NOMENCLATURE

..... Standard geologic terms as defined in the Glossary of Geology (American Geological Institute, 1987) are used where applicable. Map-unit classifications follow recommendations of the Commission on Stratigraphic Nomenclature (American Association of Petroleum Geologists, 1983). Standard terminology is used for rock names based on modal mineralogy; modal definitions have been modified slightly from the classification scheme suggested by Streckeisen (1976). Cumulate rock codes, for example, POcf or PCF, indicate mineral phases listed in decreasing order of abundance. Cumulus phases are denoted by uppercase letters, and intercumulus phases are denoted by lowercase letters. Mineral abbreviations used below are

.....P or p ..... plagioclase
.....O or o ..... olivine
.....C or c ..... clinopyroxene
.....H or h ..... hypersthene
.....I or i ..... inverted pigeonite
.....F or f ..... iron-titanium oxide
.....A or a ..... apatite

For further information on terminology and stratigraphic designations, see Miller and others (2002).

DESCRIPTION OF MAP UNITS

MESOPROTEROZOIC ROCKS

KEWEENAWAN SUPERGROUP—Volcanic and sedimentary rocks formed during the development of the Midcontinent rift system.

NORTH SHORE VOLCANIC GROUP—Suite of stratified volcanic and minor sedimentary rocks exposed in northeastern Minnesota along Lake Superior shoreline; divided into five sequences on the basis of stratigraphic position and magnetic polarity; sequences are further subdivided into individual flows and formational sequences (considerably modified from Green, 1972).

.....Schroeder–Lutsen sequence—Predominantly olivine-tholeiitic lava flows occupying upper part of volcanic group from Little Marais to Good Harbor Bay; separated from older rocks by unconformity marked by sedimentary units (**ncfs** and **nlmc**); total thickness 500–1100 m; sequence not radiometrically dated.

..... **nslb** ..... ***Undifferentiated olivine-tholeiitic basalts***—Homogeneous suite; commonly ophitic, aphyric; smooth to ropy, billowing flow tops.

..... **ndys** ..... ***Dear Yard Lake sandstone***—See Jirsa (1984) for further information.

..... **nmrb** ..... ***Manitou River basalt***—Fine-grained, intergranular, transitional basalt; abundant small plagioclase phenocrysts; flow thickness greater than 100 m.

..... **npbb** ..... ***Pork Bay breccia***—Matrix-supported breccia; pebble- to boulder-sized clasts of various volcanic rocks (mainly basalt) in red, silt- to sand-sized matrix; interpreted as mudflow deposit.

..... **ntpb** ..... ***Terrace Point basalt***—Fine-grained, ophitic olivine-tholeiite; sparse plagioclase phenocrysts; thomsonite in amygdules; forms basal flow of Schroeder-Lutsen sequence at northeast; thickness greater than 50 m.

..... **ncfs** ..... ***Cut Face Creek sandstone***—Red-brown, laminated, ripple-marked, cross-bedded volcanic sandstone and shale; marks disconformity between Schroeder–Lutsen sequence and upper northeast sequence.

..... **nlmc** ..... ***Little Marais conglomerate***—Polymict volcanic conglomerate, subangular cobble- to pebble-supported; sandy to silty matrix; marks angular unconformity between the Schroeder–Lutsen sequence and upper southwest sequence.

.....**Upper southwest sequence**—Includes basaltic, intermediate, and minor (less than 10 percent by volume) rhyolitic lava flows extending from Duluth north to Little Marais along shore of Lake Superior; normal magnetic polarity; total thickness greater than 8 km; U-Pb zircon ages indicate eruption of sequence in 1099–1096 Ma (Davis and Green, 1997).

..... **nbhl** ***Bell Harbor lavas***—Mixed suite of ophitic basalt, intergranular basalt, basaltic andesite, and aphyric rhyolite.

..... **nphr** ***Palisade Head porphyritic rhyolite***—Light-gray to pink, aphanitic; contains small quartz, K-feldspar, and oxidized mafic phenocrysts; thickness about 100 m; U-Pb age 1096.6 ± 1.7 Ma (Davis and Green, 1997).

..... **nbrl** ***Baptism River lavas***—Mixed suite of subophitic to ophitic basalt, intergranular basalt, basaltic andesite, and rhyolite; includes Silver Beaver rhyolite (unit **nsbr**) in upper part of sequence and Silver Bay porphyritic basalt (unit **nsbp)** in lower part.

..... **nsbr** ***Silver Beaver rhyolite***—Light-gray to pink, sparsely plagioclase-phyric to aphyric, microspherulitic, locally flow laminated; thickness 120–150 m.

..... **nspb** ***Silver Bay porphyritic basalt***—Ophitic olivine basalt with as much as 50% large (2–5 cm) plagioclase phenocrysts; thickness 15–20 m.

..... **ngrb** ***Gooseberry River basalts***—Ophitic, subophitic, and intergranular basalt flows, generally aphyric.

..... **nthb** ***Two Harbors basalts***—Mostly aphyric, intergranular basalt flows; some have well-developed flow-top breccia.

..... **nlmb** ***Larsmont ophitic basalts***—Homogeneous, aphyric, ophitic, olivine-tholeiitic flows; compositionally primitive.

..... **nsrb** ***Sucker River basalts***—Ophitic to subophitic basalt flows; mostly aphyric.

..... **nlwb** ***Lakewood basalts***—Mixed suite of predominantly intergranular basalt with some andesite, ferroandesite, icelandite, and rhyolite; more evolved compositions in lower part of suite.

..... **nlsl** ***Lakeside lavas***—Mixed suite of intergranular, plagioclase-phyric, and ophitic basalt, basaltic andesite, icelandite, and rhyolite; U-Pb age 1098.4 ± 1.9 Ma for icelandite (Davis and Green, 1997).

..... **nlel** ***Leif Erickson Park lavas***—Mixed suite of intergranular, plagioclase-phyric and ophitic basalt, basaltic andesite, and icelandite flows; locally recrystallized by Duluth Complex.

..... **Lower southwest sequence**—Sequence of lava flows truncated on east by Duluth Complex; primary reverse magnetic polarity reset in vicinity of the complex; total thickness less than 400 m; sequence not radiometrically dated.

..... **nepb** ***Ely's Peak basalts***—Intergranular, ophitic, and plagioclase-phyric basalt flows; basal flow is augite-phyric and locally pillowed. Basal section includes the Nopeming Sandstone, a crossbedded, quartz arenite with minor siltstone similar to the Puckwunge Sandstone beneath Lower northeast sequence.

..... **Upper northeast sequence**—Mixture of basaltic, intermediate, and abundant (greater than 50 volume percent) rhyolitic lava flows exposed along shore of Lake Superior from Hovland to Good Harbor Bay; normal magnetic polarity; total thickness about 3.8 km; U-Pb zircon ages (Davis and Green, 1997) indicate eruption of sequence began about 1100 Ma.

..... **ngha** ***Good Harbor Bay andesites***—Red-brown, aphanitic to fine-grained, porphyritic andesite flows; contains small plagioclase, clinopyroxene, and magnetite phenocrysts.

..... **nbwb** ***Breakwater basalt***—Intergranular, porphyritic transitional basalt; contains small phenocrysts of plagioclase, clinopyroxene, magnetite, and olivine; thickness about 110 m.

..... **ngmr** ***Grand Marais porphyritic rhyolite***—Light-gray to pink; contains phenocrysts of quartz, K-feldspar, and oxidized mafic minerals; thickness about 150 m.

..... **ncvb** ***Croftville basalts***—Mixed suite of intergranular to ophitic aphyric basalt, porphyritic basalt, and basaltic andesite.

..... **npmt** ***Pincushion Mountain trachybasalt***—Gray, intergranular to subophitic, porphyritic; sparse to abundant tabular plagioclase phenocrysts, especially in upper part.

..... **ndtr** ***Devil's Track rhyolite***—Tan to pink, mostly aphyric, massive to flow-banded, locally microspherulitic or diktytaxitic; thickness about 250 m.

..... **nmhr** ***Maple Hill porphyritic rhyolite***—Light-gray to tan; contains phenocrysts of quartz, K-feldspar, plagioclase, and oxidized mafic minerals; thickness about 70 m.

..... **nrcb** ***Red Cliff basalts***—Ophitic to subophitic olivine tholeiitic basalt flows, some plagioclase-phyric.

..... **nkcr** ***Kimball Creek rhyolite***—Light-gray to pink, aphanitic to finely granular, sparsely porphyritic, locally diktytaxitic rhyolite; small phenocrysts of plagioclase and oxidized mafic minerals; thickness about 370 m.

..... **nmil** ***Marr Island lavas***—Mixed suite of intergranular and ophitic basalt, basaltic andesite, icelandite, and rhyolite.

..... **nnbb** ***Naniboujou basalts***—Mixed suite of intergranular to subophitic basalt and basaltic andesite, mostly aphyric.

..... **ndkr** ***Devil's Kettle porphyritic rhyolite***—Pink to light-gray, aphanitic; contains quartz, K-feldspar, and phenocrysts of oxidized mafic minerals; thickness 235 m; U-Pb age 1097.7 ± 1.7 Ma (Davis and Green, 1997).

..... **nbrv** ***Brule River lavas***—Interbedded flows of porphyritic rhyolite and basalt; U-Pb age 1100.2 ± 2.2 Ma for rhyolite near base (Davis and Green, 1997).

..... **Lower northeast sequence**—Includes intermediate, and rhyolitic lava flows exposed along shore of Lake Superior from Hovland to Grand Portage; reverse magnetic polarity; thickness about 3 km; U-Pb zircon ages suggest eruption at about 1108 Ma (Davis and Green, 1997).

..... **nhvl** ***Hovland lavas***—Mixed suite of intergranular basalt, basaltic andesite, icelandite, and rhyolite; commonly plagioclase-phyric, some glomerporphyritic; U-Pb age 1107.7 ± 1.9 Ma (Davis and Green, 1997).

..... **nrrr** ***Red Rock porphyritic rhyolite***—Reddish to tan, aphanitic; contains quartz, K-feldspar, and oxidized mafic phenocrysts; thickness about 70 m; U-Pb age 1107.9 ± 1.8 Ma (Davis and Green, 1997).

..... **ndba** ***Deronda Bay andesite***—Brown, aphanitic to fine-grained, sparsely plagioclase-phyric flow; thickness about 90 m.

..... **ngpb** ***Grand Portage basalts***—Intergranular transitional basalt and basaltic andesite flows; compositions become more evolved upward in sequence from augite-phyric and pillowed basal flow at Grand Portage.

..... **Miscellaneous rock types**—Volcanic and sedimentary rocks of unknown stratigraphic position because they are either poorly exposed or dislocated due to faulting or intrusion.

..... **nsbh** ***Nonmagnetic basaltic hornfels***——Fine-grained, strongly granoblastic, locally meta-amygdaloidal; oxide-poor olivine gabbroic to gabbronoritic mineral asseˇmblage; subdued aeromagnetic signature.

..... **nsmb** ***Magnetic basaltic hornfels***—Fine-grained, strongly granoblastic, locally meta-amygdaloidal; oxide-rich olivine gabbroic to gabbronoritic mineral assemblages; strong aeromagnetic signature.

..... **nsih** ***Intermediate hornfels***—Fine-grained, granoblastic; quartz-bearing mineral assemblages of intermediate composition.

..... **nssh** ***Interflow sedimentary hornfels***—Fine-grained, granoblastic; relict bedding commonly preserved; oxide gabbro mineral assemblage; strong localized aeromagnetic highs.

..... **nnu** ***Undifferentiated volcanic rocks***—Normal magnetic polarity.

..... **nnb** ***Undifferentiated basalt***—Normal magnetic polarity.

..... **nnob** ***Ophitic basalt***—Normal magnetic polarity.

..... **nni** ***Intermediate volcanic rock***—Normal magnetic polarity.

..... **nnil** ***Icelandite***—Normal magnetic polarity.

..... **nnfi** ***Undifferentiated felsic to intermediate volcanic rocks***—Normal magnetic polarity.

..... **nnr** ***Rhyolite***—Aphyric; normal magnetic polarity.

..... **nnpr** ***Porphyritic rhyolite***—Quartz- and K-feldspar-phyric; normal magnetic polarity.

..... **nnvc** ***Volcaniclastic rocks***—Unsorted, variably bedded, tuffaceous, typically polymictic; normal magnetic polarity.

..... **nru** ***Undifferentiated volcanic rocks***—Reverse magnetic polarity.

..... **nrb** ***Undifferentiated basalt***—Reverse magnetic polarity.

..... **nri** ***Intermediate volcanic rocks***—Reverse magnetic polarity.

..... **nrr** ***Rhyolite***—Reverse magnetic polarity.

..... **nrbi** ***Rhyolite with basaltic inclusions***—Aphyric to feldspar-phyric rhyolite with centimeter-sized rounded inclusions of aphanitic basalt.

..... **nsu** ***Undifferentiated volcanic rocks***—Magnetic polarity unknown.

MIDCONTINENT RIFT INTRUSIVE SUPERSUITE—Intrusive rocks formed during the development of the Midcontinent rift.

BEAVER BAY COMPLEX—Multiphase intrusive complex of mostly hypabyssal intrusions emplaced in central part of North Shore Volcanic Group. Consistent normal magnetic polarity and two U-Pb ages (about 1096 Ma; Paces and Miller, 1993) suggest emplacement generally after Duluth Complex intrusions.

..... ***Silver Bay intrusions***—Suite of massive to zoned ferrogabbroic intrusions locally emplaced in Beaver River diabase; U-Pb age 1095.8 ± 1.2 Ma (Paces and Miller, 1993).

.....**sbg** *Varitextured gabbro*—Medium- to coarse-grained, subophitic to intergranular, granophyric; marginal phase of zoned intrusions.

.....**sbfc** *Foliated olivine ferrogabbro cumulate (PCFO)*—Medium-grained, locally layered; interior phase of zoned intrusions.

.....**sbpg** *Poikilitic olivine ferrogabbro cumulate (PCFoi)*—Medium-grained, foliated, texturally layered; interior phase of some zoned intrusions gradational into tunit **sbfc**.

.....**sbgp** *Melanogranophyre*—Massive; contains prismatic mafic minerals; commonly associated with varitextured gabbro (unit **sbg**).

..... ***Beaver River diabase***—Extensive mafic dike and sill complex extending from Split Rock Point to Lutsen on the shore of Lake Superior; multiple composite phases present locally.

.....**brd** *Diabase*—Undifferentiated; poorly exposed or inferred in incompletely mapped areas.

.....**brod** *Ophitic olivine diabase*—Fine- to medium-grained; granular olivine; constitutes main phase of Beaver River diabase.

.....**brg** *Intergranular olivine gabbro*—Medium- to coarse-grained, nonfoliated, variably granophyric; in narrow gradational contact with ophitic olivine diabase (unit **brod**).

.....**brfd** *Ferrodiorite*—Medium-grained, intergranular, nonfoliated to poorly foliated, granophyric, commonly leucocratic, locally olivine-bearing; in narrow gradational contact with intergranular olivine gabbro (map unit **brg**) and ferrodiorite cumulate (unit **brfc**).

.....**brfc** *Ferrodiorite cumulate (PCFO)*—Similar to ferrodiorite (unit **brfd**) but well foliated; commonly forms innermost phase of composite intrusions.

.....**brda** *Anorthosite inclusion*—Gray to pale-green, coarse- to medium-grained anorthosite to gabbroic anorthosite (more than 90 percent plagioclase); forms large (less than 500 m) blocks in unchilled ophitic olivine diabase (unit **brod**).

.....**brdg** *Granitoid inclusion*—Pinkish to orange, micrographic to intergranular leucogranite; enclosing diabase commonly chilled.

..... **vhod** ***Victor Head diabase***—Ophitic olivine diabase, fine-grained; strongly oxidized to light red; forms 50–65-m-thick sheet intruded by unit **brod** of Beaver River diabase.

..... **mpfd** ***Milepost 7 sill***—Intergranular ferrodiorite, aphanitic to medium-grained, massive, iron-oxide-rich (10–15 percent); forms 10–20-m-thick sill in Gooseberry River basalts (unit **ngrb**).

..... ***Sonju Lake intrusion***—Strongly differentiated, 1–1.5-km-thick, sheet-like intrusion emplaced beneath Finland granophyre; U-Pb age 1096.1 ± 0.8 Ma (Paces and Miller, 1993).

.....**slu** *Undivided upper cumulates*—Poorly exposed; inferred from aeromagnetic data to include olivine gabbro cumulate, oxide gabbro cumulate, apatite olivine ferrodiorite cumulate, and olivine ferromonzodiorite_ units.

.....**slmd** *Olivine ferromonzodiorite*—Coarse-grained, nonfoliated to poorly foliated, variably granophyric, apatitic; forms most differentiated unit.

.....**slad** *Apatite olivine ferrodiorite cumulate (PCFOA)*—Medium-grained, foliated; locally layered.

.....**slfg** *Oxide gabbro cumulate (PCF, PCFO)*—Medium-grained, foliated; rarely layered.

.....**slg** *Olivine gabbro cumulate (PCOf, PCf)*—Coarse-grained, foliated.

.....**sll** *Undivided lower cumulates*—Poorly exposed; inferred from subdued aeromagnetic data to include melatroctolite, dunite, and troctolite cumulates.

.....**slt** *Troctolite cumulate (PO, POcf, PcOf)*—Medium-grained to medium-coarse-grained, ophitic, foliated; locally layered in places, particularly at base.

.....**sld** *Dunite cumulate (O, Op)*—Strongly serpentinized, fine-grained.

.....**slmt** *Melatroctolite cumulate (PO, OP)*—Medium-fine-grained to fine-grained, foliated, subtly layered; grades in olivine concentration from top (80%) to bottom (40%).

.....**slog** *Ophitic olivine gabbro to augite troctolite*—Generally nonfoliated; inferred to be noncumulate extension of Sonju Lake intrusion.

.....**slbr** *Hybrid dikes*—Heterogeneous mix of fine-grained mafic and felsic rocks in orthogonal dike set; may be related to emplacement of Beaver River diabase.

..... ***Finland granophyre***—Large lens-shaped, zoned, intermediate to felsic intrusion; cuts Lax Lake gabbro, is underplated by Sonju Lake intrusion and cut by Beaver River diabase; U-Pb age 1097.8 ± 4.4 Ma (J. Vervoort, Univ. of Arizona, Tucson, written commun., 2001).

.....**fggr** *Leucogranite*—Deep red-orange; predominantly micrographic, locally spherulitic; miarolitic cavities common; forms upper part of intrusion.

.....**fgmd** *Quartz ferromonzodiorite*—Mottled pink to gray; contains 5–25 percent prismatic iron silicates; forms lower part of intrusion.

..... ***Cloquet Lake layered series***—Very poorly exposed mafic to felsic intrusive rocks forming nested, saucer-shaped intrusions; divided into upper and lower series that define crude differentiation cycles; interpreted from aeromagnetic data, rare outcrop, and scattered drill cores.

..... **cugp** *Granophyre*—Upper series; based on one drill core of micrographic leucogranite and a subdued aeromagnetic signature.

..... **cumd** *Monzodiorite and other intermediate-to-felsic rock types*—Upper series; based on one drill core and a strong aeromagnetic signature.

.....**cugd** *Gabbro to diorite*—Upper series; displays cumulate texture in drill core from north and west areas; outcrops in southeast have noncumulate texture; characterized by busy aeromagnetic signature.

.....**cuog** *Olivine gabbro to troctolite*—Upper series; interpreted from subdued aeromagnetic signature.

.....**clmd** *Monzodiorite and other intermediate rock types*—Lower series; based on few outcrops and associated strong aeromagnetic signature in southern part of intrusion.

.....**clgd** *Gabbro to diorite*—Lower series; cumulate texture in one drill core in western part; noncumulate texture in gabbroic outcrops in southeastern part of intrusion.

.....**clog** *Olivine gabbro to troctolite*—Lower series; cumulate texture observed in two of three drill cores; characterized by subdued aeromagnetic signature.

..... ***Lax Lake gabbro***—Composite mixture of mafic to intermediate rocks; outcrop and aeromagnetic data suggest a correlation with the poorly exposed lower series of the Cloquet Lake layered series.

.....**llog** *Ophitic olivine gabbro*—Medium-grained, locally porphyritic; typically forms marginal phase of intrusion.

.....**llgd** *Intergranular gabbro to diorite*—Coarse- to medium-grained, nonfoliated, variably granophyric (5–30 percent), deuteric alteration common.

.....**llmd** *Quartz monzodiorite*—Pink to gray, medium-grained, very granophyric (30–60 percent); mafic minerals commonly prismatic.

..... ***Blesner Lake diorite***—Composite mixture of mafic to felsic noncumulate rocks; isolated by intrusions of Beaver River diabase from likely correlative rock types in Lax Lake gabbro, Upper Manitou River gabbro, and Finland granophyre.

.....**blpd** *Poikilitic olivine diabase*—Medium-grained, ophitic, nonfoliated; forms southern margin of intrusion.

..... **blod** *Ophitic olivine gabbro*—Medium-grained, moderately to well-foliated; forms northern margin of intrusion.

..... **blg** *Intergranular gabbro*—Coarse-grained, nonfoliated, variably granophyric (5–12 percent); deuteric alteration common.

..... **bld** *Ferrodiorite*—Medium-grained, nonfoliated, moderately granophyric (10–35 percent); deuteric alteration common.

..... **blfc** *Foliated ferrodiorite cumulate (PCFOa)*—Medium-grained, variably granophyric (5–25 percent), apatitic.

..... **blmd** *Quartz monzodiorite*—Pink to gray, medium-grained, very granophyric (30–60%); mafict minerals commonly prismatic.

..... **blgp** *Granophyre*—Pink micrographic leucogranite; transgressive relationship to other Blesner Lake units suggests correlation with Finland granophyre (unit **fggr**).

..... ***Upper Manitou River gabbro***—Composite mixture of mafic to felsic noncumulate rocks; forms irregular to dike-like intrusions; may correlate with similar rock types in Blesner Lake diorite.

.....**umg** *Gabbro*—Ophitic olivine gabbro to intergranular granophyric gabbro, fine- to medium-coarse-grained, moderately altered; interstitial granopyre is less than 15 percent.

.....**umd** *Diorite*—Intergranular olivine ferrodiorite to quartz ferromonzodiorite, fine- to medium-grained, nonfoliated, variably granophyric (5–35 percent).

.....**umgp** *Melanogranophyre*—Micrographic quartz ferromonzonite; pinkish, fine- to medium-grained; contains 5–15 percent prismatic iron silicates and oxides.

..... **hct** ***Houghtaling Creek troctolite***—Augite troctolite to olivine gabbro cumulates (POcf, PcOf); medium-grained, ophitic, typically foliated, rarely layered; forms keel-shaped macrodike.

..... **dfgn** ***Dam Five gabbronorite***—Gabbronorite cumulates (PCI); olivine gabbro at basal margin; medium-grained, foliated; forms monoclinally dipping sequence along northern margin of Houghtaling Creek troctolite.

..... ***Wilson Lake ferrogabbro***—Plug-like zoned intrusion with dike-like extensions into surrounding granophyre and gabbroic anorthosite; southeast margin cut by Dam Five gabbronorite (unit **dfgn**).

..... **wlod** *Olivine diabase to monzogabbro*—Medium- to coarse-grained, ophitic to subophitic, locally granophyric (less than 15 percent); forms marginal phase of main intrusion and occurs in dike-like extensions.

..... **wlfg** *Ferrogabbro cumulate (PCFO) to nonfoliated monzogabbro*—Medium- to coarse-grained; ferrogabbroic rocks are foliated.

Fourmile Lake ferrogabbro—Differentiated suite of intermediate to felsic rocks within the Houghtaling Creek troctolite;

probably large xenolith related to Wilson Lake ferrogabbro or Dam Five gabbronorite.

.....**fmfg** *Ferrogabbronorite cumulate (PCIF ± O)*—Medium-grained, foliated.

.....**fmmd** *Ferromonzodiorite*—Varitextured, medium-grained to very coarse grained, poorly foliated to nonfoliated, granophyric with prismatic mafic minerals.

.....**fmgp** *Melanogranophyre*—Fine-grained, micrographic, weakly porphyritic, locally granoblastic; subprismatic mafic minerals.

..... **ccpd** ***Cabin Creek porphyritic diorite***—Ferrodiorite to quartz ferromonzodiorite, fine-grained, commonly altered, felty-textured; contains as much as 60 percent centimeter-sized plagioclase phenocrysts; forms two sheets of uncertain thickness; possible hypabyssal equivalent of anorthositic-series rocks.

..... **lvpd** ***Leveaux porphyritic diorite***—Thick (50 to more than 100 m), sheet-like intrusion of fine-grained ferrodiorite; contains abundant (about 40 percent) plagioclase phenocrysts in upper half; intruded by Beaver River diabase.

..... **slid** ***Shoepack Lake diorite***—Heterogeneous rock characterized by inclusions of felsite, basalt, gabbro, and Archean rocks in a very fine grained dioritic matrix.

.**DULUTH COMPLEX**—Multiphase igneous complex of mostly plutonic intrusions emplaced along base of North Shore Volcanic Group; subdivided into four major rock series on basis of lithology, internal structure, and age.

..... **minc** ***Inclusion of magnetic rock of uncertain type***—Mapped where bedrock not exposed on the basis of localized, strong aeromagnetic high within area of subdued aeromagnetic signature; possibly underlain by troctolite and granophyre; possible mafic volcanic hornfels or gabbroic phases of anorthositic series.

..... **trct** ***Undifferentiated troctolitic cumulates***—Areas underlain by troctolite exposure insufficiently mapped to assign to specific intrusive units.

..... **oui** ***Oxide ultramafic intrusion***—Fe-Ti oxide-bearing dunite, clinopyroxenite, and peridotite; forms irregular bodies cutting troctolitic cumulates; mapped from drill core and localized aeromagnetic highs.

.....**Layered series**—Subsuite of the Duluth Complex composed of multiple, discrete, layered mafic intrusions that display variable degrees of internal differentiation.

..... ***Layered series at Duluth***—Well-differentiated, 3.5–5-km-thick sheet-like intrusion. Known from detailed mapping (Taylor, 1964; Miller and others, 1993); subdivided into zones based on dominant cumulate mineralogy; U-Pb ages 1099.3 ± 0.3 Ma (Paces and Miller, 1993) and 1098.8 ± 1.4 Ma (Green and others, 2001).

.....**dlsb** *Basal contact zone*—Varitextured olivine gabbro to augite troctolite, coarse-grained.

.....**dlst***Troctolite zone*—Troctolitic cumulates (POcf, PO, OP), medium- to coarse-grained, foliated; locally melanocratic in lower section; modally and(or) texturally layered in places.

.....**dlsc** *Cyclic zone*—Macrocyclically layered troctolite to augite troctolite (POcf), olivine gabbro (PcOf), and olivine oxide gabbro (PCFO) cumulates; boundaries between macrocycles marked by abrupt cumulus regression (PCFO to PO) and local presence of microgabbro.

.....**dlsg** *Gabbro zone*—Cumulates of oxide gabbro (PCF), olivine oxide gabbro (PCFO), and oxide gabbronorite (PCFIp); medium-grained, foliated, locally apatitic (3–5 percent) and granophyric (less than 10 percent); contains abundant inclusions of anorthositic-series rocks.

.....**dlsu** *Upper contact zone*—Irregular mixture of fine-grained ilmenite ferrodiorite and medium-grained apatitic ferromonzodiorite to quartz ferromonzonite; nonfoliated; ferrodiorite typically forms border phase with anorthositic-series rocks.

.....**dlsm** *Melanogranophyre*—Irregular composite intrusion of ferromonzodiorite to leucogranite emplaced within anorthositic series; probably represents late-stage differentiates of the Layered series at Duluth.

.....**dlsa** *Anorthositic inclusions*—Large singular inclusion or clusters of inclusions of anorthositic-series rocks; confined to cyclic zone (unit **dlsc**) and gabbro zone (unit **dlsg**).

..... ***Osier Lake intrusion***—Unexposed, well-differentiated, circular intrusion inferred from two drill core and a ring-like aeromagnetic signature**.**

.....**oltr** *Troctolitic cumulates*—Based one drill core and a subdued aeromagnetic low.

.....**olgb** *Gabbroic cumulates*—Based on one drill core and a strong aeromagnetic high.

..... ***Bald Eagle intrusion***—Funnel-shaped, concentrically zoned layered intrusion with incomplete differentiation sequence; contains several very magnetic inclusions of unknown type in southern area; drill core indicate that one inclusion is mafic hornfels; another may be large xenolith of gabbroic cumulates (units **glgb** or **glfg**) from the Greenwood Lake intrusion.

.....**betr** *Troctolite cumulates (PO, POF, POcf)*—Medium-grained, well-foliated, modally layered, locally melanocratic; southern area unexposed; inferred from subdued aeromagnetic signature.

.....**begb** *Gabbro cumulates (PCO, PCOf)*—Medium-grained, well-foliated.

……. ***Greenwood Lake intrusion***—Poorly exposed, well-differentiated layered intrusion; inferred from limited outcrop, several drill cores, and aeromagnetic data; maximum thickness about 7 km.

.....**glog** *Noncumulate oxide olivine gabbro*—Unexposed; based entirely on an aeromagnetic high and one drill core.

.....**gltr** *Troctolitic cumulates*—Inferred from one drill core and subdued aeromagnetic signature.

.....**glgb** *Gabbroic cumulates*—Inferred from two drill cores, outcrop in northern area, and variable aeromagnetic high.

.....**glfg** *Ferrogabbroic cumulates*—Inferred from two drill cores and a very strong aeromagnetic signature known as the Snake anomaly.

..... ***Boulder Lake intrusion***—Poorly exposed layered intrusion inferred from scattered outcrop, drill cores, and aeromagnetic data; possibly composed of two major differentiation cycles of troctolite to gabbro.

.....**bltr** *Troctolite cumulates*—Inferred from scattered outcrop and drill core near western margin, and from a subdued aeromagnetic signature.

.....**blgb** *Gabbro cumulates*—Inferred from several drill cores and linear aeromagnetic highs.

…… **wmtr** ***Western margin intrusion***—Generally troctolitic cumulates; inferred from scattered drill cores and outcrop along western margin and subdued aeromagnetic signature; sulfide mineralization confined to small localized areas along basal contact.

..... ***South Kawishiwi intrusion***—Generally troctolitic cumulates; known from outcrop, drill cores along basal contact, and aeromagnetic data; several Cu-Ni + PGE sulfide deposits lie along basal contact.

.....**skcz** *Contact zone*—Varitextured olivine gabbro, troctolite, gabbronorite, and footwall inclusions; commonly sulfide-bearing; includes unit *scz* of Green and others (1966); unit *g2* of Bonnichsen (1971); and units *BAN*, *BH*, *U1*, *U2*, *U3*, and *UW* of Severson (1994).

.....**sktr** *Troctolite cumulates (PO, POcf)*—Medium-grained, foliated, ophitic; layered in places; includes unit *spt* of Green and others (1966), unit *poCx* of Foose and Cooper (1978), and upper part of unit *ta* of Bonnichsen (1971).

.....**skat** *Augite troctolite cumulates (POcf)*—Medium-grained, foliated, subophitic; includes unit *sat* of Green and others (1966) and lower part of unit *ta* of Bonnichsen (1971).

.....**skta** *Interlayered troctolite and anorthositic rocks*—Mostly troctolite cumulates with lensoidal layers of anorthositic cumulates of variable thickness and lateral extent; larger layer_s shown; includes units *poC* and *pC* of Foose and Cooper (1978), and unit *mta* of Green and others (1966).

.....**skpt** *Poikilitic leucotroctolite cumulate (PPo)*—Medium-grained, foliated; 1–3-cm-diameter olivine oikocrysts; forms discontinuous layers in augite troctolite; includes parts of unit *ago* of Green and others (1966) and Phinney (1967).

.....**skgp** *Gabbroic pegmatite*—Coarse-grained to pegmatitic oxide gabbro; unit *sp* of Green and others (1966).

.....**skog** *Olivine oxide gabbro to augite troctolite cumulates*—Coarse-grained, ophitic to subophitic, poorly foliated; includes unit *mas* of Phinney (1967), unit *tam* of Bonnichsen (1971), and main *AGT* unit of Severson (1994).

..... ***Wilder Lake intrusion***—North-dipping, well-differentiated layered intrusion; known from two areas of mapping (Miller, 1986; Phinney, 1967–1969).

.....wlog *Olivine gabbro*—Fine- to coarse-grained, ophitic, nonfoliated to poorly foliated; forms lower contact with anorthositic-series rocks.

.....wllt *Layered troctolite cumulates (PO, POcf)*—Medium-grained, modally layered, foliated.

.....wltr *Troctolite cumulates (PO, POcf)*—Medium-grained, massive, foliated.

.....wlfg *Ferrogabbro cumulates (POF, PCOF)*—Medium-grained, foliated; locally contains anorthositic-series inclusions.

.....wlrz *Roof zone*—Mixture of troctolite to olivine gabbro; locally contains anorthositic-series inclusions in upper part of intrusion.

..... ***Lake One troctolite***—Generally troctolitic cumulates (Miller, 1986); lateral extent and relationship to South Kawishiwi and Tuscarora intrusions are unknown.

.....l1cz *Contact zone*—Varitextured mix of augite troctolite, olivine gabbro, gabbronorite, and hornfels inclusions; sulfide-bearing in places.

.....l1og *Olivine gabbro to augite troctolite cumulates (PcOf to POcf)*—Coarse- to medium-grained, foliated, ophitic, locally layered.

.....l1tr *Troctolite cumulates (PO, POcf)*—Medium-grained, foliated, ophitic, locally layered.

.....l1ft *Oxide troctolite cumulates (POF)*—Fine- to medium-grained, foliated, well-layered; typically in abrupt contact with augite troctolitic cumulates below and in gradational contact with troctolitic cumulates above.

.....l1mx *Mixed troctolitic and anorthositic cumulates*—Structurally complex zone of anorthositic-series inclusions in troctolitic host rock.

.....l3tr ***Lake Three troctolite***—Area of troctolitic cumulates (POcf, POf) within rocks of the anorthositic series; known from outcrop at northern extent (Miller, 1986); areal extent inferred from aeromagnetic data.

……. ***Tuscarora Intrusion***—Troctolitic to anorthositic cumulates (Morey and others, 1981; Beitsch and Weiblen, 1980); intrusive into Poplar Lake intrusion; western extent poorly known.

.....tuat *Augite troctolite cumulates (POcf, PcOf)*—Fine- to medium-grained, ophitic; unit *ttp* of Morey and others (1981).

.....tutr *Troctolite cumulates (PO, POcf)*—Fine- to medium-grained, foliated, locally layered, ophitic; units *ttf* and *ttm* of Morey and others (1981).

.....tuta *Interlayered anorthositic and troctolitic cumulates*—High contrast modal layering on centimeter-to-meter scale; unit *tta* of Morey and others (1981).

..... ***Partridge River intrusion***—Generally troctolitic cumulates; known from rare to abundant outcrop, drill cores along base, and aeromagenetic data; several Cu-Ni sulfide occurrences along basal contact zone.

.....prcz *Basal contact zone*—Varitextured troctolite, olivine gabbro, and footwall inclusions; consistently sulfide-bearing; includes unit *Ppcz* of Severson and Miller (1999), unit *I* of Severson and Hauck (1990).

.....prhz *Heterogeneous zone*—Similar to basal contact zone but not sulfide-bearing; near contact with South Kawishiwi intrusion; known from drill core only (Severson and others, 1994).

.....prmt *Melatroctolite and troctolite cumulates (OP, PO)*—Medium- to fine-grained, foliated, modally layered; known largely from drill core; includes unit *Ppmt* of Severson and Miller (1999) and unit *II* of Severson and Hauck (1990).

.....prpt *Poikilitic leucotroctolite cumulates (Po)*—Medium-grained, foliated, 1–3-cm-diameter olivine oikocrysts; includes unit *Pppt* of Severson and Miller (1999) and unit *III* of Severson and Hauck (1990).

.....prat *Augite troctolite cumulates (POcf)*—Coarse- to medium-grained, foliated, ophitic; includes unit *Ppat* of Severson and Miller (1999) and unit *IV* of Severson and Hauck (1990).

.....prct *Coarse troctolite cumulates (POcf)*—Coarse-grained, poorly foliated to nonfoliated, ophitic, leucocratic;

includes unit *Ppct* of Severson and Miller (1999) and part of unit *V* of Severson and Hauck (1990).

.....**prtr** *Troctolite cumulates (PO, POcf)*—Medium-grained, foliated, ophitic, variably leucocratic, locally layered; contains melatroctolite layers in places; includes unit *Ppt* of Severson and Miller (1999) and units *V-VIII* of Severson and Hauck (1990).

..... Anorthositic series—Predominantly plagioclase-rich gabbroic cumulates; complex internal structure suggests multiple intrusions but individual intrusive bodies difficult to delineate; two U-Pb zircon ages indicate emplacement at 1099 Ma (Paces and Miller, 1993).

..... **asau** ***Undifferentiated anorthositic cumulate rocks***—Includes range of medium- to coarse-grained leucogabbroic to anorthositic rock types composed of 70–98 percent cumulus plagioclase, as much as 25 percent cumulus to intercumulus olivine, and 2–30 percent intercumulus phases, including augite, iron-oxide, orthopyroxene, biotite, and granophyre; inferred from busy to subdued aeromagnetic signature in areas of poor exposure,

..... **asgb** ***Gabbroic rocks***—Typically coarse-grained, ophitic to intergranular, locally leucocratic, variably olivine-bearing oxide gabbro; includes unit *Pmog* of Severson and Miller (1999), Powerline gabbro of Bonnichsen (1974), and unit *og* of Davidson (1969a, 1977a).

..... **asmx** ***Anorthositic, gabbroic, and mafic hornfels rocks***—Mixture of rock types inferred in areas of poor exposure from highly variable aeromagnetic signature.

..... **aspa** ***Poikilitic olivine gabbroic anorthosite cumulate (PPocf)***—Medium- to coarse-grained, foliated, plagioclase cumulate contains 1–10-cm-diameter olivine oikocrysts; includes unit *ago* of Green and others (1966) and units *spoa* and *poa* of Miller (1986).

..... **asna** ***Poikilitic noritic anorthosite cumulate (PPh)***—Medium-grained; unit *agh* of Green and others (1966).

..... **aspg** ***Porphyritic olivine gabbro***—Medium-grained, ophitic olivine gabbro; contains 5–15-percent plagioclase phenocrysts; may represent flow-differentiated contact zone of anorthositic series at Duluth (Miller and others, 1993).

..... **akga** ***Katydid Lake gabbroic anorthosite***—Medium- to coarse-grained, poorly foliated, intergranular, plagioclase-porphyritic gabbroic anorthosite; commonly altered.

..... **aslg** ***Scott Creek leucogabbro***—Fine- to coarse-grained, plagioclase-porphyritic leucogabbro to ferrodiorite; cuts Katydid Lake gabbroic anorthosite (unit **akga**) in roof zone of Duluth Complex.

..... Early gabbro series—Early mafic phase of Duluth Complex as indicated by U-Pb zircon ages and reverse magnetic polarity; dominantly composed of gabbroic cumulates in multiply intruded sheet-like intrusions.

.....**clgb** ***Crocodile Lake gabbro***—Generally gabbroic cumulates; identified from reconnaissance mapping of Grout and others (1959); U-Pb ages 1107.0 ± 1.1 Ma (Davis and Green, 1997) and 1107.9 ± 0.3 Ma (Paces and Miller, 1993).

..... ***Poplar Lake intrusion***—Interlayered suite of dominantly gabbroic cumulates and minor troctolite and anorthositic cumulates; known from mapping by Nathan (Morey and Nathan, 1977, 1978; Mathez and others, 1977); U-Pb age 1107.9 ± 0.3 (Paces and Miller, 1993).

.....**plcz** *Contact zone*—Varitextured, nonfoliated, biotitic olivine gabbro, augite troctolite, and gabbronorite; locally granophyric and sulfide-bearing; unit *df* of Morey and Nathan (1977, 1978).

.....**plfg** *Ferrogabbroic cumulates (POF, PCFO, POCF)*—Coarse-grained, foliated, layered, biotitic, locally altered, and sulfide-bearing; unit *dg* of Morey and Nathan (1977, 1978).

.....**plox** *Oxide-rich ferrogabbroic rocks*—Fine- to medium-grained, granular to weakly foliated; subunit of ferrogabbroic cumulates (unit **Plfg**); includes units *dc, dd, dh, dt,* and *dv* of Morey and Nathan (1977, 1978).

.....**plgb** *Gabbroic cumulates (PC, PCif, PChOf)*—Fine- to medium-grained, foliated, locally plagioclase porphyritic; units *db* and *dp* of Morey and Nathan (1977).

.....**pltr** *Troctolite cumulates (PO, POci)*—Fine- to medium-grained, foliated, locally leucocratic; units *da* and *dq* of Morey and Nathan (1977, 1978).

.....**plas** *Anorthositic cumulates (PPcif)*—Medium- to coarse-grained, foliated, ophitic, locally altered, and sulfide-bearing; units *dj* and *ds* of Morey and Nathan (1977, 1978). Some rocks may be related to the Anorthositic series.

..... Felsic series—Massive, intermediate to felsic intrusive rocks; forms isolated to segmented bodies in roof zone of the Duluth

Complex; preliminary U-Pb ages indicate emplacement 1109–1106 Ma (J. Vervoort, Univ. of Arizona, Tucson, written commun., 2001).

..... **fgpu** ***Undivided granophyric rocks***—Small, isolated areas of felsic rocks not associated with major granophyre bodies.

..... **fimu** ***Undifferentiated intermediate rocks***—Small areas of intermediate rock related to small granophyre bodies or forming isolated masses.

..... **ffbg** ***Fairbanks–Brimson granophyre***—Granophyre inferred from subdued aeromagnetic anomaly patterns.

..... **fmwg** ***Mt. Weber granophyre***—Micrographic to intergranular pink leucogranite; known from sparse outcrop and subdued aeromagnetic anomaly signature; U-Pb age 1106.3 ± 3.6 Ma (J. Vervoort, Univ. of Arizona, Tucson, written commun., 2001).

..... **fisg** ***Isabella granophyre***—Micrographic to intergranular pink leucogranite; known from two drill cores and subdued aeromagnetic signature.

..... **fwfg** ***Whitefish Lake granophyre***—Micrographic to intergranular pink leucogranite; locally spherulitic; U-Pb age 1109.6 ± 4.0 Ma (J. Vervoort, Univ. of Arizona, Tucson, written commun., 2001).

..... **fblg** ***Beth Lake granophyre***—Micrographic to intergranular pink leucogranite; may correlate with Whitefish Lake granophyre (unit **fwfg**); unit *gpy* of Davidson (1977a).

..... **fwlm** ***Wine Lake monzodiorite***—Medium- to coarse-grained, intergranular granodiorite to quartz ferromonzodiorite; underlies Beth Lake granophyre (unit **fblg**); units *hgd*, *fgd*, and *grd* of Davidson (1977b).

..... ***Misquah Hills granophyre***—Elongate body of felsic and lesser intermediate rocks lying above Poplar Lake intrusion of the early gabbro series; U-Pb age 1106 ± 4.2 Ma (J. Vervoort, Univ. of Arizona, Tucson, written commun., 2001).

..... **fmhg** *Leucogranite*—Micrographic to intergranular, pink; main phase.

..... **fmhm** *Quartz ferromonzodiorite to granodiorite*—Medium- to coarse-grained, intergranular; marginal phase.

..... ***Cucumber Lake granophyre***—Elongate body of felsic rocks and lesser amounts of intermediate rocks overlying Crocodile Lake gabbro; U-Pb age 1106 ± 2.7 Ma (J. Vervoort, Univ. of Arizona, Tucson, written comun., 2001).

..... **fclg** *Leucogranite*—Micrographic to intergranular, pink; main phase.

..... **fclm** *Mixed granophyre and gabbro*—Irregular transition zone between Crocodile Lake gabbro (unit **clgb**) and leucogranite (unit **fclg**).

. **MISCELLANEOUS INTRUSIONS**—Isolated hypabyssal intrusions within Keweenawan volcanic rocks or Paleoproterozoic sedimentary rocks; correlation with other intrusive units of the Beaver Bay and Duluth Complexes is uncertain.

..... **diab** ***Diabase***—Extent not well mapped, poorly exposed, or inferred from linear aeromagnetic high.

..... **gpy** ***Granophyre to intermediate rocks***—Extent not well mapped or poorly exposed; age uncertain.

..... **mif** ***Mafic intrusion in Paleoproterozoic rocks adjacent to Duluth Comple***x—Age uncertain; two sheet-like bodies inferred from aeromagnetic data to be west of Duluth Complex margin; drilling suggests they may not be exposed at bedrock surface; other drilling into circular body at southwestern map edge shows oxide-rich gabbro that occurs at junction of two reverse polarity dikes.

..... **ppgb** ***Pigeon Point sill***—Olivine gabbro, intermediate rocks, and granophyre; forms south-dipping, 120-m-thick, differentiated intrusion emplaced in Rove Formation (unit **prv**); includes units *PPo*, *PPa*, and *PPp* of Mudrey (1977).

..... **prdb** ***Pigeon River diabase***—Olivine diabase; forms thick, northeast- and northwest-trending dikes cutting Rove Formation (unit **Prv**) and volcanic rocks of the lower northeastern sequence.

..... ***Brule Lake–Hovland gabbro***—Gabbroic to intermediate rocks emplaced as sheet-like intrusions between volcanic rocks of reverse and normal polarity; capped by Pine Mountain and Eagle Mountain granophyre bodies; unit not well mapped.

..... **bhdg** *Diabase to gabbro*—Undifferentiated; mostly ophitic olivine diabase to gabbro; includes eastern *olg* unit of Davidson (1977c, e, f), Hovland diabase complex of Jones (1963), and "gabbro" outcrops of Grout and others (1959).

..... **bhog** *Olivine gabbro*—Medium- to coarse-grained, foliated; strong, banded aeromagnetic anomaly signature

suggests unit may be lithologically diverse and multi-intrusive; western unit ;*olg* of Davidson (1977a, b, d) and Davidson and Burnell (1977).

.....**bhfg** *Oxide gabbro*—Foliated and modally layered; "South Range" oxide-rich gabbro of Grout (1949–1950).

.....bhrd *Diabase*—Ophitic olivine gabbro, locally monzodioritic**,** fine- to coarse-grained; locally layered and foliated; forms shallow-dipping sheet; Reservation River diabase of Jones (1963).

.....**bhfd** *Ferrogabbro to monzodiorite*—Lower part foliated; upper part unfoliated and coarser grained; Hovland Sill of Jones (1963).

..... ***Pine Mountain granophyre***—Elongate body of felsic and lesser intermediate rocks lying between Brule Lake–Hovland gabbro and volcanic rocks of normal polarity; U-Pb age 1095.4 ± 3.7 Ma (J. Vervoort, Univ. of Arizona, Tucson, written comun., 2001).

.....**pmgp** *Leucogranite*—Micrographic to intergranular, pink; main upper phase.

.....**pmmd** *Quartz ferromonzodiorite to granodiorite*—Medium- to coarse-grained, intergranular; lower marginal phase.

..... ***Eagle Mountain granophyre***—Double-pronged body of felsic and lesser intermediate rocks lying between Brule Lake–Hovland gabbro and volcanic rocks of normal polarity; U-Pb age 1098.5 Ma (J. Vervoort, Univ. of Arizona, Tucson, written comun., 2001).

.....**emgp** *Leucogranite*—Micrographic to intergranular, pink; main phase.

.....**emmd** *Quartz ferromonzodiorite to granodiorite*—Medium- to coarse-grained, intergranular; lower marginal phase.

..... **elog** ***Elbow Lake olivine gabbro***—Zoned mafic dike; marginal phase is fine-grained ophitic olivine diabase; medial phase is foliated olivine gabbro; core phase is pegmatitic oxide olivine gabbro (unit *elog* of Boerboom and Miller, 1994).

..... **sbgb** ***Sawbill Lake gabbro***—Coarse-grained, foliated ophitic oxide gabbro; reconnaissance map unit *gab* of Davidson (1977a); aeromagnetic data suggest possible connection with Elbow Lake olivine gabbro (map unit **elog**).

..... **lcdb** ***Lake Clara diabase***—Olivine gabbro to monzogabbro; ophitic to subophitic; aeromagnetic signature suggests possible link to Monker Lake diabase (unit **mldb**)

..... **mldb** ***Monker Lake diabase***—Olivine diabase, ophitic, locally plagioclase-phyric; forms south-dipping dike; strong magnetic signature.

..... **lldb** ***Lichen Lake diabase***—Olivine diabase to gabbro, subophitic to ophitic; local weak layering; aeromagnetic signature suggests possible connection with Houghtaling Creek troctolite of Beaver Bay Complex (unit **hct**).

..... **srif** ***Split Rock intrusive felsite***—Pink, sparsely porphyritic, aphanitic to fine-grained felsite; intrusive into Gooseberry River basalts (unit ngrb) in Split Rock River area.

..... **lbdb** ***Lafayette Bluff diabase***—Olivine diabase, fine- to medium-grained intergranular; subtle modal layering; distinguished from Silver Creek diabase by Pope (1976).

..... ***Silver Creek diabase to granophyre***—Bimodal intrusive suite; well exposed near lakeshore, poorly exposed inland; largely inferred from aeromagnetic data and sparse outcrop.

..... **scdg** *Diabase to gabbro*—Includes Silver Cliff diabase of Pope (1976) and sparse outcrops north of Two Harbors (Bonnichsen, 1971; Green and others, 1977).

.....**scgp** *Granophyre*—Inferred from sparse outcrops north of Two Harbors (Bonnichsen, 1971; Green, 1977) and subdued aeromagnetic signature.__

..... ***Sawmill Lake gabbro granophyre***—Poorly exposed, bimodal intrusive suite largely inferred from aeromagnetic data and rare outcrop.

.....**smgb** *Gabbro*—Inferred from sparse outcrop (Bonnichsen, 1971; Green, 1977) and locally high aeromagnetic signatures.

.....**smgp** *Granophyre*—Inferred from sparse outcrop (Bonnichsen, 1971) and subdued aeromagnetic signature.

spdb ***Stony Point diabase***—Medium-grained, ophitic; occurs as slightly discordant sheet about 35 m thick.

.....**lrdb** ***Lester River sill***—Composite intrusion of intergranular gabbro at margins and ophitic olivine gabbro in core; granophyre in upper part; thickness about 280 m.

.....**nldb** ***Northland sill***—Olivine gabbro; locally grades upward into intermediate and granophyric rocks.

..... ***Endion sill***—Composite mafic sill; thickness about 425 m; northern extent based on scattered outcrop and aeromagnetic data; unit appears to cut Duluth Complex.

.....**endb** *Diabase*—Ophitic olivine gabbro, intergranular gabbro, and monzodiorite, medium-grained, locally altered.

.....**engp** *Melanogranophyre*—Grades upward from intermediate rocks.

..... ***St. Louis River diabase dikes***—Northeast-trending dike swarm intrusive into Thomson Formation and Ely's Peak basalt; magnetic polarity of exposed dikes determined from Green and others (1987) and Reichhoff (1987); polarity of unexposed dikes inferred from aeromagnetic data.

.....**sldn** *Normal polarity dikes*—Generally ophitic olivine diabase; cuts Ely's Peak basalts (unit **nepb**).

.....**sldr** *Reverse polarity dikes*—Intergranular to subophitic olivine diabase; cuts Thomson Formation (unit **Ptm**).

.....**gpdb** ***Grand Portage diabase dikes***—Basalt to trachybasalt, locally plagioclase-phyric; reverse magnetic polarity; unit forms east-trending swarm cutting Grand Portage basalt (unit **ngpb**).

.....**bppd** ***Brule Lake porphyry intrusions***—Plagioclase-porphyritic diabase; 20–60 percent plagioclase phenocrysts in fine-grained, intergranular to ophitic, gabbroic matrix; unit forms 100–300-m-thick sheet-like intrusions in reverse magnetic polarity volcanic rocks; *pdi* unit of Davidson (1977c, f) and Davidson and Burnell (1977).

.....**lsdb** ***Logan intrusions***—Diabase to gabbro, locally granophyric, fine- to coarse-grained, ophitic to intergranular; upper part commonly plagioclase-phyric; commonly altered; forms thick (50–200 m) sills and dikes in Rove Formation; U-Pb age 1108.8 + 4/- 2 Ma for sill in Ontario (Davis and Sutcliffe, 1985).

SEDIMENTARY ROCKS—Fluvial sedimentary rocks that formed before Puckwunge and after Fond du Lac magmatic phase of Midcontinent rift (1108–1086 Ma).

.....**kfdl** ***Fond du Lac Formation***—Feldspathic sandstone and shale; basal quartz-pebble conglomerate locally; red to dark brown, massive to well-bedded.

.....**kps** ***Puckwunge Sandstone***—Quartz arenite; gray, cross-bedded; some quartz-pebble conglomerate.

PALEOPROTEROZOIC ROCKS

ANIMIKIE GROUP—Sedimentary rocks that formed in the foreland basin of the Penokean Orogen.

.....**Psh** ***Argillaceous to quartzose hornfels inclusion in Duluth Complex.***

..... **Pif** ***Iron-formation hornfels inclusion in Duluth Complex.***

..... **Ptm** ***Thomson Formation***—Gray to black pelitic slate; well-bedded, broadly folded metasiltstone and metagraywacke; recrystallized near Duluth Complex; correlative with upper part of Virginia Formation.

.....**Pvr** ***Virginia Formation***—Well-bedded argillaceous siltstone, carbonaceous shale, mudstone and graywacke; recrystallized near Duluth Complex; poorly exposed.

.....**Prv** ***Rove Formation***—Argillaceous siltstone, carbonaceous shale, mudstone and graywacke; recrystallized near Duluth Complex and Logan intrusions (unit **lsdb**).

.....**Pbi** ***Biwabik Iron Formation***—Iron-bearing strata of alternating thick-bedded granular cherty intervals and finely bedded

slaty intervals that are locally tuffaceous.

..... **Pgi** ***Gunflint Iron Formation***—Iron-bearing strata similar to Biwabik Iron Formation but slaty intervals more dominant; U-Pb age 1878 ± 2 Ma from lapilli tuff in Ontario (Fralich and Kissin, 1998).

..... **Ppk** ***Pokegama Quartzite***—Well-bedded quartz arenite, argillaceous siltstone, shale, and basal conglomerate.

LATE ARCHEAN ROCKS

INTRUSIVE ROCKS—Granitic and metamorphosed supracrustal rocks of the Wawa and Quetico subprovinces of the Superior Province; mostly syn- to post-kinematic granitoid rocks emplaced 2.67–2.69 Ma.

.....Agr ***Undivided granitoid rocks*.**

.....Avg ***Vermilion Granitic Complex***—Undivided schistose and granitoid rocks.

.....Ast ***Saganaga Tonalite***—Mostly quartz tonalite; dioritic border phase; U-Pb age 2689 ± 1 Ma (Corfu and Stott, 1998).

.....Aslg ***Snowbank Lake Granite***—Composite stock of mostly syenodiorite.

..... ***Giants Range batholith***—Multiphase granitoid batholith composed of older (2685 ± 4 Ma) gneissic and younger (2674 ± 5 Ma) massive phases; U-Pb ages from Boerboom and Zartman (1993).

.....**Agrn** *Heterogeneous tonalitic gneiss.*

.....Agre *Equigranular monzonite, quartz monzonite, and granodiorite.*

.....**Agrp** *Porphyritic quartz monzonite and granodiorite.*

..... **Apda** ***Porphyritic dacite, andesite, and rhyodacite***—Dikes, sills, and irregular intrusions and extrusive equivalents; U-Pb age 2683 ± 1.4 Ma west of map area (Peterson and others, 2001), but ages probably span a range.

..... **Amu** ***Mafic and ultramafic intrusions***—Variably metamorphosed.

SUPRACRUSTAL ROCKS—Variably deformed, moderately metamorphosed sedimentary and volcanic rocks; granitic and metamorphosed supracrustal rocks of the Wawa and Quetico subprovinces of the Superior Province.

..... **Amv** ***Undifferentiated mafic volcanic rocks.***

..... Acg ***Undifferentiated conglomerate.***

..... Aam ***Amphibolite***—Mafic volcanic strata; contact metamorphosed by the Giants Range batholith.

Knife Lake Group—Metasedimentary rocks and minor felsic metavolcanic rocks.

..... **Akcg** *Conglomerate*—Clast- and matrix-supported; locally includes clasts of Saganaga Tonalite (unit **Aat**).

..... **Akga** *Graywacke and argillite*—Well-bedded, commonly deformed, and moderately metamorphosed.

..... **Akfv** *Felsic tuff*—Tuffaceous sandstones and breccias of dacitic protolith.

..... **Akph** *Phyllitic and phyllonitic rocks*—Metasedimentary and tuffaceous protoliths.

..... **Alvf** ***Lake Vermilion Formation***—Graywacke and felsic volcaniclastic rock.

Newton Lake Formation—Komatiitic and tholeiitic mafic volcanic rocks, calc-alkalic dacite, and layered peridotite to gabbro sills.

..... **Anms** *Conglomerate, iron-formation, and graywacke*—Commonly sheared; present as thin lenses.

..... **Anfv** *Dacitic flows, breccia, and tuff*—Graywacke and siliceous marble also present.

..... **Anmv** *Tholeiitic basalt and basaltic komatiite*—Pillowed and massive.

..... **Aegs** ***Ely Greenstone***—Dominantly pillowed and massive, mafic to intermediate volcanic rock; interbedded iron-formation (unit **Aif**); calc-alkalic dacite and rhyolite lavas and volcaniclastic rocks common in lower part; also minor clastic rock units; strongly metamorphosed in the vicinity of the Giants Range batholith; U-Pb age 2722 ± 1 Ma from felsic unit (Peterson and others, 2001).

.....**Aif** .. ***Undifferentiated iron-formation***.

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