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COUNTY ATLAS SERIES
ATLAS C-10, PART A
Plate 2—Bedrock Geology

BEDROCK GEOLOGY

By

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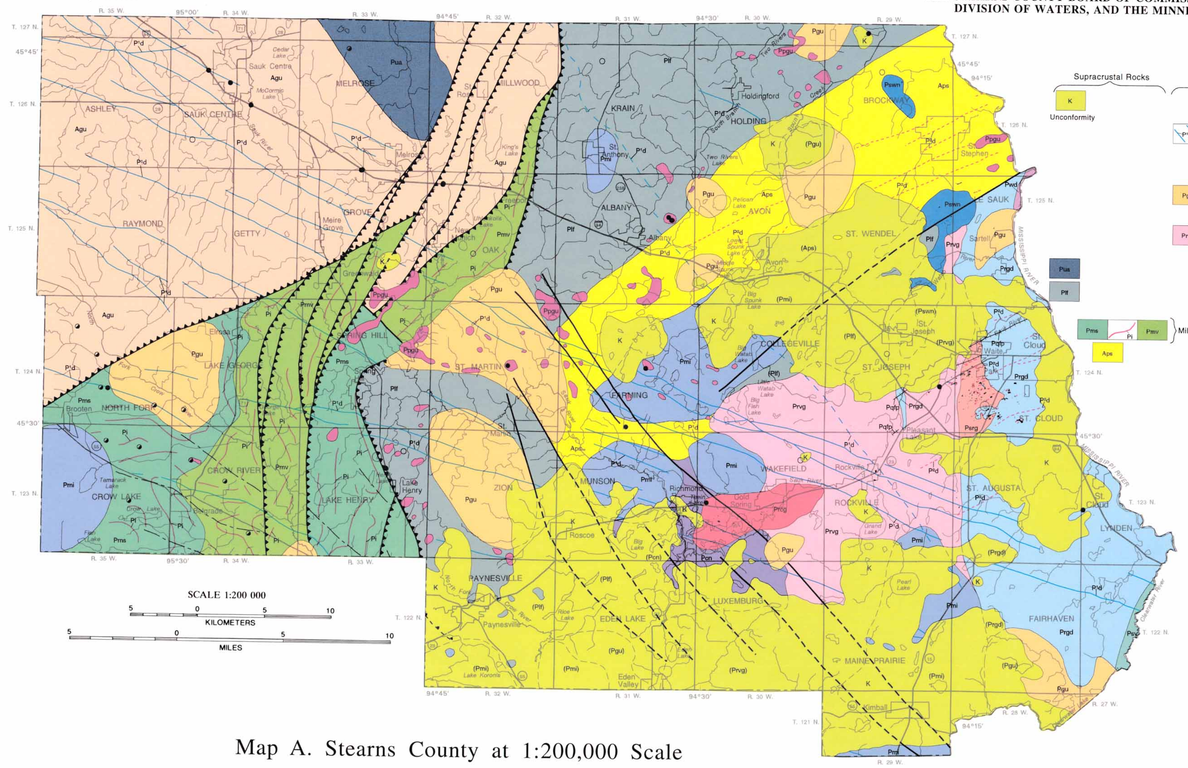
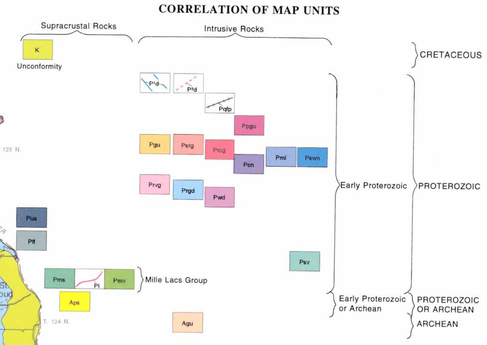
1995



Map A. Stearns County at 1:200,000 Scale

CORRELATION OF MAP UNITS



Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based; however, the Minnesota Geological Survey does not warrant or guarantee that there are no errors. Users may wish to verify critical information; sources include both the references listed here and information on file at the offices of the Minnesota Geological Survey in St. Paul. In addition, effort has been made to ensure that the interpretation conforms to sound geologic and cartographic principles. No claim is made that the interpretation shown is rigorously correct, however, and it should not be used to guide engineering-scale decisions without site-specific verification.

DESCRIPTION OF MAP UNITS

Note: Labels for geologic units that extend beneath Cretaceous rocks are indicated on the map by enclosing parentheses—for example, **(Pmi)**.

MESOZOIC ROCKS

K — **Cretaceous rocks, undivided**—Poorly lithified rocks include sandstone, siltstone, shale, and rare marl; carbonaceous, especially near base; thin beds of lignite near base; sequence generally becomes progressively finer grained upward; shale is kaolinitic, particularly near contact with saprolith that is developed on Precambrian rocks.

EARLY PROTEROZOIC ROCKS

The geologic units were chiefly mapped using information drawn from geophysical maps; thus, geophysical characteristics are noted below. Saprolith, a kaolinite-rich clay weathering residuum on igneous and metamorphic rocks, is not shown on map. It varies in thickness and composition depending on the composition of the protolith and extent of fracturing within it. Saprolith composition varies upward from nearly that of the protolith to mostly silica, alumina, and iron at the top of the residuum. The residuum was nearly continuous in Stearns County prior to Quaternary erosion; it is eroded the least where Cretaceous rocks are present. Residuum thickness locally exceeds 30 meters.

P'd — **Northwest-trending diabase dikes**—Dark green, medium-grained apatitic quartz-hornblende ferrodiorite with a vague northwest-oriented trachytic foliation. Extensive deuteric alteration or greenschist-facies metamorphism has altered most clinopyroxene to a mixture of uralitic amphibole, chlorite, and coarse epidote; fine-grained sphene has partially replaced ilmenite. The only physical evidence of the dikes is a single outcrop in Sauk Centre and a drill core along strike to the northeast; most of the mapping was surmised from linear aeromagnetic anomalies. Dikes are inferred to have a maximum thickness of 100–150 meters. Unit includes one normally polarized, 8-meter-thick, northwest-trending dike within unit **Psrg** (St. Cloud Township; NW1/4, Sec. 20, T. 124 N., R. 28 W.) that cuts a northeast-trending diabase dike (**P'd**) and granite. This dike is a dark greenish-black, fine-grained, strongly magnetic, intergranular diabasic ferrogabbro with abundant clinopyroxene, opaque oxides, pyrrhotite, and apatite. Dikes are not shown where overlain by Cretaceous strata.

Dike inferred to have negative polarity (aeromagnetic lows).

Dike inferred to have positive polarity (aeromagnetic highs).

P'd — **Northeast-trending diabase dikes**—Dark greenish-black, fine-grained diabasic gabbro in which most clinopyroxene has been altered to actinolite and chlorite due to greenschist-facies retrograde metamorphism. Dikes are generally less than two meters thick, but locally are as much as three meters thick; they commonly contain small round amygdules and are sharply chilled. Dikes lack an apparent aeromagnetic expression owing to their generally nonmagnetic character and narrow dike width. However, several subdued linear northeast-trending positive and negative magnetic anomalies near the exposed dikes may reflect either larger, more magnetic dikes or swarms of closely spaced diabase dikes. Alternatively, these anomalies may reflect the subparallel dikes of unit **Pdp**. Short dike segments were mapped from outcrops; long segments were inferred from aeromagnetic data. Weak positive linear magnetic anomalies within the Sartell Gneiss (unit **Aps**) are inferred to be diabase dikes, but may reflect stratigraphic horizons within the gneiss. Dikes are not shown where overlain by Cretaceous strata.

Pdp — **Porphyritic microgranite**—Pink, fine- to locally coarse-grained granite characterized by phenocrysts of quartz and feldspar in a fine-grained, variably spherulitic quartzofeldspathic groundmass. Phenocrysts measuring as much as one centimeter consist of embayed-unit quartz grains and euhedral, zoned, armored microperthitic potassium-feldspar, as well as a lesser proportion of plagioclase. Dikes trend northeast, generally measure less than 25 meters wide but locally are as much as 90 meters wide. Margins of dikes are strongly chilled and locally flow banded against the host granites. An inactive quarry (St. Joseph Township; NW1/4, sec. 27, T. 124 N., R. 29 W) is developed within a coarse-grained version of this rock in the interior of an uncommonly thick dike. The thickest exposed dikes are shown schematically interconnected; others to the south are shown only where they are exposed. Dikes are not shown where overlain by Cretaceous strata.

Pgu — **Mafic to ultramafic intrusions**—Ultramafic to mafic serpentinized peridotite, pyroxenite, hornblendite, quartz gabbronorite/gabbro/diorite, and minor anorthosite. Small plug-like to amoeboid-shaped intrusions are characterized by positive magnetic anomalies. Some aeromagnetic anomalies attributed to this unit may be related to unit **Pswn**.

Pgu — **Granitoid intrusions**—Granite to granodiorite, post-tectonic plutons emplaced contemporaneously with units **Parg**, **Prvg**, and **Prgd**. Geophysically defined by weak magnetic anomalies and pronounced negative gravity anomalies.

Psrg — **St. Cloud Granite**—Grayish-pink, coarse-grained, moderately trachytic hornblende-biotite granite; characterized by peppered black and white mottling against dark pink matrix. Forms an intricate series of generally northeast-oriented dikes and sills intruding the Reformatory granodiorite; thickness ranges from one centimeter to as much as 50 meters; trachytic fabric is parallel to the dike/sill walls; cut by a minor proportion of late-phase differentiated pink aplitic dikes. Angular inclusions of unit **Prgd** are common. Many quarries, now inactive, were developed within this unit in the Waite Park area.

Prvg — **Richmond charnockitic granite**—Pink, greenish-pink, to dark green, very coarse grained trachytic rapakivi granite to quartz monzonite with charnockitic characteristics; locally cut by differentiated quartz- and feldspar-phyric aplite dikes. Plagioclase-rimmed megacrysts of microcline, measuring two to six centimeters, are prominent, as well as smaller and fewer plagioclase phenocrysts. Contains as much as 10 percent each of biotite and hornblende; also accessory sphene, apatite, abundant zircon, rare yellow garnet, and secondary epidote and chlorite. Hypersthene is present locally but generally absent or replaced by biotite and hornblende. Westernmost outcrops are dark gray, medium-grained, weakly porphyritic, trachytic, apatitic hornblende-biotite-quartz ferromonzodiorite (or jotunite in charnockite terminology); interpreted as border phase. Blocky inclusions of this border phase, measuring as much as one meter, are present in the western margin of the granite. Unit is geophysically characterized by moderate to high aeromagnetic anomalies but generally low gravity anomalies. Unit is well exposed.

Pmi — **Mafic intrusive rocks, undivided**—Includes a variety of inferred rock types, including gabbro, norite, anorthosite, and diorite; possibly charnockitic in part. Characterized by strong positive magnetic and gravity anomalies. No exposure.

Pcn — **Noritic hornblende ferrogabbro (charnockite)**—Dark gray, medium grained with moderate north-northwest-trending trachytic foliation, with one to three centimeter poikilitic hornblende in places. Contains inclusions as much as 0.5 meter wide of modally banded noritic anorthosite. Interpretation of unit is based on a lone outcrop along its eastern margin, near Thein Lake. Moderately to highly magnetic, with a uniform positive gravity signature.

Pswn — **St. Wendel quartz gabbro**—Gray to greenish-gray, generally fine- to medium-grained biotite norite to locally coarse-grained quartz gabbro/diorite. Hypersthene is generally abundant but variably altered to fibrous amphibole and reflects charnockitic affinity of rock. Locally contains hercynite-bearing hornfels inclusions of unit **Aps**. Coarse-grained phase is cognate with, but intrusive into, finer grained phases, which make up the bulk of the intrusion. Rare pink garnet-bearing aplitic granite dikes cut this rock as thin, one- to two-centimeter straight-walled dikelets; these may be a late differentiated phase. Smaller northern intrusion consists of fine-grained biotite-quartz norite (charnockite) and biotite-hornblende tonalite; both are intrusive into upper amphibolite/lower granulite–grade gneissic rocks of unit **Aps**. A minor proportion of pink biotite granite pegmatite intrudes the tonalitic phase. These charnockites may represent an in-situ melt formed during granulite-grade metamorphism.

Prvg — **Rockville Granite**—Grayish-pink to white, very coarse grained porphyritic granite with variable rapakivi texture. Weak to moderate trachytic fabric is defined by aligned perthite and plagioclase phenocrysts. Unit is massive but locally contains cognate inclusions, measuring as much as 0.5 meter, of finer grained trachytoid, potassium-rich granite or medium-grained black biotite-hornblende-pyroxene lamprophyre. Pink to white color varies slightly across width of pluton. See Morey (1978) for detailed mineralogical descriptions.

Prgd — **Reformatory granodiorite**—Gray to pinkish-gray, medium-grained, weakly porphyritic and trachytic hornblende-biotite granodiorite. Contains ubiquitous ovoid inclusions, 2 to 10 centimeters wide, or larger angular inclusions of fine-grained, dark gray diorite (cognate xenoliths). Inclusions of metamorphic country rock are rare and consist of amphibolite, garnet-amphibolite, charnockitic gneiss, and granitic gneiss. Most xenoliths are less than one meter, except southwest of Waite Park where some gneissic inclusions are as much as 20 meters long.

Pwd — **Watab quartz diorite**—Dark grayish-green to pinkish-green, fine-grained, locally plagioclase-porphyritic hornblende ferrodiorite/appinite. Retrograde assemblage of hornblende and biotite after earlier pyroxene is indicative of either deuteric alteration or retrogressive thermal metamorphism related to emplacement of nearby Reformatory granodiorite and St. Cloud Granite. Similar inclusions of rock occur throughout the Reformatory granodiorite, and this diorite is inferred to be an early phase related to the Reformatory Granite. Intruded by light grayish-pink, coarse-grained trachytic and weakly porphyritic granite that may be either a differentiated phase of the diorite or an external intrusion. May be related to unit **Pswn**.

Pun — **Unnamed units within the Long Prairie basin (Animikie Group)**—Gray siltstone, argillite, and graywacke of the Long Prairie basin, metamorphosed in this area to greenschist facies. See Southwick (1988) for a detailed description.

Plf — **Little Falls Formation**—Gray pelitic schist characterized by staurolite crystals 1 to 3 centimeters wide, garnet crystals 1 to 3 millimeters wide, and fibrous sillimanite in a fine-grained matrix of quartzofeldspathic biotite schist. Centimeter-scale beds of more felsic composition and, hence, lighter color contain smaller and fewer staurolite and garnet crystals. Bedding orientation is near vertical.

Psv — **Schist and quartzofeldspathic intrusions**—Schist of volcanic and volcaniclastic protolith, and variably deformed quartzofeldspathic intrusions; mostly felsic to intermediate composition and variably metamorphosed from greenschist to amphibolite grade. See Jirsa and Chandler (1995).

Mille Lacs Group—The Mille Lacs Group in Stearns County is inferred to consist of a north-striking group of mafic metavolcanic rocks, and metagraywacke with a possible component of felsic volcanic rocks; both components contain thin units of magnetic iron-formation and are overthrust by the slightly younger Little Falls Formation.

Pms — Metasedimentary and metavolcanic rocks—Inferred to consist largely of graywacke and felsic volcanic or volcaniclastic rocks, with significant interbedded iron-formation. Geophysical signature shows pronounced linear positive magnetic anomalies and low to moderate gravity anomalies. Cuttings from a drill hole placed over a strong magnetic anomaly near the north edge of unit consist of grayish-green phyllitic schist with relatively abundant tourmaline.

Pif — Iron-formation—Inferred from linear positive aeromagnetic anomalies. Found in both units **Pms** and **Pmv**.

Pmv — Metabasalt—Defined geophysically by moderate to high magnetic and gravity signatures. Geophysical data suggest that several thrust faults are present both within this unit and between it and unit **Pms**; the two units may in part be interbedded.

EARLY PROTEROZOIC AND ARCHEAN ROCKS

Aps — **Sartell Gneiss (Early Proterozoic or Archean)**—Gray to pink medium-grained gneiss of widely varied composition ranging from granite to quartzofeldspathic schist to noritic gabbro. Relict conglomeratic textures are preserved locally. Contains hornblende, biotite, garnet, cordierite, orthopyroxene, clinopyroxene, and, locally, hercynite and corundum. Intruded by mildly deformed pyroxene-hornblende syenite and hornblende-biotite granite of unknown affinity.

Agu — **Granitoid gneiss (Archean)**—Predominantly pink to pinkish-gray quartzofeldspathic gneisses of granitic to granodioritic composition, including granitic pegmatite. Mapped from scattered outcrops in northwestern part of county and inferred elsewhere from geophysical data. Outcrops in Ashley Township (sec. 17 and 18, T. 126 N., R. 35 W.) show pervasive epidote alteration.

DESCRIPTION OF MAP SYMBOLS

Contacts for Cretaceous rocks are delineated from drilling data. Contacts and faults in Precambrian rocks are based entirely on geophysical data, except very locally where outcrop was sufficient to support conventional mapping methods. Digital files of structural measurements are available from the Minnesota Geological Survey.

Geologic contact—Dashed where Precambrian rock units extend beneath Cretaceous cover.

Thrust fault—Teeth on upper plate; dashed where extended beneath Cretaceous cover.

Steeply dipping fault—No sense of movement indicated; dashed where extended beneath Cretaceous cover.

Inferred axial trace of fold axis—Unknown fold sense.

Selected drill holes—Includes those that aided interpretation of Precambrian bedrock geology. Filled circle, drill core available; half-filled circle, cuttings of fresh rock available; open circle, cuttings of saprolite with preserved indicator minerals.

Bedrock outcrop—Size exaggerated.

ACKNOWLEDGMENTS

Partial funding for this project was approved by the Minnesota Legislature (M.L. 91, Ch. 254, Art. 1, Sec. 14, Subd. 4[F], and M.L. 93, Ch. 172, Sec. 14, Subd. 11[g]) as recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund.

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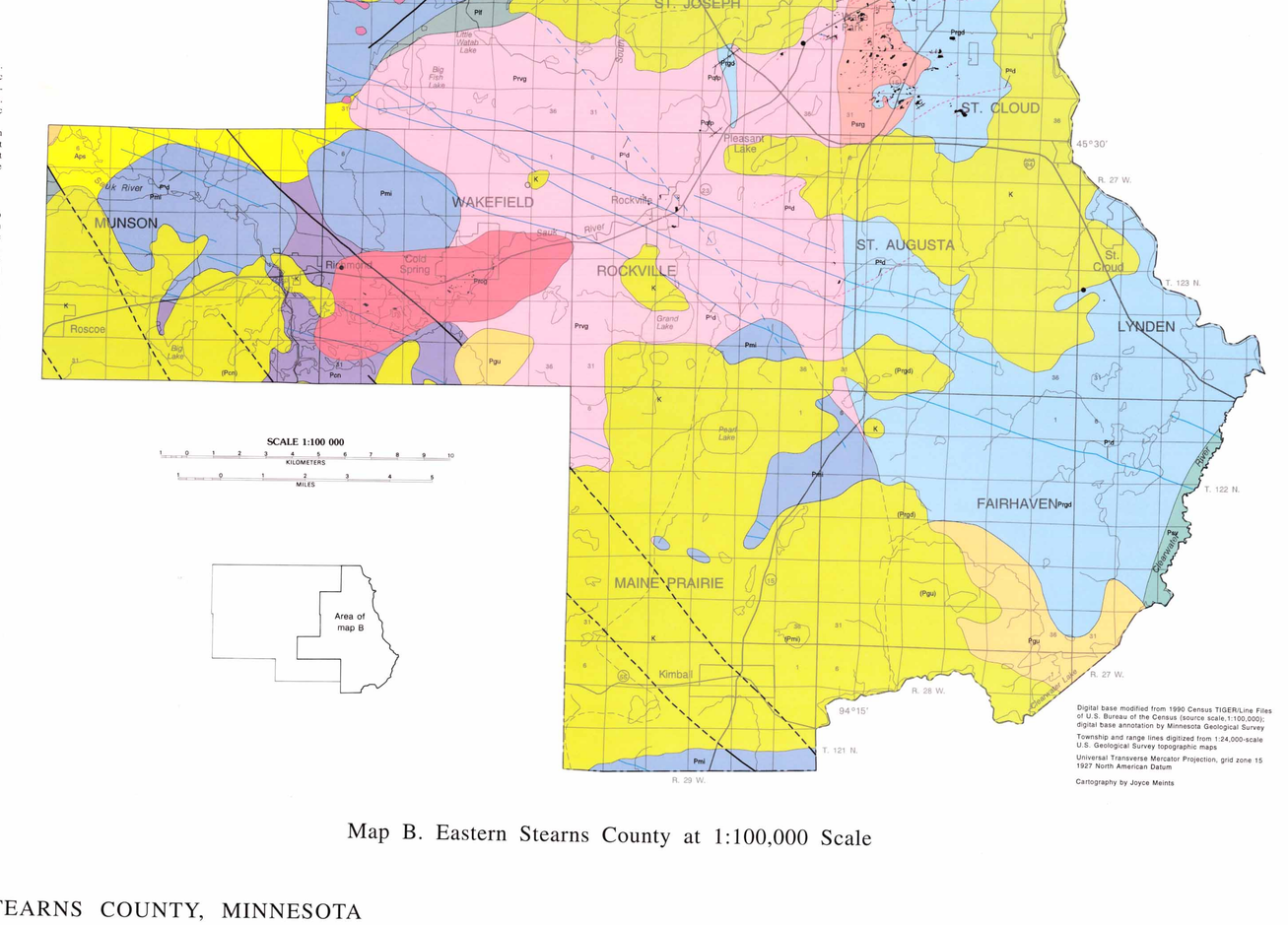
Jirsa, M.A., and Chandler, V.C., 1995, Preliminary bedrock geologic map of east-central Minnesota: Minnesota Geological Survey Open-File Report 95-1.



Digital base modified from 1990 Census TIGER/Line Files of U.S. Bureau of the Census (source scale,1:100,000); digital base annotation by Minnesota Geological Survey

Township and range lines digitized from 1:24,000-scale U.S. Geological Survey topographic maps

Universal Transverse Mercator Projection, grid zone 15
1927 North American Datum

Cartography by Joyce Meints

Map B. Eastern Stearns County at 1:100,000 Scale

GEOLOGIC ATLAS OF STEARNS COUNTY, MINNESOTA