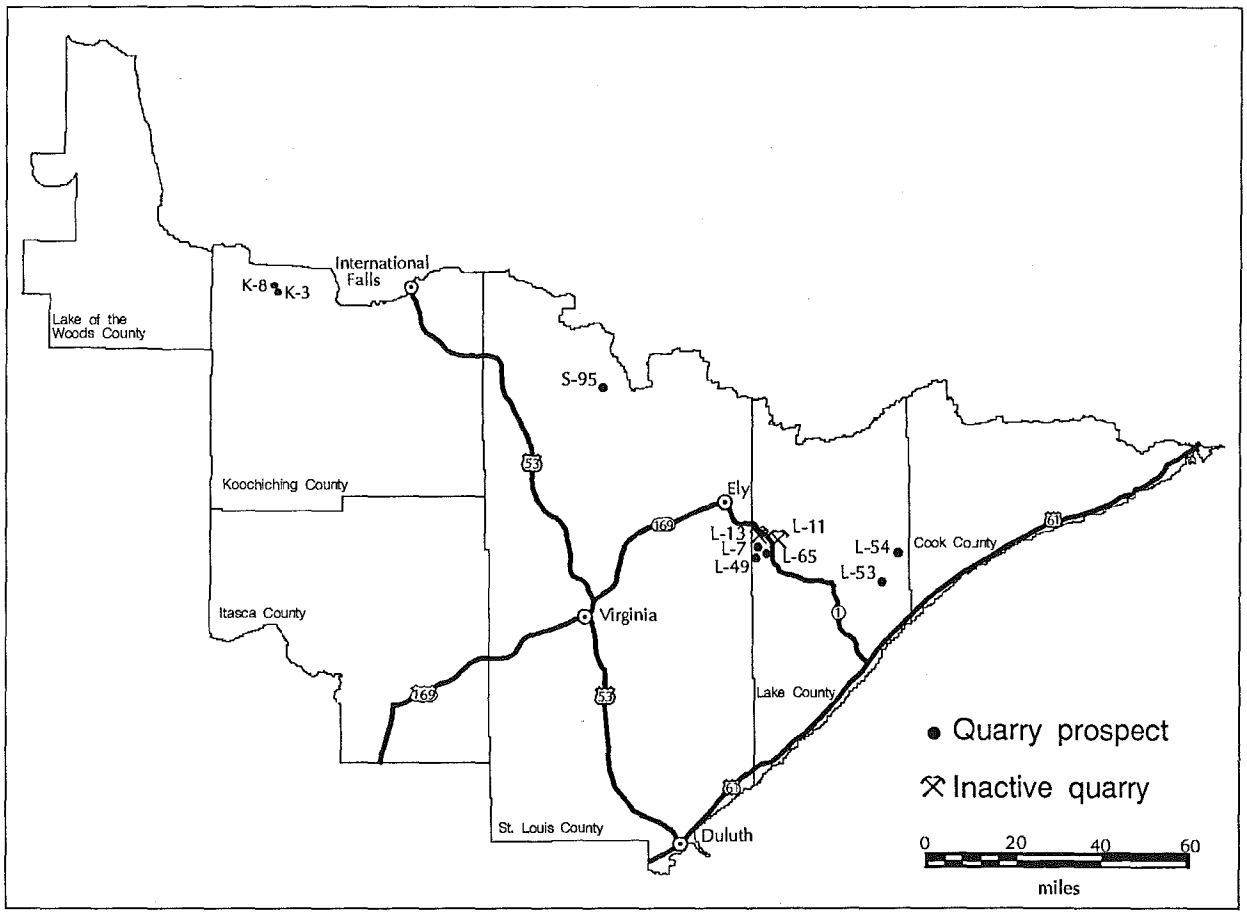

Figure 5. Location of quarry prospects and inactive quarries within the study area.

Joint Pattern: regular pattern (recurring joints of relatively uniform strike and dip), irregular pattern (randomly oriented joints, often discontinuous or curved). The strike and dip of dominant joint sets were recorded when possible.

Joint Intensity:
intense: average spacing < 1.5 ft (0.5 m)
moderate: average spacing 1.5 - 6 ft (0.5 - 2 m)
limited: average spacing > 6 ft (2 m)

Geological Setting: geological rock unit

Geology: geologic description of site

Mineralogy: determined by division petrologist from thin section study

Other Features: features such as veins, inclusions, dikes, pegmatitic masses, etc.

Deleterious Minerals: for example sulfides, such as pyrite, may rust upon weathering

Outcrop Exposure:

Quarry Block Potential:

Surface and Mineral Ownership:

Photo: photo of outcrop taken

Use of explosives: previous blasting may affect joint and fracture densities

Sample No.:

Thin Section No.:

Polished Tile No.:

Location Map:

Physical Property Tests:

Quarry Prospect Descriptions (areas of potential)

Site No.: Koochiching - 3

Commodity: Grayish-pink granite
Geological Rock Name: Gneissic alkali granite

County: Koochiching
TRS: T 159 N R 27 W Sec 8 E1/2 SE1/4
UTM: 417210mE, 5383590mN, Zone 15
USGS Quadrangle Map: Birchdale SE

Access: This site can be reached by a gravel road leading south from County State Aid Highway 4.

Color: **Fresh Surface** - Grayish-pink, uniform
Weathered Surface - Pink

Texture: Weakly foliated; subhedral grains

Grain Size: Medium, uniform

Joint Pattern: Regular

Joint Intensity: Limited; joint spacing range from 6 to 65 ft (2 to 20 m)

Geological Setting: This area is underlain by Late Archean granitoid rocks.

Geology: This rock is a grayish-pink gneissic alkali granite. It is medium-grained and displays a weak foliation resulting from the alignment of dark minerals. Regular joint patterns were observed. Joint spacings range from 6 to 65 ft (2 to 20 m). Large areas of outcrop exhibit widely spaced joints. The dominant joint sets trend at 360° and 85°. Sheeting is evident but difficult to assess due to the low lying nature of the exposure. Black, elongate segregations of biotite and amphibole occur scattered throughout the exposure.

Mineralogy: Thin section study indicates a composition of approximately 48% albite, 23% microcline, 22% quartz, 7% biotite, amphibole, epidote, and accessory sphene and oxide.

Other Features: Black, elongate segregations of biotite and amphibole, ranging in length from 0.5 to 12 in. (1 to 30 cm), occur scattered throughout the exposure. A small quartz vein was noted. Exfoliation is observed on portions of the outcrop surface.

Deleterious Materials: None observed

Outcrop Exposure: Moderate; elongate low lying outcrops intermittently exposed in a 820 x 100 ft (250 x 30 m) area

Quarry Block Potential: Good

Surface Ownership: State of MN

Mineral Ownership: Consolidated Conservation Area

Photo: Yes

Use of Explosives: No

Sample No.: 23285

Thin Section No.: 23285

Polished Tile No.: K-3

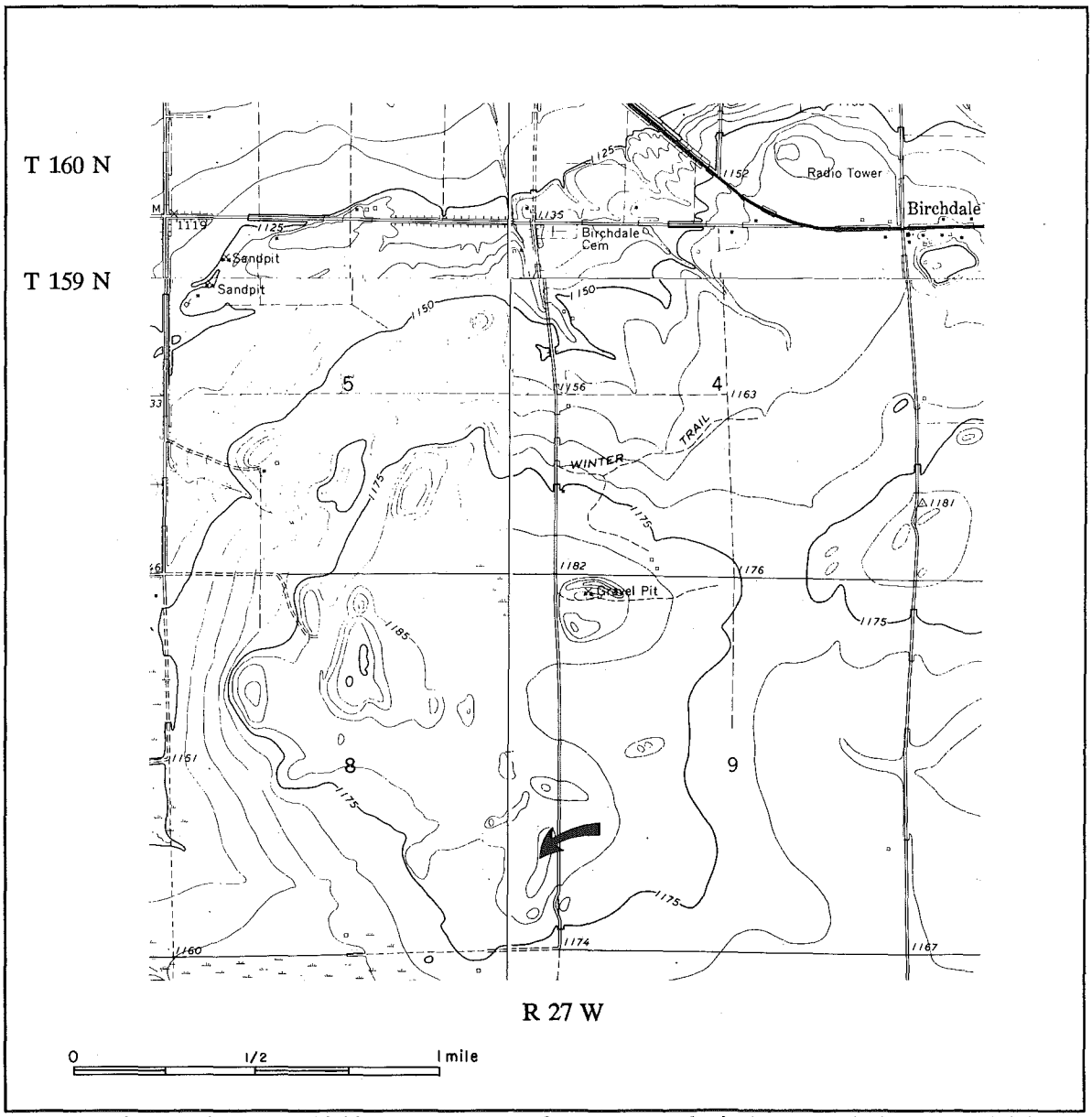

Figure 6. Site Number: Koochiching - 3. Base map from U.S. Geological Survey Birchdale, Birchdale SE, Birchdale SW, and Stratton 7.5 minute quadrangles.

Site No.: Koochiching - 8

Commodity: Grayish-pink granite
Geological Rock Name: Gneissic alkali granite

County: Koochiching
TRS: T 159 N R 27 W Sec 8 NW1/4 NE1/4
UTM: 416450mE, 5384560mN, Zone 15
USGS Quadrangle Map: Birchdale SW

Access: This site can be reached by gravel road UT 393 leading east off of County Road 87.

Color: **Fresh Surface** - Grayish-pink, uniform
Weathered Surface - Pink

Texture: Weakly foliated; anhedral grains

Grain Size: Medium, uniform

Joint Pattern: Regular and irregular

Joint Intensity: Moderate to limited; joint spacings range from 1.5 to 60 ft (0.5 to 18 m). Sheeting is observed with 1.5 to 3 ft (0.5 to 1 m) spacings at the surface.

Geological Setting: This area is underlain by Late Archean granitoid rocks.

Geology: This rock is a grayish-pink gneissic alkali granite. It is medium-grained and displays a weak foliation resulting from the alignment of dark minerals. Regular and irregular joint patterns are present. Joint spacings range from 1.5 to 60 ft (0.5 to 18 m). The dominant joint sets trend at approximately 360° and 100°. Sheeting is observed with 1.5 to 3 ft (0.5 to 1 m) spacings at the surface. Black, elongate segregations of biotite occur scattered throughout the exposure.

Mineralogy: Thin section study indicates a composition of approximately 36% microcline, 34% quartz, 22% albite, and 8% biotite, chlorite, epidote, opaques, and sphene.

Other Features: Black, elongate segregations of biotite, ranging in length from 0.5 to 12 in. (1 to 20 cm), are observed scattered throughout the exposure, trending at 70°. Local healed fractures (black lines) were noted. Exfoliation was observed on portions of the outcrop surface.

Deleterious Materials: None observed

Outcrop Exposure: Good; large elongate knob

Quarry Block Potential: Good

Surface Ownership: State of MN

Mineral Ownership: Consolidated Conservation Area

Photo: Yes

Use of Explosives: No

Sample No.: 23286

Thin Section No.: 23286

Polished Tile No.: K-8

ASTM Physical Property Tests: Sample sent to U.S. Bureau of Mines

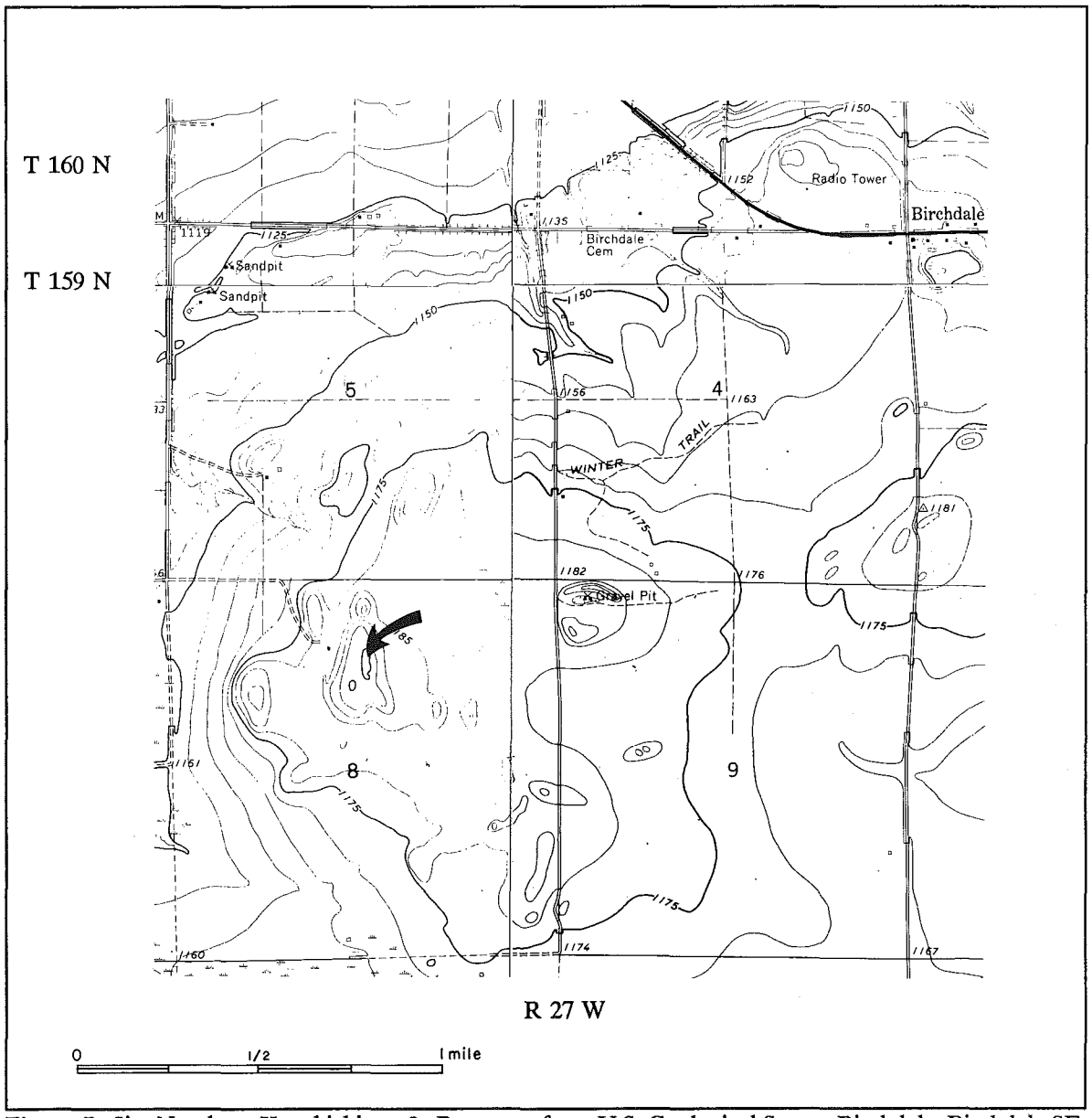

Figure 7. Site Number: Koochiching - 8. Base map from U.S. Geological Survey Birchdale, Birchdale SE, Birchdale SW, and Stratton 7.5 minute quadrangle.

Site No.: Lake - 7

Commodity: Black granite
Geological Rock Name: Troctolitic anorthosite

County: Lake
TRS: T 61 N R 11 W Sec 28 NE1/4 NE1/4
T 61 N R 11 W Sec 21 SE1/4 SW1/4 SE1/4 and SW1/4 SE1/4 SE1/4
UTM: 595180mE, 5288820mN, Zone 15, N.
USGS Quadrangle Map: Slate Lake West

Access: This site can be reached by a primitive road leading north from Forest Road 424 (Tomahawk Road).

Color: **Fresh Surface** - Gray, uniform
Weathered Surface - Gray

Texture: Weakly laminated; subhedral plagioclase grains

Grain Size: Medium to coarse, uniform

Joint Pattern: Regular and irregular

Joint Intensity: Variable; joint spacings range from 1 to 23 ft (0.3 to 7 m), ledges exhibit sheeting spacings of up to 6 ft (2 m)

Geological Setting: This area is underlain by Middle Proterozoic mafic intrusive rocks of the Duluth Complex.

Geology: This rock is a troctolitic anorthosite of uniform gray color. It is medium- to coarse-grained and exhibits a weak lamination resulting from the preferred orientation of plagioclase laths. When polished the plagioclase crystals appear translucent with varying shades of gray. The darker minerals include olivine and magnetite. Regular and irregular joint patterns are present. The dominant joint sets trend at approximately 10°; other joint sets trend from 50° to 100°. Joint spacings are variable ranging from 1 to 23 ft (0.3 to 7 m). Exposures commonly display joint spacings greater than 10 ft (3 m). Some ledges exhibit sheeting spacings of up to 6 ft (2 m). In one area of the outcrop, an oxide rich segregation was observed.

Mineralogy: Thin section study indicates a composition of approximately 80% plagioclase, 19% olivine, 0.5% opaque, and accessory clinopyroxene, amphibole, biotite, symplectite, and apatite.

Other Features: Slightly magnetic; local oxide rich segregation observed

Deleterious Materials: None observed

Outcrop Exposure: Fair to good; a series of elongate ridges with intermittently exposed outcrops

Quarry Block Potential: Moderate to good

Surface Ownership: USA

Mineral Ownership: USA

Photo: Yes

Use of Explosives: No

Sample No.: 22639

Thin Section No.: 22639

Polished Tile No.: L-7

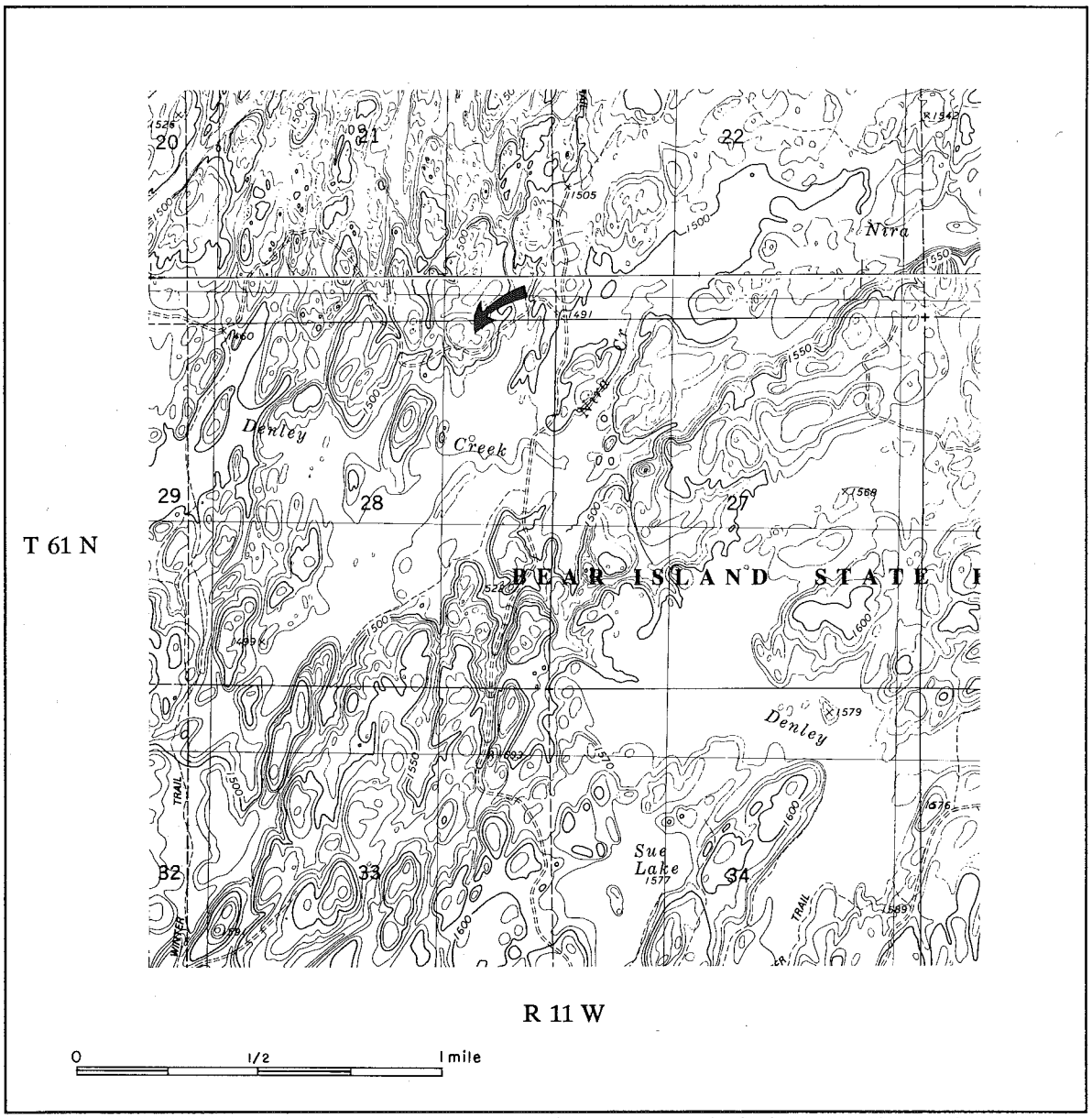

Figure 8. Site Number: Lake - 7. Base map from U.S. Geological Survey Slate Lake West and Bogberry Lake 7.5 minute quadrangles.

Site No.: Lake - 49

Commodity: Black granite
Geological Rock Name: Olivine-bearing anorthosite

County: Lake
TRS: T 60 N R 11 W Sec 5 SW1/4 NE1/4 (south of lot 2)
UTM: 594025mE, 5285330mN, Zone 15, N.
USGS Quadrangle Map: Slate Lake West

Access: This site can be reached by a gravel road leading north from Forest Road 424 (Tomahawk Road).

Color: **Fresh Surface** - Dark gray, uniform
Weathered Surface - Gray

Texture: Weakly laminated; subhedral plagioclase grains

Grain Size: Medium to coarse, uniform

Joint Pattern: Regular and irregular

Joint Intensity: Moderate to limited; joint spacings range from 3 to 16 ft (1 to 5 m). Sheeting spacings range from 0.5 to 6 ft (0.15 to 2 m) at the surface.

Geological Setting: This area is underlain by Middle Proterozoic mafic intrusive rocks of the Duluth Complex.

Geology: This rock is an olivine-bearing anorthosite of uniform dark gray color. It is medium- to coarse-grained and displays a weak lamination resulting from the preferred orientation of plagioclase laths. The predominant mineral is plagioclase with subordinate olivine. When polished the plagioclase crystals have a translucent gray appearance and the individuality of the yellowish-green olivine grains is lost in a dark gray background. Outcrops are intermittently exposed along an elongate ridge. Regular and irregular joint patterns are present. The dominant joint sets trend at approximately 320°. In a 100 x 80 ft (30 x 25 m) area joint spacings of 10 ft (3 m) or greater are common. Sheeting spacings ranges from 0.5 to 6 ft (0.15 to 2 m) at the surface. Other exposures in the immediate vicinity tend to have closer spaced joints. The limited exposure prevents a complete analysis of joint patterns.

Mineralogy: Thin section study indicates a composition of approximately 90% plagioclase, 10% olivine, and accessory clinopyroxene and oxides.

Other Features:

Deleterious Materials: None observed

Outcrop Exposure: Poor; large elongate knob with intermittently exposed outcrops. Smooth sloping outcrop in a 100 x 80 ft (30 x 25 m) area on west side of gravel road.

Quarry Block Potential: Moderate

Surface Ownership: USA

Mineral Ownership: USA

Photo: Yes

Use of Explosives: No

Sample No.: 22645

Thin Section No.: 22645

Polished Tile No.: L-49

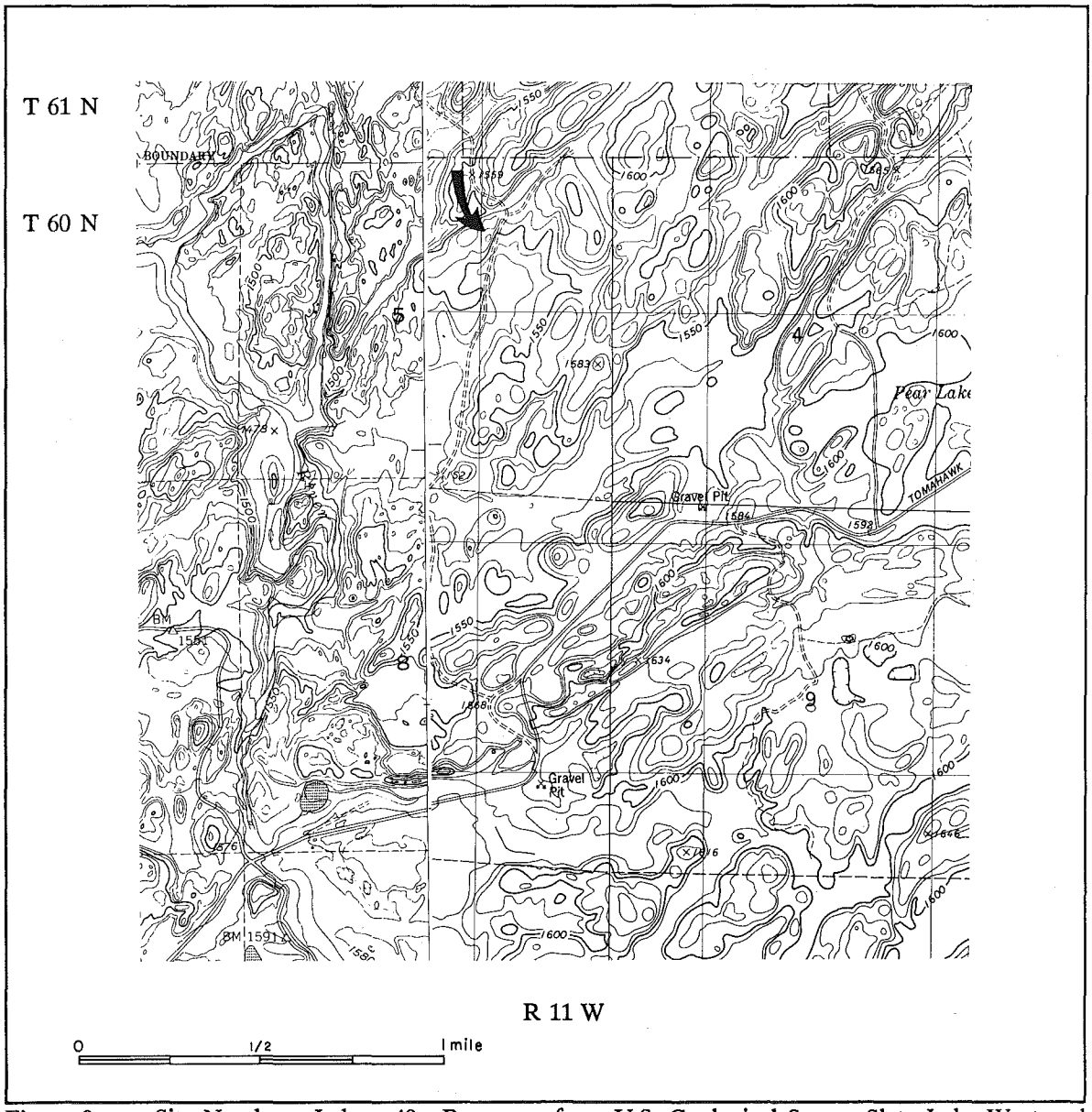

Figure 9. Site Number: Lake - 49. Base map from U.S. Geological Survey Slate Lake West and Babbitt NE 7.5 minute quadrangles.

Site No.: Lake - 53

Commodity: Green granite
Geological Rock Name: Porphyritic gabbroic anorthosite

County: Lake
TRS: T 60 N R 7 W Sec 35 NW1/4 NE1/4
UTM: 636660mE, 5278200mN, Zone 15, N.
USGS Quadrangle Map: Silver Island Lake

Access: This site can be reached by a forest access road leading north from Forest Road 172 (Wanless Road).

Color: **Fresh Surface** - Greenish-gray, uniform
Weathered Surface - Whitish-gray

Texture: Porphyritic, euhedral-granular; consistent

Grain Size: Medium to very coarse, non-uniform

Joint Pattern: Regular and irregular

Joint Intensity: Joint spacings range from 1.5 to 16 ft (0.5 to 5 m), sheeting spacings range from 1.5 to 8 ft (0.5 to 2.5 m) at the surface.

Geological Setting: This area is underlain by Middle Proterozoic mafic intrusive rocks of the Duluth Complex.

Geology: This rock is a greenish-gray, medium- to very coarse-grained porphyritic gabbroic anorthosite. Light greenish-gray, coarse- to very coarse-grained plagioclase crystals (phenocrysts) are distributed in a dark-green to gray mafic ground mass. The color and porphyritic texture that make this rock unique appear to be consistent throughout all the exposures. Regular and irregular joint patterns are present. Joint spacings range from 1.5 to 16 ft (0.5 to 5 m); much of the jointing is spaced greater than 8 ft (2.5 m). The dominant joint sets trend at approximately 320° and have near vertical dips. Sheeting spacings range from 1.5 to 8 ft (0.5 to 2.5 m) at the surface. Healed fractures (black lines) were noted in some areas of the outcrop but are reasonably spaced to permit the quarrying of large blocks.

Mineralogy: Thin section study indicates a composition of approximately 70-75% plagioclase, the plagioclase crystals appear fractured and exhibit sericite and chlorite alteration, 10-15% clinopyroxene altering to amphibole, 3-6% chlorite/serpentine?, 5-10% interstitial granophyric intergrowths (K-feldspar and quartz), 1% opaque, and accessory apatite, quartz, and sulfide.

Other Features: Magnetic; 12 in. (30 cm) wide basaltic dike observed

Deleterious Materials: Trace amount of sulfides

Outcrop Exposure: Fair; intermittently exposed ledges 3 to 20 ft high (1 to 6 m) and bald knobs in clearcut area

Quarry Block Potential: Good

Surface Ownership: USA

Mineral Ownership: USA

Photo: Yes

Use of Explosives: No

Sample No.: 22638 **Thin Section No.:** 22638

Polished Tile No.: L-53

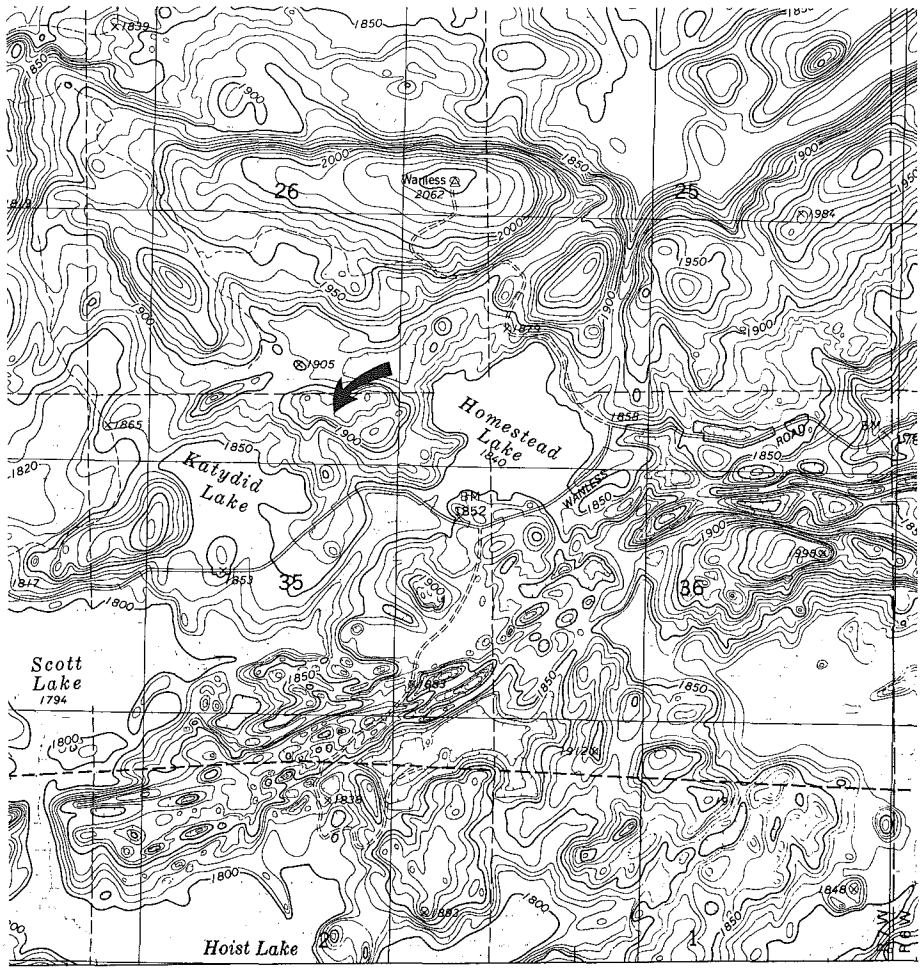

Figure 10. Site Number: Lake - 53. Base map from U.S. Geological Survey Silver Island Lake 7.5 minute quadrangle.

Site No.: Lake - 54

Commodity: Black granite
Geological Rock Name: Anorthositic gabbro

County: Lake
TRS: T 61 N R 6 W Sec 15 NW1/4 SW1/4
T 61 N R 6 W Sec 15 S1/2 SW1/4 NW1/4
UTM: 643630mE, 5291960mN, Zone 15, N.
USGS Quadrangle Map: Kawishiwi Lake

Access: This site can be reached by a primitive road leading northwest from County Road 7.

Color: **Fresh Surface** - Gray with white to brown tones
Weathered Surface - Gray

Texture: Subophitic

Grain Size: Coarse, uniform

Joint Pattern:

Joint Intensity: Limited; sheeting undetermined

Geological Setting: This area is underlain by Middle Proterozoic mafic intrusive rocks of the Duluth Complex.

Geology: This rock is a coarse-grained anorthositic gabbro of dark gray color. Plagioclase, the predominant mineral, is distributed in an interesting arrangement of long tabular crystals with varying orientations. When polished the plagioclase crystals exhibit gray with white to brown tones. The jointing that is exposed is widely spaced. In a 50 x 30 ft (16 x 10 m) exposure, two joints were observed trending at 40° and 120°. The limited exposure prevents a complete analysis of joint patterns.

Mineralogy: Thin section study indicates a composition of approximately 75% plagioclase, 20% clinopyroxene, 3% olivine, 2% opaque, and accessory sulfide.

Other Features:

Deleterious Materials: Trace amounts of sulfides

Outcrop Exposure: Poor; smooth sloping outcrop, 50 x 30 ft (16 x 10 m) exposure

Quarry Block Potential: Moderate to good

Surface Ownership: USA

Mineral Ownership: USA

Photo: Yes

Use of Explosives: No

Sample No.: 23282 **Thin Section No.:** 23282

Polished Tile No.: L-54

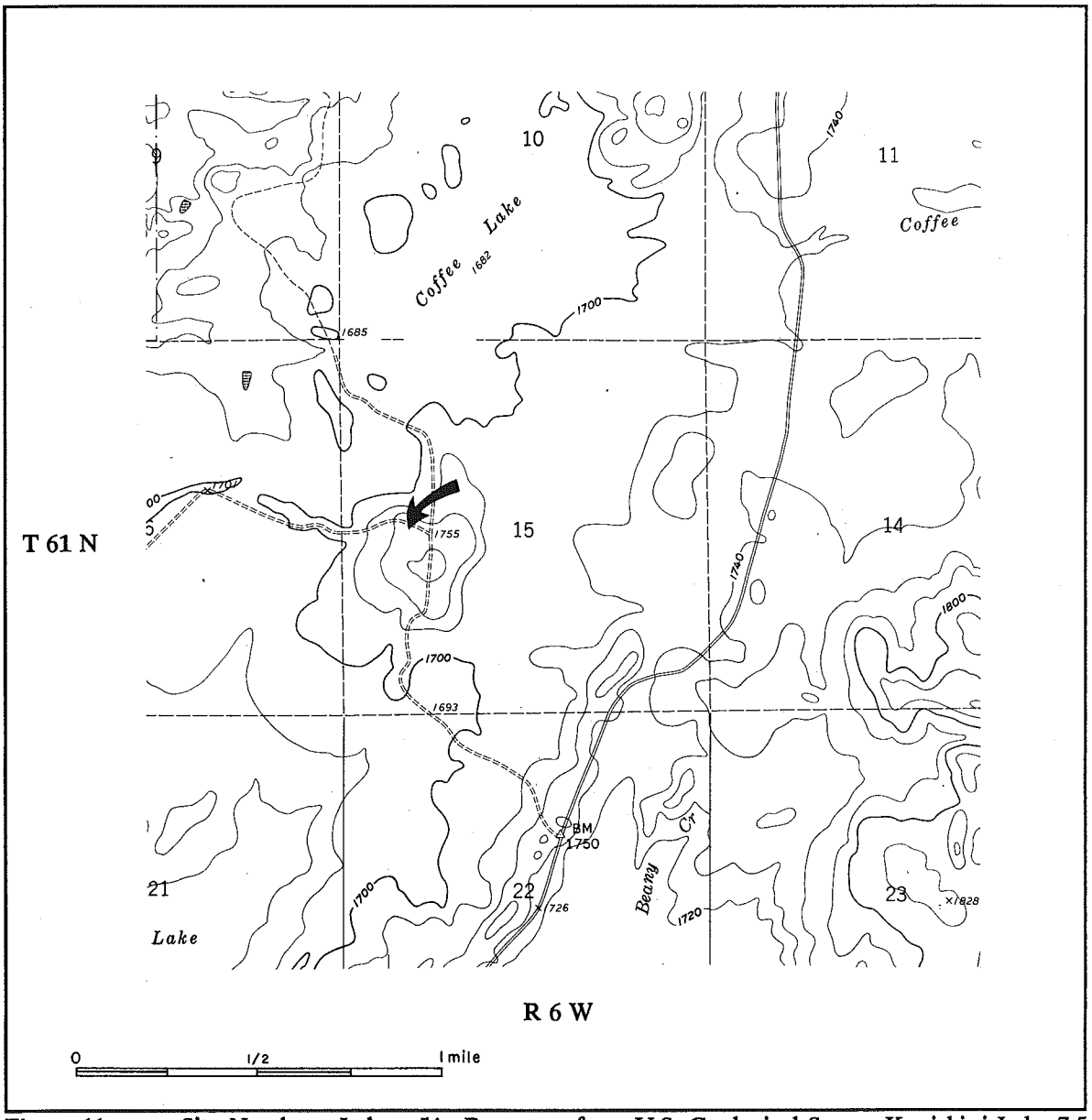

Figure 11. Site Number: Lake - 54. Base map from U.S. Geological Survey Kawishiwi Lake 7.5 minute quadrangle.

Site No.: Lake - 65

Commodity: Black granite
Geological Rock Name: Gabbroic anorthosite

County: Lake
TRS: T 61 N R 11 W Sec 24 S1/2 SW1/4 and W1/2 SW1/4 SE1/4
T 61 N R 11 W Sec 25 N1/2 NW1/4
UTM: 599340mE, 5289070mN, Zone 15, N.
USGS Quadrangle Map: Bogberry Lake and Slate Lake West

Access: This site can be reached by a primitive road leading north from Forest Road 424 (Tomahawk Road).

Color: **Fresh Surface** - Dark gray, uniform
Weathered Surface - Gray with black blotches

Texture: Ophitic; weakly laminated

Grain Size: Medium to coarse

Joint Pattern: Regular and irregular

Joint Intensity: Moderate to limited; joint spacings range from 0.5 to 23 ft (0.15 to 7 m). Sheeting is 5 ft (1.5 m) at the surface.

Geological Setting: This area is underlain by Middle Proterozoic mafic intrusive rocks of the Duluth Complex.

Geology: This rock is an ophitic gabbroic anorthosite of uniform dark gray color. It is medium- to coarse-grained and displays a weak lamination resulting from the preferred orientation of plagioclase laths. When polished the plagioclase crystals have a translucent gray appearance. Black clinopyroxene oikocrysts (large crystal of clinopyroxene enclosing smaller crystals of plagioclase) are seen consistently throughout most of the exposures. Regular and irregular joint patterns are present. The dominant joint sets trend at approximately 360°; other joint sets were noted trending at 90° and 120° to 140°. The joint spacings range from 0.5 to 23 ft (0.15 to 7 m). Sheeting is 5 ft (1.5 m) at the surface.

Mineralogy: Thin section study indicates a composition of approximately 85% plagioclase, 10% clinopyroxene, 3% oxide, and 2% olivine.

Other Features: Local healed fractures and pyroxene rich zones were noted.

Deleterious Materials: None observed

Outcrop Exposure: Moderate to poor; smooth low lying outcrops intermittently exposed along primitive road

Quarry Block Potential: Moderate to good

Surface Ownership: USA

Mineral Ownership: USA

Photo: Yes

Use of Explosives: No

Sample No.: 23283

Thin Section No.: 23283A, 23283B

Polished Tile No.: L-65

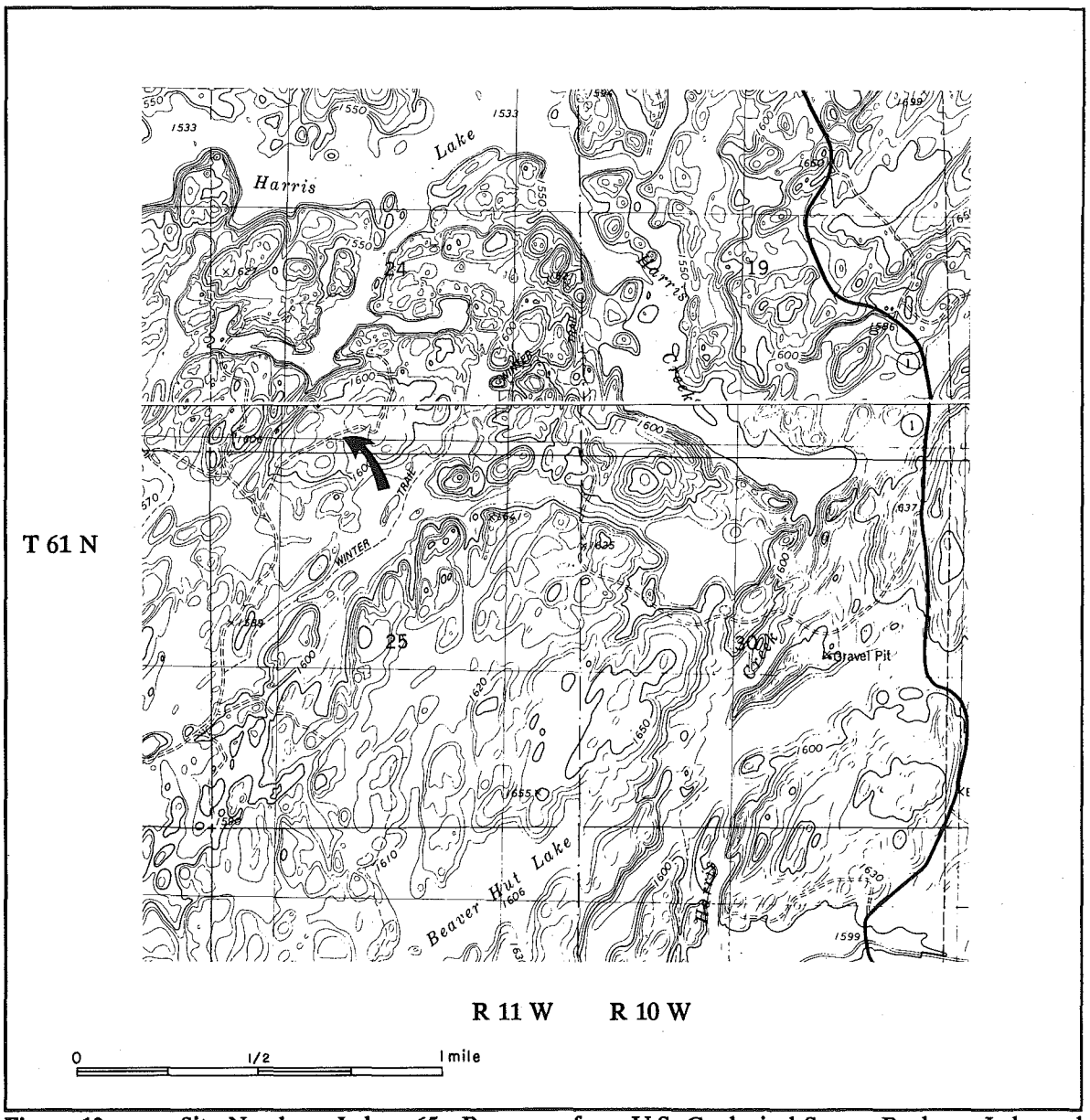

Figure 12. Site Number: Lake - 65. Base map from U.S. Geological Survey Bogberry Lake and Slate Lake West 7.5 minute quadrangles.

Site No.: St. Louis - 95

Commodity: Grayish-pink and brownish-gray granite
Geological Rock Name: Granite

County: St. Louis
TRS: T 66 N R 17 W Sec 2 SW1/4 SE1/4 and SE1/4 SE1/4
UTM: 538600mE, 5341030mN, Zone 15, N.
USGS Quadrangle Map: Echo Lake

Access: This site can be reached by a logging road leading west off of County Road 24.

Color: **Fresh Surface** - Grayish-pink and brownish-gray
Weathered Surface - White to light gray

Texture: Slightly porphyritic; consistent

Grain Size: Medium to coarse, non-uniform

Joint Pattern: Regular

Joint Intensity: Limited; joint spacings range from 3 to 50 ft (1 to 16 m), ledges exhibit sheeting spacings of up to 6 ft (2 m)

Geological Setting: This area is underlain by Archean rocks of the Vermilion Granitic Complex.

Geology: Two colors of granite are present at this site; a grayish-pink and a brownish-gray. The rock is predominantly medium-grained but is weakly porphyritic, containing some coarse-grained feldspar crystals (phenocrysts) averaging 0.5 in. (1 cm) in length. This texture is consistent throughout most of the exposures. Regular joint patterns were observed. The dominant joint sets trend at approximately 360°, with secondary joint sets trending at 40° and 70°. Large areas of outcrop exhibit widely spaced joints; joint spacings of up to 50 ft (16 m) were observed. Some ledges exhibit sheeting spacings of up to 6 ft (2 m). Minor dikes and irregular shaped masses of pegmatite were noted, but most of the rock appears to be pegmatite free.

Mineralogy: Thin section study indicates a composition of approximately 32-41% microcline, 30-40% plagioclase, 16-30% quartz, 4-8% biotite, and accessory apatite, sphene, and muscovite.

Other Features: Local pegmatitic dikes and irregular shaped masses noted; however, most of the rock appears to be pegmatite free.

Deleterious Materials: None observed

Outcrop Exposure: Good; large knob and low lying outcrops

Quarry Block Potential: Very good

Surface Ownership: T 66 N R 17 W Sec 2 SW1/4 SE1/4: State of MN
Mineral Ownership: T 66 N R 17 W Sec 2 SW1/4 SE1/4: State of MN

Surface Ownership: T 66 N R 17 W Sec 2 SE1/4 SE1/4: USA
Mineral Ownership: T 66 N R 17 W Sec 2 SE1/4 SE1/4: USA

Photo: Yes

Use of Explosives: No

Sample No.: 23284

Thin Section No.: 23284A, 23284B

Polished Tile No.: S-95

ASTM Physical Property Tests: Sample sent to U.S. Bureau of Mines

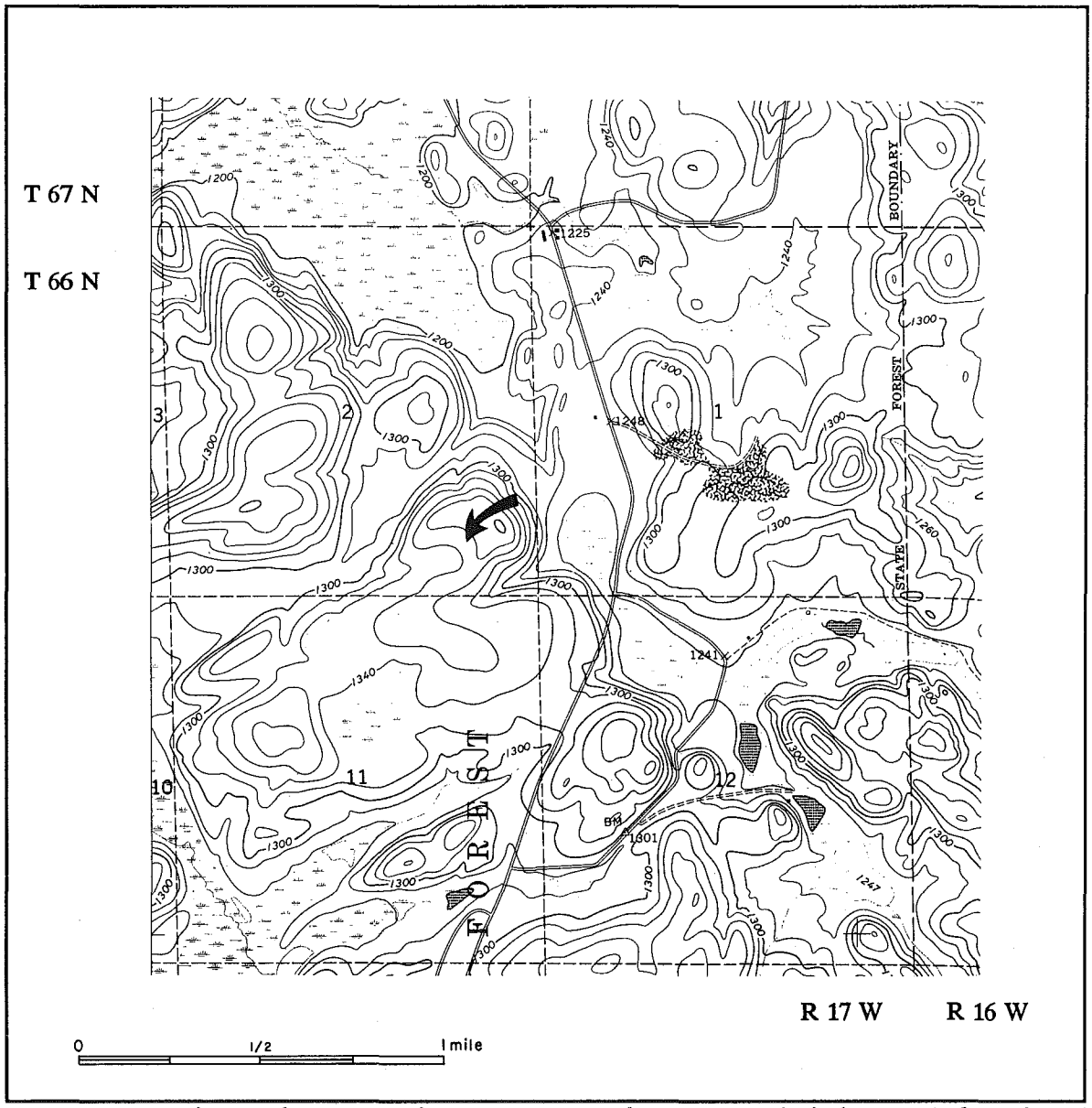

Figure 13. Site Number: St. Louis - 95. Base map from U.S. Geological Survey Echo Lake 7.5 minute quadrangle.

Inactive Quarry Descriptions

Site No.: Lake - 11

Commodity: Black granite
Geological Rock Name: Troctolitic anorthosite

County: Lake
TRS: T 61 N R 11 W Sec 13 SE1/4 NE1/4
UTM: 600230mE, 5291570mN, Zone 15, N.
USGS Quadrangle Map: Bogberry Lake

Access: The quarry can be reached by an old quarry road leading approximately 300 ft (90 m) east off of State Hwy 1.

Color: **Fresh Surface** - Dark gray, uniform
Weathered Surface - Gray

Texture: Weakly laminated; subhedral plagioclase grains

Grain Size: Medium to coarse, uniform

Joint Pattern: Regular and irregular

Joint Intensity: Variable; joint spacings range from 1.5 to 23 ft (0.5 to 7 m), sheeting spacings range from 1 to 10 ft (0.3 to 3 m)

Geological Setting: This area is underlain by Middle Proterozoic mafic intrusive rocks of the Duluth Complex.

Geology: This rock is a troctolitic anorthosite of uniform dark gray color. It is medium- to coarse-grained and displays a weak lamination resulting from the preferred orientation of plagioclase laths. Regular and irregular joint patterns are present. The dominant joint sets trend at approximately 360°, other joint sets trend from 65° to 75°. Joint spacings range from 1.5 to 23 ft (0.5 to 7 m); sheeting spacings range from 1 to 10 ft (0.3 to 3 m). Various sizes of angular to rectangular blocks are present in waste piles in and near the quarry. Blocks of up to 8 x 5 x 3 ft (2.5 x 1.5 x 1 m) were observed. This quarry has been inactive for many years.

About 500 ft (150 m) southwest of the quarry, a small outcrop along Hwy 1 displays joint spacings of up to 26 ft (8 m).

Mineralogy: Thin section study indicates a composition of approximately 84% plagioclase, 14% olivine, 2% oxides, and accessory clinopyroxene and sulfides.

Other Features:

Deleterious Materials: Trace amount of sulfides

Outcrop Exposure: Good; large knob

Quarry Block Potential: Moderate to good

Surface Ownership: USA

Mineral Ownership: USA

Photo: Yes

Use of Explosives: No

Sample No.: 22643

Thin Section No.: 22643

Polished Tile No.: L-11

ASTM Physical Property Tests: Sample sent to U.S. Bureau of Mines

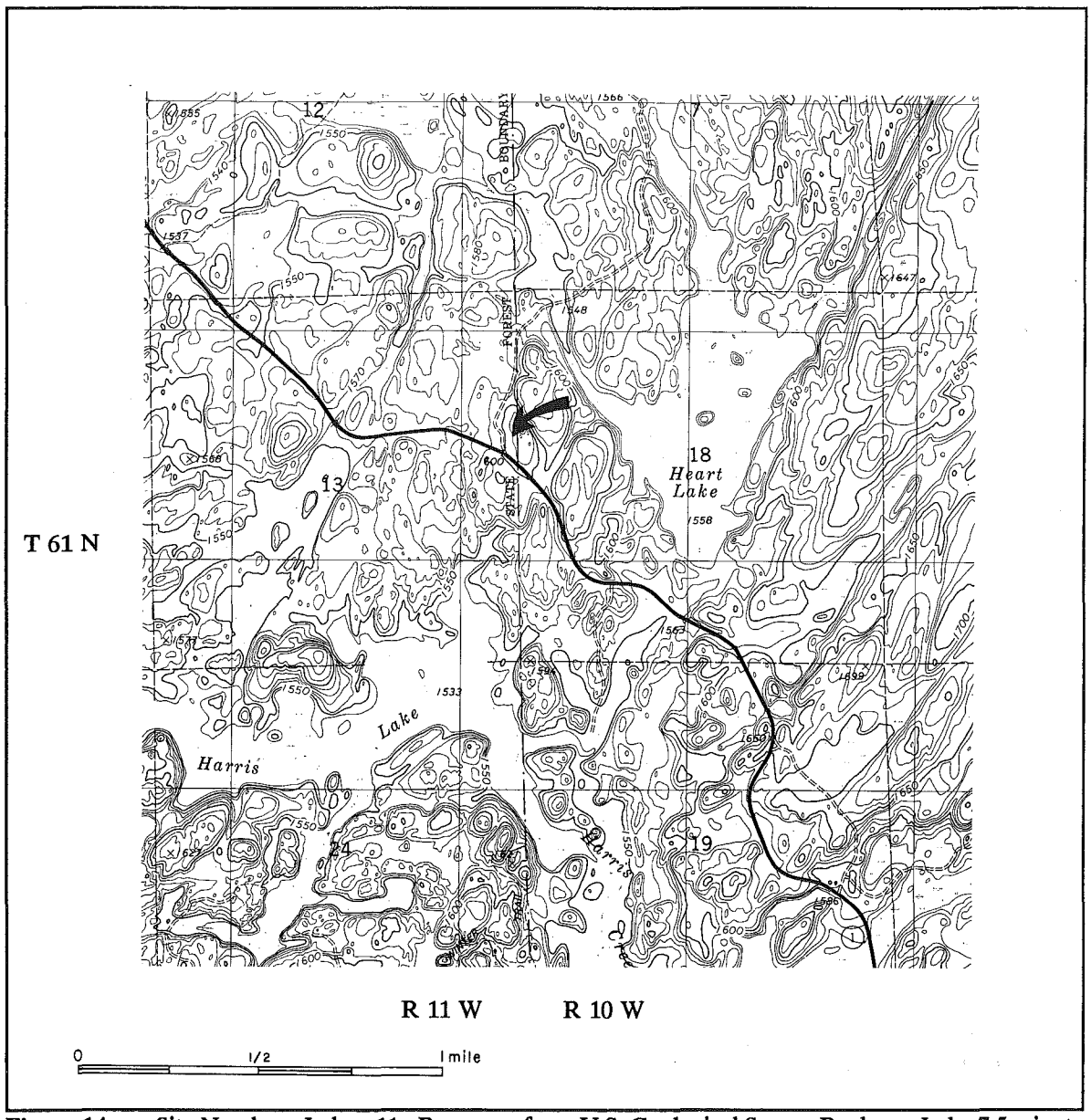

Figure 14. Site Number: Lake - 11. Base map from U.S. Geological Survey Bogberry Lake 7.5 minute quadrangle.

Site No.: Lake - 13

Commodity: Black granite
Geological Rock Name: Gabbroic or troctolitic anorthosite

County: Lake
TRS: T 61 N R 11 W Sec 11 SE1/4 NW1/4
UTM: 597710mE, 5293150mN, Zone 15, N.
USGS Quadrangle Map: Bogberry Lake

Access: The quarry can be reached by an abandoned quarry road, which runs approximately 1180 ft (360 m) to the west off of State Hwy 1.

Color: **Fresh Surface** - Dark gray, uniform
Weathered Surface - Gray

Texture: Weakly laminated; euhedral plagioclase grains

Grain Size: Medium to coarse, uniform

Joint Pattern: Regular and irregular

Joint Intensity: Variable; joint spacings range from 1 to 16 ft (0.3 to 5 m), sheeting spacings range from 0.3 to 6 ft (0.1 to 2 m)

Geological Setting: This area is underlain by Middle Proterozoic mafic intrusive rocks of the Duluth Complex.

Geology: This rock is a gabbroic or troctolitic anorthosite of uniform dark gray color. It is medium- to coarse-grained and exhibits a weak lamination resulting from the preferred orientation of plagioclase laths. Regular and irregular joint patterns are present. The dominant joint sets trend at approximately 360°, and dips range from 70° to 90°; other joints trend from 280° to 320°. Joint and sheeting spacings are variable throughout the quarry. Joint spacings range from 1 to 16 ft (0.3 to 5 m), sheeting spacings range from 0.3 to 6 ft (0.1 to 2 m). Angular to rectangular blocks of up to 10 x 5 x 3 ft (3 x 1.5 x 1 m) in size were observed in waste piles near the quarry. These blocks on the average are smaller than those of quarry L-11. This quarry has been inactive for many years.

Approximately 165 ft (50 m) east of the quarry is a low lying outcrop where joint spacings of up to 10 ft (3 m) and greater are common. The joints trend at 290°, 240°, and 280°. The moss cover prevents a complete analysis of the joint patterns. Drill holes and anchor bolts were noted at this exposure. This outcrop appears to be less jointed then the remaining outcrop at the quarry site.

Mineralogy: Thin section study indicates a composition of approximately 82% plagioclase, 8% olivine, 6% clinopyroxene, 3% opaques, and 1% symplectite.

Other Features:

Deleterious Materials: Trace amount of sulfides

Outcrop Exposure: Good

Quarry Block Potential: Moderate in quarry, more promising in surrounding area

Surface Ownership: USA

Mineral Ownership: USA

Photo: Yes

Use of Explosives: Yes

Sample No.: 22642

Thin Section No.: 22642

Polished Tile No.: L-13

ASTM Physical Property Tests: Sample sent to U.S. Bureau of Mines

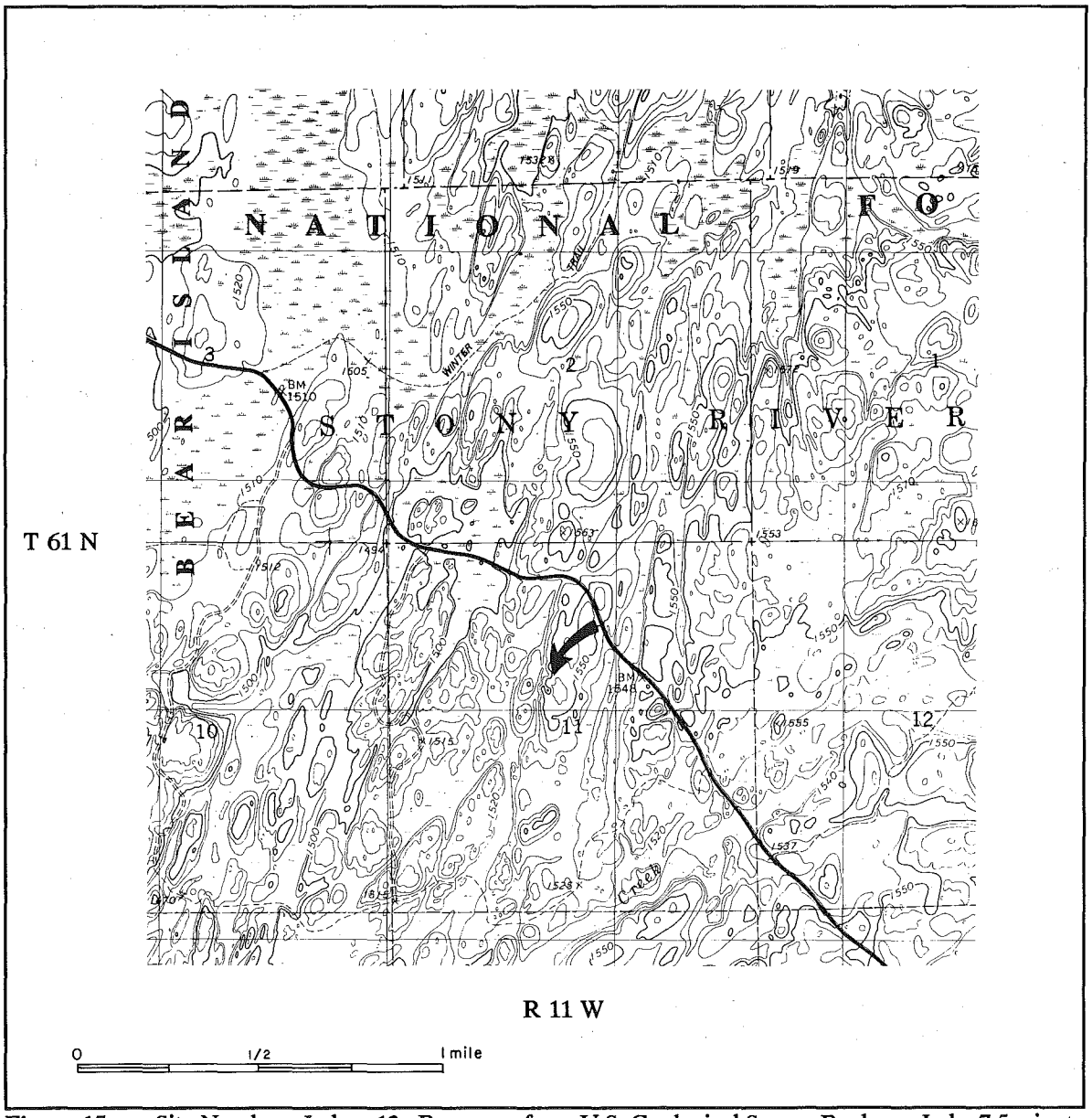

Figure 15. Site Number: Lake - 13. Base map from U.S. Geological Survey Bogberry Lake 7.5 minute quadrangle.

Additional Information

A brochure containing photographs of polished tiles from prospects is available upon request. The brochure was produced through a cooperative agreement between the Minnesota Department of Natural Resources and the Superior National Forest, USDA. For further information contact the MDNR Minerals offices in Hibbing (218-262-6767) or St. Paul (612-296-4807), or the Zone Geologist from the Superior National Forest in Duluth (218-720-5360).

The U.S. Bureau of Mines is currently compiling information on the physical properties of various crystalline rocks found throughout the United States, including test results from selected sites identified by this inventory. This information will be available in a forthcoming U.S. Bureau of Mines report. For further information contact the Group Supervisor of the Geotechnology Section of the U.S. Bureau of Mines in Minneapolis (612-725-4580).

During the 1991 field season, the Minerals Division will expand the evaluation of outcrops to include outcrops further from roads and areas previously not evaluated within the original survey area.

Summary

A total of two hundred forty-four rock outcrops were described during the first two years of the MDNR's dimension stone inventory. The sites were classified into three groups: (1) **Prospects** (areas of potential), (2) **Inactive quarries** and (3) **Occurrences** (sites of little or no potential).

Eight prospects and two inactive quarries were identified by the inventory. Because these deposits were evaluated primarily by surface observations, further evaluation and sampling may be required to determine if they are of suitable quality and quantity for quarrying. Information on the occurrences is not included in this report, but it is available as open-file information at the division's Hibbing office.

A brochure containing photographs of polished tiles from prospects is available upon request from the Minnesota Department of Natural Resource and the Superior National Forest, USDA.

Polished tiles from the prospects and inactive quarries are available for inspection at the MDNR Minerals offices in Hibbing and St. Paul, and the Superior National Forest office in Duluth.

Physical property test results from selected sites are available upon request from the U.S. Bureau of Mines.

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Publication Notification