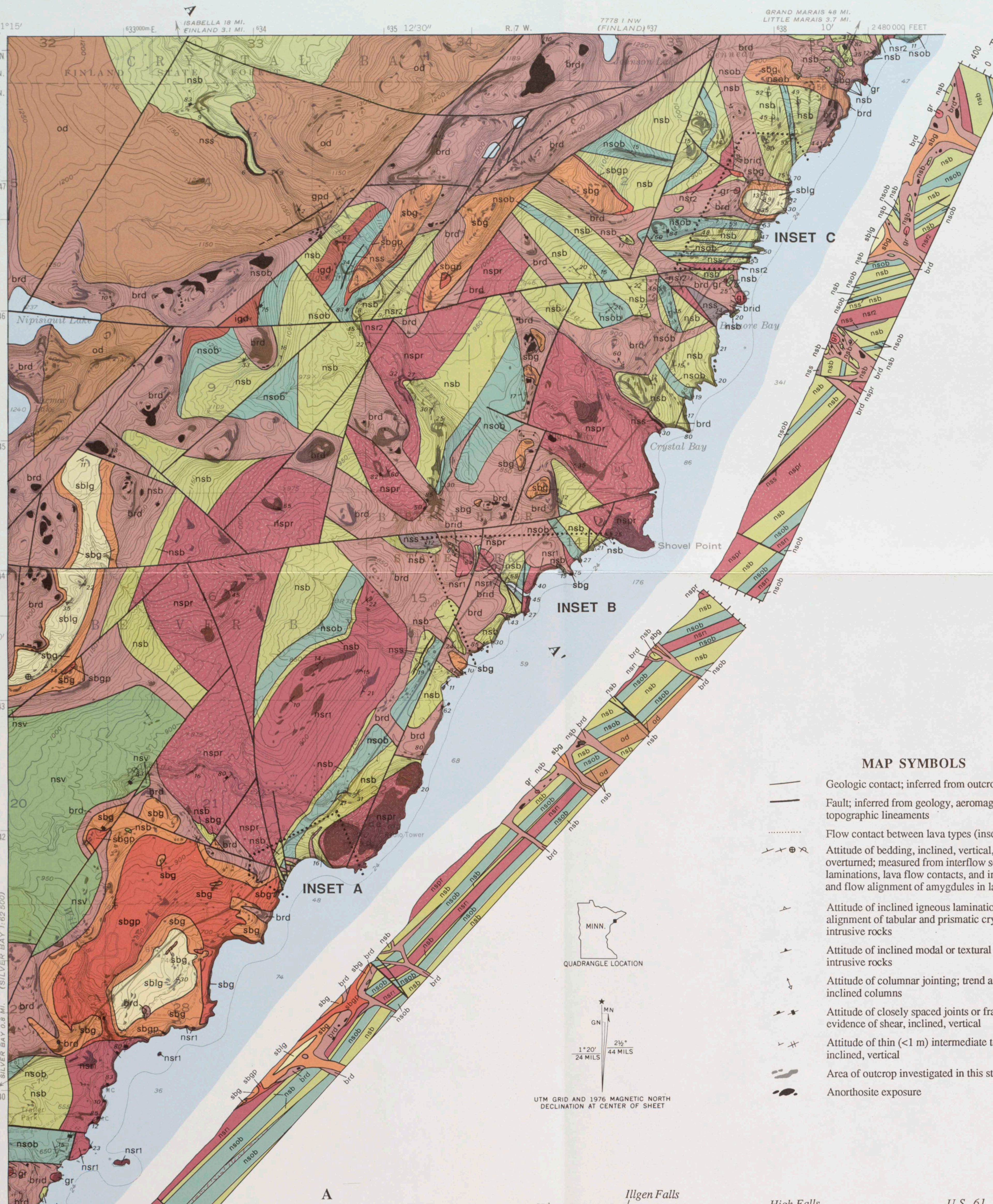
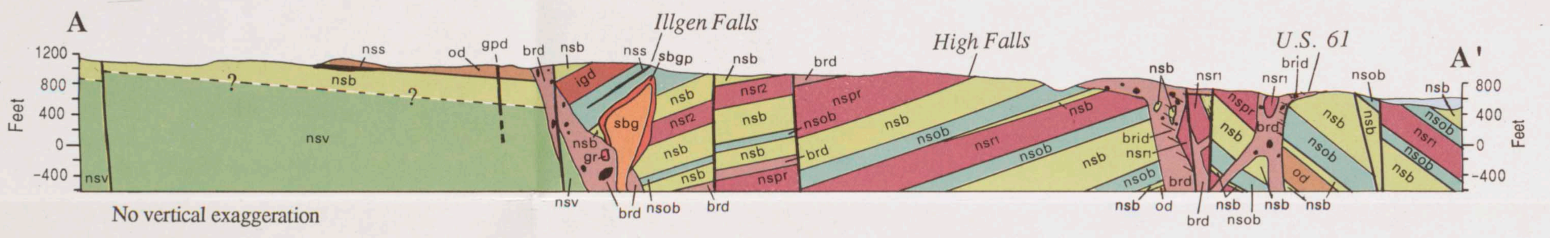
UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
Priscilla C. Grew, Director

MAPPED IN COOPERATION WITH THE
U.S. GEOLOGICAL SURVEY COOPERATIVE GEOLOGIC MAPPING (COGEOMAP) PROGRAM

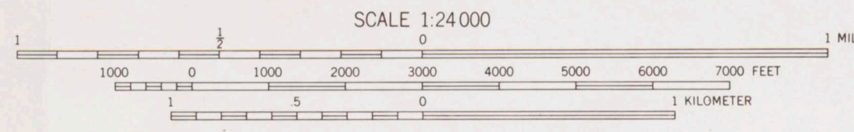
MISCELLANEOUS MAP SERIES
M-66
Illgen City Quadrangle





MAP SYMBOLS

- Geologic contact; inferred from outcrop control
- Fault; inferred from geology, aeromagnetic data, and topographic lineaments
- Flow contact between lava types (insets only)
- Attitude of bedding, inclined, vertical, horizontal, overturned; measured from interflow sediment laminations, lava flow contacts, and internal banding and flow alignment of amygdules in lava flows
- Attitude of inclined igneous lamination (planar alignment of tabular and prismatic crystals) in intrusive rocks
- Attitude of inclined modal or textural layering in intrusive rocks
- Attitude of columnar jointing; trend and plunge of inclined columns
- Attitude of closely spaced joints or fractures with evidence of shear, inclined, vertical
- Attitude of thin (<1 m) intermediate to felsic dikes; inclined, vertical
- Area of outcrop investigated in this study
- Anorthosite exposure

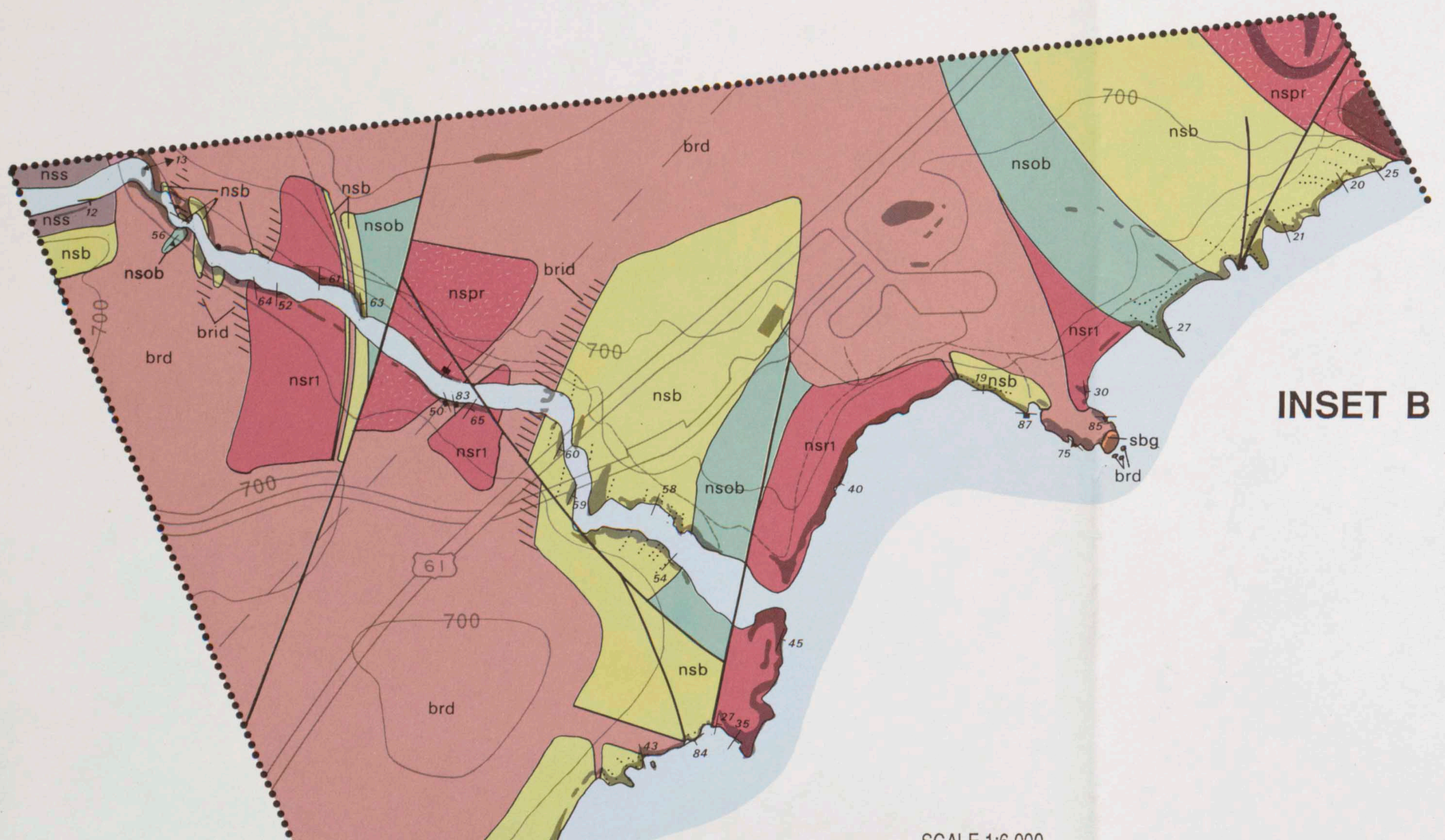


SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS 601 FEET

Base modified from U.S. Geological Survey, 1956-76.

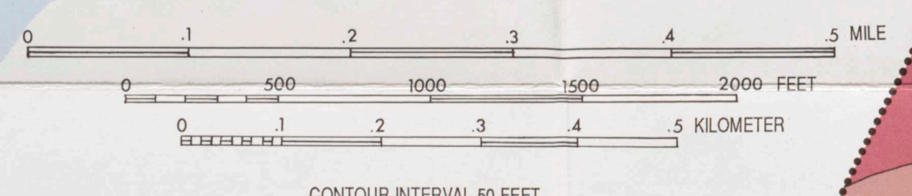
Geology mapped 1986-1987 with the assistance of Colin Reichhoff, Drummond Earley III, Daniel K. Holm, Michael J. Spicuzza, and W. James Dunlap.



INSET B

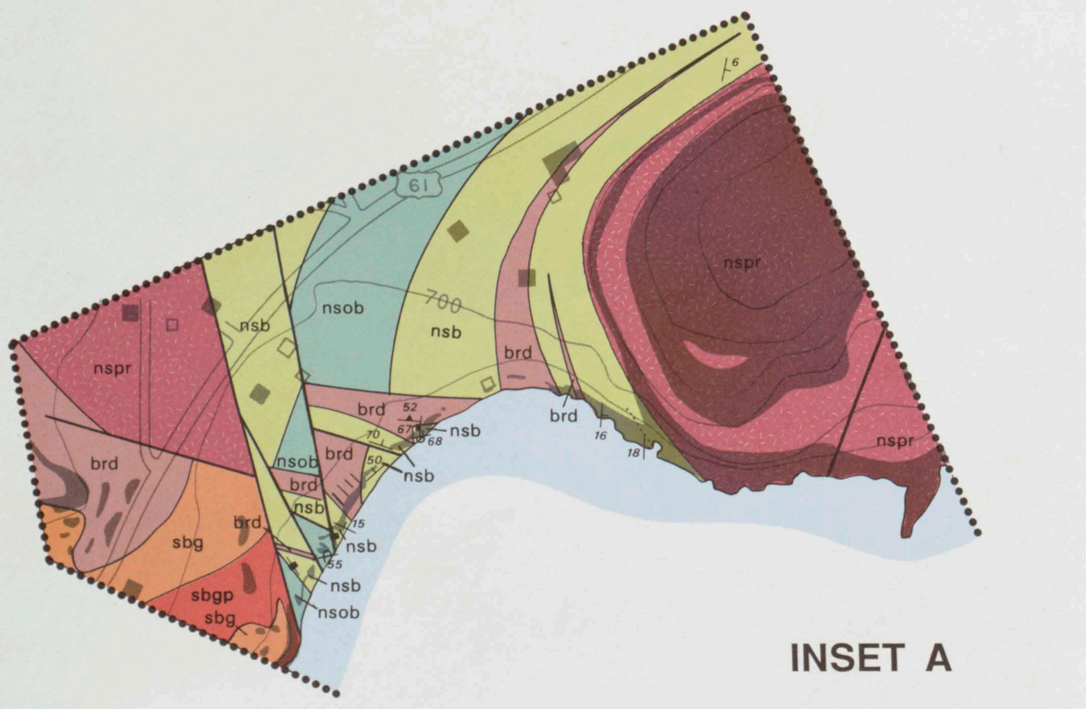
ADDITIONAL MAP SYMBOLS

- Power transmission line
- Trail
- Road
- Gravel pit

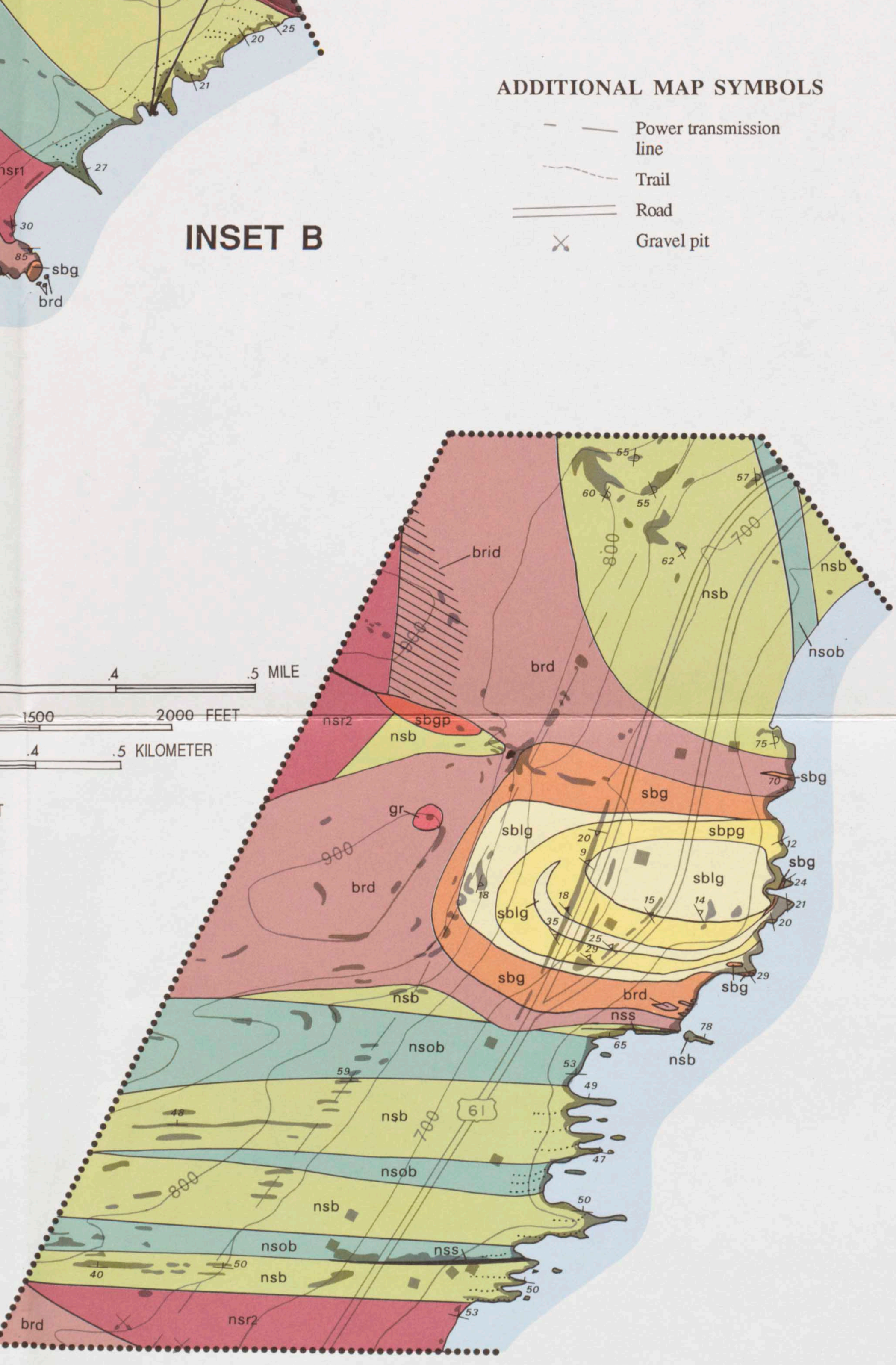


SCALE 1:6,000

CONTOUR INTERVAL 50 FEET

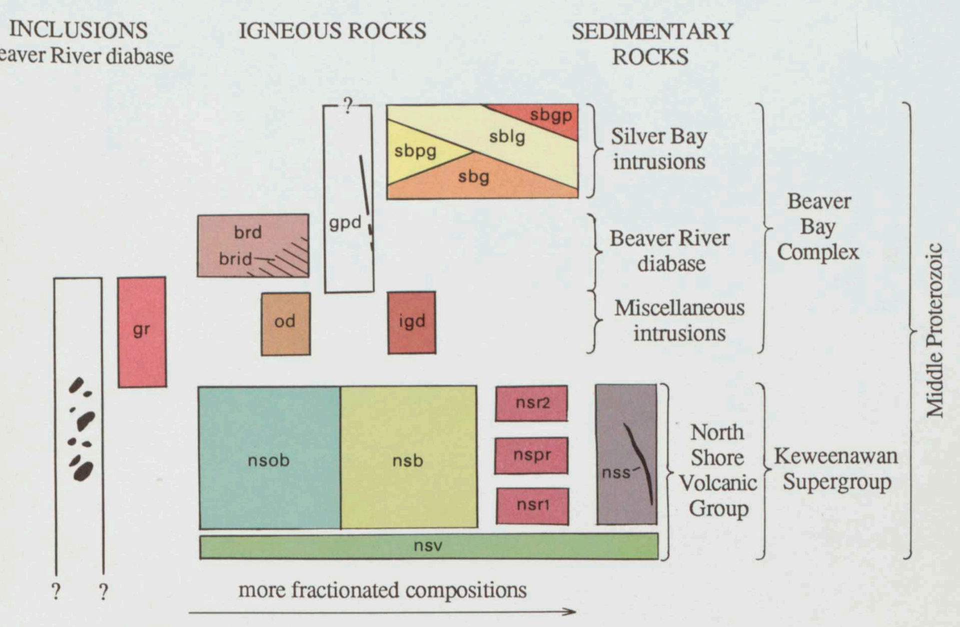


INSET A



INSET C

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

BEAVER BAY COMPLEX—an igneous supersuite unit that is part of the Midcontinent rift system. Includes all intrusive rocks occurring along the North Shore of Lake Superior between Split Rock Point and the Caribou River and traceable at least 30 km inland (after Grout and Schwartz, 1939).

SILVER BAY INTRUSIONS—an informal lithodemic unit consisting of gabbroic to granitic rocks in strongly differentiated, zoned, saucer-shaped intrusions and in irregularly shaped bodies, which were emplaced within or adjacent to Beaver River diabase (**brd**) intrusions. Contacts with Beaver River diabase are sharp but not chilled. Contacts among Silver Bay rocks are typically gradational. Zoned intrusions are generally divisible into a marginal zone of varitextured gabbro/diorite (**sbg**) and an interior of laminated olivine gabbro/diorite cumulates (**sblg** and **sbpg**), which commonly display more fractionated compositions upsection. Some irregularly shaped masses are composed of only coarse, decussate gabbroic to dioritic rocks similar to those forming the margins of the zoned intrusions. Both intrusion types locally contain variably sized, irregularly shaped masses of granophyre (**sbgp**), which typically grades into granophyric diorite (**sbg**) on a centimeter to meter scale, or which cuts the other rock types as thin dikes.

sbg Varitextured gabbro/diorite—medium- to coarse-grained, locally pegmatitic, subophitic to intergranular, decussate to rarely laminated, variably granophyric gabbro to quartz monzodiorite. Composed of 40-50% subhedral to euhedral, strongly zoned plagioclase ($An_{60\text{-}18}$; cores > An_{40}); 20-30% subophitic to prismatic, augite-ferroaugite ($En_{42\text{-}20}$ $Fs_{20\text{-}44}$ $Wo_{41\text{-}34}$), commonly with minor rims of pigeonite (e.g., En_{51} Fs_{40} Wo_{9}) and brown hornblende; 0-15% typically altered poikilitic to prismatic olivine ($Fo_{57\text{-}15}$); 5-10% platy ilmenite and anhedral magnetite; 1-4% prismatic apatite; and 5-25% granophyre mesostasis, consisting mostly of quartz, dusty orthoclase, and Na plagioclase (typically as micrographic intergrowths) with iron oxides, chlorite, clay minerals, zeolite, fluorite, zircon, and calcite. Very coarse, accessory-mineral-rich pink granophyre segregations as much as 1 m across are irregularly distributed throughout the unit. These segregations, which are similar in composition to **sbgp** rocks, characteristically contain coarse blades of ferroaugite, trellis-patterned needles of altered iron-rich olivine as much as 25 cm in length, and miarolitic cavities lined with euhedral quartz and alkali feldspar and filled with clay minerals. The rock is commonly deeply weathered to a brown grus. Equivalent to Black Bay gabbro of Gehman (1957).

sbpg Poikilitic olivine gabbro/diorite—medium-grained, equigranular, laminated, poikilitic olivine gabbro cumulate. Olivine oikocrysts (1-4 cm) comprise 5-15% of the rock and are typically altered to a vitreous, black (reddish-brown in thin section), Fe-sheet silicate mineral (hisingerite). Also composed of 40-55% lath-shaped, zoned plagioclase ($An_{55\text{-}37}$; cores > An_{42}); 20-30% prismatic augite-ferroaugite ($En_{40\text{-}25}$ $Fs_{23\text{-}36}$ $Wo_{42\text{-}37}$); 2-10% interstitial pigeonite ($En_{39\text{-}33}$ $Fs_{50\text{-}58}$ $Wo_{11\text{-}7}$); 5-10% platy ilmenite and subhedral magnetite; and 0-5% apatitic and Fe-oxide-bearing granophyre mesostasis. Occurs interlayered with sblg rocks in the interior of the intrusion north of Belmore Bay (see Inset C). Equivalent to part of Beaver Bay ferrogabbro of Gehman (1957).

sblg Laminated olivine ferrodiorite—medium-grained, equigranular, moderately to well-laminated, rarely layered, slightly to moderately granophyric, olivine ferrodiorite cumulate. Alignment of plagioclase and prismatic mafics define a characteristic lamination. Layering of olivine habit and mode is locally developed. Composed of 40-55% lath-shaped, zoned plagioclase ($An_{45\text{-}8}$; cores > An_{34}) with micrographic overgrowth rims common in more evolved (Fe-rich) rocks; 5-10% commonly altered, subpoikilitic to granular olivine ($Fo_{36\text{-}1}$); 20-30% anhedral granular to subprismatic Fe-augite-ferrohedenbergite ($En_{30\text{-}4}$ $Fs_{28\text{-}53}$ $Wo_{43\text{-}37}$); 5-10% anhedral granular to platy Fe-Ti oxide; and 5-15% mesostasis of micrographic quartz and feldspar, pigeonite, apatite, chlorite, zircon, zeolite, clay, and calcite. Equivalent to part of Beaver Bay ferrogabbro of Gehman (1957).

sbgp Granophyre—Mottled pink to green, fine- to medium-grained, hypidiomorphic granular to micrographic granite to quartz monzodiorite. Composed of 75-90% quartz, dusty orthoclase, and Na plagioclase ($An_{45\text{-}30}$; commonly altered to albite and sericite) in modal proportions averaging about 1:1:2; 5-10% commonly uralitized, subprismatic augite ($En_{40\text{-}37}$ $Fs_{17\text{-}20}$ $Wo_{42\text{-}43}$); 3-10% skeletal prismatic Fe-Ti oxides; 2-5% poikilitic calcite; and minor chlorite, zircon, apatite, fluorite, and clay minerals. Plagioclase, orthoclase, and quartz typically display micrographic intergrowth textures, but anhedral to subhedral granular crystals of these phases, especially plagioclase, also occur. In finer grained varieties, plagioclase, augite, and oxides commonly occur as prismatic phenocrysts. This rock type occurs as small dikes and irregular masses in most Silver Bay intrusions, particularly in **sbg**, though only the large-scale occurrences are shown.

BEAVER RIVER DIABASE—an informal lithodemic unit consisting of noncumulate hypabyssal mafic rocks that form an extensive network of dikes, sills, and thick sheets throughout the area. Formerly termed Beaver River gabbro by Gehman (1957).

brd Ophitic olivine diabase—fine- to medium-grained, massive, slightly plagioclase porphyritic, ophitic olivine diabase. Composed of 50-60% subhedral moderately zoned, plagioclase ($An_{80\text{-}45}$, cores > An_{55}); 0-5% plagioclase phenocrysts (xenocrysts?) ($An_{75\text{-}60}$); 15-35% ophitic to subophitic (1-10 cm oikocrysts) augite ($En_{48\text{-}35}$ $Fs_{12\text{-}28}$ $Wo_{41\text{-}37}$); 5-15% poikilitic (1-2 cm) to more commonly granular olivine ($Fo_{75\text{-}32}$); and 2-10% anhedral granular Fe-Ti oxides. Subtle olivine layering is commonly developed near intrusion margins. Interiors of larger sheets typically develop coarse-grained and subophitic to intergranular textures, become enriched in Fe-Ti oxide and granophyre (<5%), and contain more iron-rich mafic phases. Large (1-100 m) inclusions of anorthosite (shown in solid black) and, less commonly, medium-grained granite (larger bodies labeled **gr**) are irregularly distributed throughout the diabase but tend to be concentrated along the base of sills and sheets (see descriptions below). The diabase is slightly chilled against granitic inclusions but not against anorthosite.

brid Inclusion-rich diabase—fine-grained to aphanitic, intergranular diabase with millimeter-sized quartz and feldspar megacrysts and abundant inclusions of anorthosite, granite, basalt, and partially assimilated felsite. Typically occurs near the margins of ophitic olivine diabase intrusions or as inclusions in them. May represent earlier intrusions of Beaver River magma that incorporated and assimilated various volcanic inclusions.

MISCELLANEOUS INTRUSIONS—includes individual dike and sill intrusions emplaced within volcanic rocks. All intrusions, with the possible exception of **gpd**, are older than Beaver River diabase.

gpd Glomeroporphyritic diabase—fine-grained to aphanitic, intergranular, olivine-bearing diabase with 3-10 mm clusters of plagioclase and rare individual pigeonite megacrysts. Groundmass consists of 55-65% plagioclase ($An_{55\text{-}45}$), 20-25% anhedral granular augite ($En_{40\text{-}25}$ $Fs_{20\text{-}37}$ $Wo_{40\text{-}37}$), 5-8% skeletal granular Fe-Ti oxide, 2-3% largely altered olivine (Fo_{72}), and 5-15% fibrous chlorite/clay mesostasis. Medium-grained plagioclase ($An_{82\text{-}60}$) phenocrysts typically occur in clusters of 5-10 crystals. Pigeonite ($En_{59\text{-}55}$ $Fs_{30\text{-}31}$ $Wo_{11\text{-}14}$) megacrysts are rimmed by augite with a compositional range similar to the groundmass. Occurs as a single, strongly columnar-jointed, 15-m-wide vertical dike cutting ophitic diabase (**od**).

od Ophitic diabase—fine-grained, locally layered, ophitic olivine diabase with small (<0.5 cm) augite oikocrysts ($En_{46\text{-}40}$ $Fs_{17\text{-}26}$ $Wo_{39\text{-}31}$) enclosing subhedral plagioclase ($An_{70\text{-}53}$). Interophite area is composed of plagioclase, anhedral Fe oxide, typically altered olivine ($Fo_{50\text{-}44}$), pigeonite (En_{48} Fs_{43} Wo_{9}), biotite, chlorite, and clay minerals. Locally contains up to 5% plagioclase phenocrysts ($An_{78\text{-}68}$). Subtle centimeter-scale layering results from variations in ophite density. In weathered rocks, the interophite area commonly displays a distinctive brick red iron stain. Occurs in the northwest corner of the map area as a single 50- to 65-m-thick sill. Similar in texture and mineralogy to the finer grained varieties of **brd** rocks that intrude it, but is more compositionally evolved than those.

igd Intergranular diabase—aphanitic to medium-grained, massive, intergranular to locally intersertal, oxide-rich diabase. Contains 40-50% subhedral plagioclase ($An_{58\text{-}38}$); 30-40% anhedral granular (rarely prismatic or subophitic) augite ($En_{41\text{-}35}$ $Fs_{23\text{-}33}$ $Wo_{37\text{-}30}$); 10-15% anhedral granular Fe-Ti oxide and rare pyrite; 2-5% altered olivine; and minor interstitial biotite, orthoclase, quartz, calcite, apatite, hornblende, chlorite, and brown cryptocrystalline mesostasis (altered glass?). Occurs in the central part of the map area as a single 10- to 20-m-thick sill.

INCLUSIONS IN BEAVER RIVER DIABASE

Anorthosite—coarse-grained, locally tectonized, plagioclase cumulate. Largely 85-99% tabular to granular calcic plagioclase ($An_{80\text{-}54}$), together with various amounts of granular hypersthene, granular to poikilitic olivine, subophitic to ophitic augite, and anhedral granular Fe-Ti oxide. Isotopic and trace element evidence for the age of these inclusions is ambiguous but suggests that they may be pre-rift (Morrison and others, 1983).

gr Granite—pink, medium-grained, hypidiomorphic granular to micrographic granite, commonly with miarolitic cavities. Composed of 35-50% subhedral to micrographic, commonly perthitic, alkali feldspar; 15-25% anhedral granular to micrographic quartz; 10-20% subhedral Na plagioclase; and 5-15% Fe-rich, typically altered, subpoikilitic to anhedral granular pyroxene and rare garnet and Fe-olivine. May be inclusions of Finland granite, which occurs in the Finland quadrangle to the north.

KEWEENAWAN SUPERGROUP—stratified rocks that also are part of the Midcontinent rift system.

NORTH SHORE VOLCANIC GROUP—a thick (3-7 km) sequence of lava flows and minor interflow sedimentary rocks extending along the North Shore of Lake Superior from Duluth to Grand Portage. In this area, the rocks belong to the upper part, which has normal polarity. The volcanic sequence may be divided into several stratigraphic packages of basaltic lavas occurring between thick and areally extensive rhyolite flows. These packages, which may contain a laterally variable succession of basaltic lava types, are termed the Gooseberry River basalts below **nsr**1, the Baptism River lavas between **nsr**1 and **nspr**, and the Bell Harbor lavas above **nspr** (Green, 1972).

nsv Undifferentiated volcanic rocks—generally low areas with little or no outcrop presumed to be mostly underlain by volcanic rocks and minor interflow sedimentary rocks. May also include miscellaneous intrusions.

nsb Basalt and basaltic andesite—volcanic sequence dominated by fine-grained, intergranular to intersertal and locally subvariolitic basalt and basaltic andesite. Sequence may include other volcanic rock types, but if so, they are uncommon. Typically strongly altered from original mineralogy, which consisted of plagioclase (locally flow-aligned), augite, low-Ca pyroxene, iron oxide, and rare olivine. Some flows are plagioclase porphyritic (<5%). Some more andesitic compositions display mm-scale laminations reflecting varied degrees of oxidation. Strongly amygdaloidal flow tops are typically brecciated and infilled with sandstone. Recrystallization textures and granophyre dikes are common in the vicinity of intrusive rocks.

nsob Olivine tholeiite/ophitic basalt—volcanic sequence dominated by fine- to medium-fine-grained, intergranular to ophitic, basaltic lava flows. Many lava interiors, especially in thicker flows (>10-15 m), display ophitic texture with oikocrysts of augite as much as 5 mm across enclosing labradoritic plagioclase, altered granular olivine, and granular iron oxide. Flow tops and bottoms and the interior of thin flows are typically subophitic to intergranular or intersertal with altered cryptocrystalline to glassy interstices and diktytaxitic cavity fillings. Plagioclase phenocrysts are common (<5%) and groundmass plagioclase locally displays trachytic texture. Where well exposed, olivine tholeiite flows that do not display ophitic texture may be recognized by smooth, billowing, amygdaloidal flow tops, pipe vesicles at their base, and locally vesicle cylinders in their interiors. The **nspb** unit identified in the lakeshore cross section is a plagioclase porphyritic ophitic basalt flow, which is exposed in the Silver Bay quadrangle to the west (Miller, 1988).

nsr Aphyric rhyolite—pink to light-gray, aphanitic to fine-grained, intergranular to quartz poikilitic (after tridymite), commonly spherulitic, aphyric to mildly feldspar-porphyritic rhyolite. Commonly displays flow banding of mm- to cm-thick, light-colored layers, which are typically uniform in orientation but locally are convoluted and brecciated, especially near the base and top of the flow. Quartz-lined vesicles are common in brecciated flow top. A greenish clay layer locally occurs at the base and top of the unit, possibly representing an altered ash. Occurs as two distinct flows in the area. The lower unit (**nsr**1—termed the Silver Beaver felsite) is the better exposed of the two and is 120 to 150 m thick. The upper rhyolite flow (**nsr**2) is incompletely exposed but is perhaps at least 50 m thick in places.

nspr Porphyritic rhyolite—salmon-pink to pinkish-gray, aphanitic to fine-grained, intergranular to quartz-poikilitic rhyolite with phenocrysts of quartz, alkali feldspar, and rare, altered, prismatic Fe-rich mafic minerals. Displays flow banding at the base, which is commonly recumbently folded. The flow interior is characteristically massive but gives way to a folded, flow banded base and a flow banded and amygdaloidal top, which is brecciated and convoluted and commonly contains lithophysae. Occurs as a single flow 100 to 200 m thick termed the Palisade Head rhyolite.

nss Interflow sedimentary rock—red-brown, buff, and tan, volcaniclastic and feldspathic, interbedded siltstone, sandstone, and conglomerate. Finer grained rocks are commonly laminated and locally crossbedded. Two particularly thick (10-20 m) occurrences of conglomerate (colored units) are noted in the area, but their stratigraphic positions are unclear, because of faulting or isolation by intrusion.

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GEOLOGIC MAP OF THE ILLGEN CITY QUADRANGLE, LAKE COUNTY, MINNESOTA

By
James D. Miller, Jr., John C. Green, and Terrence J. Boerboom

1989