

U.S DEPARTMENT OF THE INTERIOR  
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LITHOLOGIC DESCRIPTIONS OF BEDROCK CORE FROM THE ROSEAU  
1°X2° QUADRANGLE, NORTHERN MINNESOTA

by  
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This report is preliminary and has not been reviewed  
for conformity with U.S. Geological Survey editorial  
standards and stratigraphic nomenclature.

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A drilling program was initiated by the Minnesota Department of Natural Resources (MDNR) during the months of August and September of 1989 for the purpose of obtaining reconnaissance samples of the quaternary glacial overburden and representative samples of the underlying crystalline rocks. The drill holes locations are given in Table 1. The bedrock samples from the drilling project were logged and representative intervals selected for petrographic and chemical analysis during November, 1989, at the MDNR office in Hibbing, Minnesota. Thin sections from the intervals selected were prepared by the MDNR and then examined to characterize the bedrock as an aid in completing a geologic map of the Roseau quadrangle for use in a mineral resource assessment being conducted under the USGS Conterminous United States Mineral Resource Assessment (CUSMAP) program.

In the following descriptions, the first section describes the general characteristics of the cored interval followed by a descriptive summary of the thin sections. The abbreviation CA in these sections refers to the longitudinal axis of the vertical drill core. Volumetric estimates for the minerals are only approximate, with a limited number of grains counted usually ranging from 100 to 200. Grain size was estimated by comparing minerals to previously calibrated crosshairs at appropriate magnification. Plagioclase compositions were estimated using the Michel-Levy method.

Table 1 Locations of drill-holes in the Roseau 1°x2° quadrangle. Latitude is in degrees north latitude and longitude is in degrees west longitude. The abbreviation Sec. represents section, T. represents township, and R. represents range.

hole	Sec.	T.	R.	latitude	longitude
OBD-501	17	158	31	48.5108	94.6628
OBD-502	20	159	31	48.5725	94.6492
OBD-503	14	160	31	48.6717	94.5922
OBD-505	22	158	32	48.4906	94.7539
OBD-506	22	159	32	48.5819	94.7561
OBD-507	5	160	32	48.7008	94.7822
OBD-508	15	157	33	48.4228	94.8814
OBD-509	23	158	33	48.4839	94.8558
OBD-510	36	159	33	48.5439	94.8389
OBD-511	8	160	33	48.6844	94.9253
OBD-512	24	157	34	48.4003	94.9506
OBD-513	23	158	34	48.4819	94.9742
OBD-514	15	159	34	48.5861	95.0117
OBD-515	32	160	34	48.6322	95.0400
OBD-516	36	157	35	48.3706	95.0819
OBD-517	30	158	35	48.4808	95.1967
OBD-518	22	159	35	48.5789	95.1319
OBD-519	16	160	35	48.6731	95.1611
OBD-520	29	159	36	48.5467	95.3189
OBD-521	30	160	36	48.6411	95.3344

## LITHOLOGIC DESCRIPTIONS:

**OB-501**

The interval sampled below the glacial deposits is all saprolite developed from fine-grained, equigranular quartz monzonite. Fine-grained (1-2 mm) quartz and weathered feldspars in a light gray to tan clay-rich matrix. Five to seven centimeter thick medium-grained granite dikes intruded the quartz monzonite at 162 and 164 feet. A very fine-grained, six inch intercept of biotite-rich xenolith with relict diabasic texture (mafic volcanic or hypabyssal intrusive) is present from 163 to 166 feet. Biotite is altered to chlorite and plagioclase to epidote. All the bedrock has a moderately to strongly developed  $S_1$  fabric.

**OB-502**

Pink to tan, medium-coarse grained biotite-bearing syenite. The biotite is ragged, mostly altered to chlorite, and forms a variably present, moderately well developed foliation at  $45^\circ$  to core axis (CA). The original coarse-grained feldspars have recrystallized to anhedral patches comprised of very fine-grained, sausseritized feldspars separated by intergranular micas.

Thin section description: sample at 181 feet

Mineralogy: microcline (44 %), plagioclase (48%), biotite (4%), epidote (4%), accessory minerals (garnet, opaque).

Texture: hypidiomorphic-granular, with 0.5 to 0.8 mm diameter, generally equigranular, feldspars. Light brown, slightly pleochroic biotite is present in glomeroporphyritic megacrysts 0.9 mm in diameter.

Lithology: syenite

**OB-503**

Light yellow-tan, fine-grained rock with very fine-grained biotite-rich augen 1 x 5 mm comprise 5 to 10% of the rock. Augen are not folded but some are rounded. Light green, altered plagioclase(?) clasts (3 mm) show rotation of up to  $30^\circ$ . Two foliations are present with a strongly developed  $S_1$  parallel to CA and weak  $S_2$  at  $30^\circ$  to CA. A composite, 0.5-2 cm thick quartz vein composed of light gray translucent quartz with numerous chloritic wall rock inclusions is nearly continuous over the length of the core. White quartz with a well developed fibrous texture is found along the boundaries of the gray, crack-seal quartz veins. Fibers are oriented perpendicular to the vein walls. Iron oxide pseudomorphs after pyrite are present in trace amounts within the veins. Calcite replacement of the wallrock is

apparent in the deepest core samples where it has not been removed by weathering.

Thin section description: samples at 250 and 256 feet.

Mineralogy: plagioclase (40%), blue-green biotite (40%), quartz (10%), epidote (5%), fine-grained white mica (3%), apatite (trace.), calcite (in vein)

Texture: Porphyroclasts of plagioclase and quartz are commonly 0.05 to 0.08 mm long (with up to 5:1 flattening in quartz). Broken plagioclase is rotated from 1/3 to 1/2 and quartz contains many biotite inclusions. Biotite is commonly intergranular with some growth in pressure shadows adjacent to plagioclase. Well developed cataclastic foliation. Calcite, in a late vein, incorporates previously-deformed host rock.

Lithology: mylonite (protolith may have been a quartz-bearing plutonic rock).

#### OB-505

Light gray, equigranular, biotite quartz monzonite composed of 1 to 2 mm subhedral plagioclase, 5% quartz and 5% biotite. Moderately well-developed  $S_1$  foliation is at 45° to the CA.

Thin section description: sample at 262 feet.

Mineralogy: plagioclase (33%), microcline (25%), quartz (21%), dark green biotite (20%), apatite (trace).

Texture: Hypidiomorphic-granular with zoned, subhedral plagioclase (0.5-3 mm long) and recrystallized anhedral microcline and quartz (0.2-0.7 mm diameter). Biotite is subhedral usually 0.5 to 1.5 mm long with moderate chloritization and clay alteration (weathering). The cores of the zoned plagioclase are extensively altered to white mica.

Lithology: Weathered biotite quartz monzonite

#### OB-506

Most of the cored interval is gray-green, fine-grained and strongly foliated with an undulating  $S_1$  foliation parallel to CA with poorly defined by fine-grained biotite layers. Abundant quartz and quartz-feldspar veins generally show 5:1 flattening. Between 237 and 240 feet calcite replaces the groundmass surrounding a diffuse calcite vein which is perpendicular to the CA. In the same interval, the carbonate replaced wall rock is cut by 0.5 to 2 cm quartz and quartz feldspar veins which show well developed

boundinage. A crosscutting, gray quartz, containing trace amounts of fine-grained disseminated pyrite and chalcopyrite, fills the central part of the quartz-feldspar vein or surrounds the early quartz-feldspar veins. The late, gray quartz portion of vein is completely pulled apart at one location with the in-filling host rock showing the same foliation as the adjacent wall rocks. Between 240 and 245 brittle deformation caused by a closely spaced fracture cleavage at  $45^{\circ}$  to CA offsets earlier fine-grained, gray calcite veinlets which are parallel to CA. The protolith was probably a dark gray to black, strongly foliated and brecciated mafic rock with 3 mm diameter stumpy euhedral plagioclase porphyroclasts that have been highly deformed and variably replaced by sericite, calcite, and minor biotite.

Thin section description: samples at 240 and 241 feet.

Mineralogy: porphyroclastic hornblende (30%), chlorite (20%), calcite (20%), epidote (15%), quartz (10%), plagioclase (2%), opaques (pyrite, chalcopyrite, iron or iron-titanium oxides (2%).

Texture: Intensely deformed hornblende (dark green), porphyroclasts with rotation up to  $1/2$  commonly have chlorite and quartz pressure shadows. Chlorite and elongation of the hornblende porphyroclasts defines the foliation. Fine-grained plagioclase porphyroclasts are broken. Epidote is present prismatic euhedral crystals or as irregular, anhedral patches. A 3 mm-wide calcite is composed of anhedral recrystallized, with fine-grained intergranular calcite replacing the host rock near the vein. A thin (0.3 mm) quartz vein is displaced along the prominent shear plane. Subdomains within the thin section show rotation along the vein boundaries.

Lithology: protomylonite with quartz and calcite veins (protolith gabbro). (Subophitic gabbro is poorly preserved locally in the sample at 240 feet)

#### OB-507

The entire sampled interval below glacial deposits is saprolite derived from aplite dikes which intrude a black, biotite- and plagioclase-rich, porphyritic mafic plutonic rock. Aplite is white, fine-grained, with 1 to 2 mm quartz, plagioclase and muscovite phenocrysts. Mafic pluton is medium-grained and porphyritic with 3 to 4 mm parallel plagioclase laths, in a biotite-rich matrix, which are locally parallel in structural subdomains. From 243 to 246 feet a medium green-gray, clay-rich saprolite is highly deformed showing a strong foliation and brecciation with small-scale S-folds of tectonic breccia clasts (0.5-2 cm long,  $> 5:1$  flattening). Many clasts are flattened and show

pressure shadows. The mafic and felsic layers in this interval alternate rapidly with contacts parallel to the prominent foliation. Mafic layers are warped into discontinuous, low-amplitude, open folds and are tectonically thinned by ductile-style deformation. Aplite layers show brittle deformation. A few percent calcite is disseminated throughout.

#### OB-508

Gray-green, medium- to coarse-grained graywacke with subangular to subrounded feldspars in a green biotitic matrix.  $S_0$  defined by contact with fine-grained well sorted laminated siltstone is locally parallel with  $S_1$ . At 282 feet mylonitic shear bands are present at a scale of 3 to 8 cm. Mylonite consists of quartz and sericite.  $S_0$  and  $S_1$  are parallel and folded (oriented at  $30-60^\circ$  to CA) at the top of the cored interval by  $D_2$  which caused cataclasis near the bottom of the interval.  $S_2$  is developed by closely spaced shear-bands oriented  $30^\circ$  to CA and discordant to  $S_0$  and  $S_1$ . At 283 feet fish-hook folds terminate against a deformed quartz vein in a zone 4 cm wide.

Thin section description: samples at 282 and 284 feet.

Mineralogy: quartz (70%), plagioclase (20%), biotite (10%)

Texture: Strained and recrystallized, elongate quartz (0.1-0.5 mm) and plagioclase (0.1-0.3 mm) usually show interlocking boundaries. Brown biotite (0.05 mm) is lepidoblastic.

Primary sedimentary layering ( $S_0$ ) is nearly parallel to  $S_1$ . In the sample from 284 feet, feldspar is coarser (0.5-2.0 mm) and extensively altered to white mica.

Lithology: meta-graywacke

#### OB-509

Medium to dark gray, coarse-grained gabbro, subophitic, with ferromagnesian megacrysts (0.5 cm) enclosed by 0.1 to 0.2 mm plagioclase and ferromagnesian minerals with a diabasic texture. Plagioclase is pink to tan color. Ferromagnesian minerals up to 60 % usually enclose disseminated subhedral pyrite (1%). Magnetite disseminated in the ferromagnesian minerals. Some primary? biotite is present. No penetrative fabric is observed.

Thin section description: sample at 100 feet.

Mineralogy: Pyroxene and fibrous amphibole (51%), plagioclase (36%), biotite (9%), iron oxide and pyrite (4%), sphene (trace)

**Texture:** Subophitic, with large subhedral uralite-altered pyroxene porphyroclasts partly enclosing plagioclase (An 60) laths. Large subhedral brown biotite grains usually occupy intergranular areas whereas green biotite is altering from the fibrous amphibole. Plagioclase crystals are intergrown with amphibole where they are in contact. No penetrative fabric is present. The textures suggest an autometamorphic origin for the amphibole and some of the green biotite. Brown biotite may be a magmatic mineral.

**Lithology:** Gabbro (plagioclase-pyroxene cumulate)

#### **OB-510**

Very dark gray, coarse-grained gabbro, subophitic pyroxenes (now chlorite) with sausseritized plagioclase from 0.5 to 1 cm long. Several pyrite veinlets (2-5 mm thick) and small amounts of disseminated pyrite are found in a metabasalt xenolith. One 4 mm wide magnetite-rich (0.1 mm diameter crystals) layer occurs at 107 feet. No penetrative fabric is observed.

**Thin section description:** samples at 108 and 109 feet.

**Mineralogy:** plagioclase (67%), biotite (22%), augite (9%), iron and iron-titanium oxides (2%).

**Texture:** Hypidiomorphic-granular with subhedral plagioclase (0.5-1 mm) laths enclosing intergranular anhedral augite (0.1-0.3 mm) now altered to fibrous amphibole ("uralite"). Green biotite replaces fibrous amphibole whereas brown biotite occupies intergranular areas and may be a primary magmatic mineral. Plagioclase slightly altered to white mica. No penetrative fabric is observed.

**Lithology:** plagioclase-cumulate rock

#### **OB-512**

Light gray, medium-grained, equigranular meta-graywacke with a moderately well developed  $S_1$ . The rock contains 0.5% light pink garnet (1 mm), 10% biotite, 5% muscovite, and 0.5% disseminated pyrite (0.5 mm). Two 0.5 cm vertical, light gray, translucent quartz veins are associated with locally coarse-grained biotite and contain no apparent sulfide mineralization.

**Thin section description:** sample at 116.

**Mineralogy:** plagioclase (55%), quartz (18%), biotite (16%), muscovite (8%), garnet (1%), opaque minerals (trace).

Texture: Red-brown biotite and muscovite are lepidoblastic (0.1-1.4 mm long) and define a moderately well-developed fabric. Quartz and plagioclase (both 0.1-0.3 mm) are xenoblastic. Quartz is strained and recrystallized. Syntectonic garnets range in size from 0.7 to 1.0 mm.

Lithology: meta-graywacke

#### OB-513

Pyrrhotitic massive sulfide with minor amounts of pyrite. Intercepts of swirling, highly-deformed, banding alternate with intervals of wispy banding. A one foot interval (at 111) feet of a deformed pyrrhotite-cemented breccia with some light gray, chlorite-rich, fragments showing a seriate texture which developed before sulfide replacement of the groundmass. Subhedral to euhedral pyrite crystals are present in aggregates ranging from 0.3 to 1 cm in diameter. Pyrrhotite sometimes fills fractures in crosscutting, highly silicified, medium gray quartz-feldspar porphyry dikes. Blue, waxy, quartz? veins and patches may be related to the silicification of the porphyry dikes. All lithologies show a moderate to strongly developed  $S_1$  at  $10^0$  to CA.

#### OB-514

Light gray-green, massive, very fine-grained mafic volcanic rock. Very distinctive disseminated 0.3 mm magnetite phenocrysts. Moderately well-developed, vertical  $S_1$  from alignment of chlorite.

Thin section description: sample at 260 feet.

Mineralogy: chlorite (0.03-0.07 mm), epidote (0.05-0.1 mm), plagioclase, quartz, magnetite (0.1-0.3 mm), pyrite (trace)

Texture: Very fine-grained non-pleochroic chlorite is lepidoblastic with anhedral masses of epidote (after plagioclase) disseminated throughout. Magnetite octahedra show quartz-filled pressure shadows. The original plagioclase is very poorly preserved.

Lithology: metabasalt

#### OB-515

Black, fine-grained, massive, metabasalt with a locally poorly-preserved diabasic texture is metamorphosed to the biotite-facies and exhibits a poorly developed tectonic fabric. Several very thin veinlets and crushed zones containing epidote and trace amounts of pyrite. A 15 cm intercept of an aplite dike at 222 feet is cut by a vertical 2 cm-thick white quartz vein.



Thin section description: sample at 214 feet.

Mineralogy: hornblende (0.2-0.6 mm), plagioclase (0.1-0.2 mm), epidote, sphene, chlorite

Texture: Blastosubophitic hornblende preserves the texture of the original pyroxene mineral. Plagioclase is recrystallized and extensively altered to epidote. Sphene occurs in irregular patches.

Lithology: metabasalt

#### OB-516

Gray green, medium-grained, massive graywacke is moderately well-sorted with a gradual decrease in grain size downward. with 1% disseminated pyrite. Pyrite is present in a 2 cm-thick quartz vein as stringers and disseminated (1%) in the host rock.  $S_0$  is  $50^\circ$  to CA is cut by a nearly vertical, poorly developed  $S_1$  defined by the alignment of biotite.

Thin section description: sample at 60 feet.

Mineralogy: quartz (37%), plagioclase (33%), biotite (24%), garnet (5%), iron oxides (trace)

Texture: Poorly sorted and massive with xenoblastic plagioclase (0.05-0.4 mm) and quartz (0.04-0.3 mm) and porphyroblastic garnet (0.5-0.7 mm) and red-brown biotite (0.1-1.2 mm). Penetrative fabric is poorly developed by the alignment of biotite.

Lithology: meta-graywacke

#### OB-517

Dark gray fragmental rock is comprised of 1-3 mm long dark gray angular rock fragments and some equant plagioclase clasts are in a fine-grained chloritic matrix. The breccia alternates with intervals of fine-grained, medium gray chloritic rock which contains 3% light red fragments that show more than 10:1 flattening (0.5 x 5 cm). Moderately to strongly developed  $S_1$ , that sometime warps around the rock fragments, is parallel to  $S_0$  at  $30^\circ$  to CA.

Thin section description: samples at 224 and 226 feet.

Mineralogy: chlorite, amphibole (0.1-1.4 mm long, after pyroxene ?), plagioclase (0.2-0.7 mm), epidote (after plagioclase), magnetite

Texture: A highly foliated, chlorite and epidote-rich groundmass flows around porphyroblasts of amphibole (after pyroxene ?) and plagioclase. Pressure shadows of chlorite are adjacent to some of the larger porphyroblasts which show slight rotation. Some of the rock fragments are extremely fine-grained altered porphyritic basalt.

Lithology: mafic mylonite

#### OB-518

A medium gray-green, well-foliated, intermediate volcaniclastic rock contains 5% 3-4 mm rounded, dark, soft, pre-tectonic crystals that have an occasionally well-preserved prismatic habit. Sericitically-altered, stumpy plagioclase occur at 268 feet. Anastomosing  $S_1$ ? cleavage is parallel to CA.

Thin section description: sample at 262 feet

Mineralogy: chlorite, plagioclase, quartz, epidote, white mica

Texture: Blastoporphyrictic, pre-tectonic euhedral to anhedral, commonly broken, lath-like, plagioclase crystals (An 10?, most 0.3-0.5 mm, some >5 mm long) are aligned and accompanied by quartz and green, pleochroic, chlorite filling pressure shadows. The matrix is well foliated chlorite and lenses of recrystallized quartz transected by a widely-spaced chlorite-rich shear bands. Epidote and white mica are alteration products of plagioclase.

Lithology: protomylonite

#### OB-519

Medium gray, coarse-grained, slightly porphyritic biotite tonalite contains both subhedral and anhedral biotite with ragged terminations. Most of the plagioclase is subhedral (4 mm to 1 cm diameter) with some intervals containing 1 cm tabular plagioclase megacrysts. Up to 1% disseminated, 1mm diameter, pyrite is present. Numerous 1 to 2 cm aplite and pegmatite veins intrude the tonalite. No penetrative fabric was observed.

Thin section description: sample at 187 feet

Mineralogy: plagioclase (56%), hornblende (16%), quartz (12%), biotite (10%), potash feldspar (6%)

**Texture:** Hypidiomorphic-granular texture is developed with subhedral plagioclase (1-4 mm) and intergranular subhedral hornblende (1-3 mm), anhedral quartz (0.5-0.7 mm) and potash feldspar (0.7 mm). Plagioclase is altered to white mica along widely-spaced fractures and exhibit some myrmekitic intergrowths. Biotite is formed from the alteration of hornblende. No penetrative fabric is apparent.

**Lithology:** hornblende tonalite

#### **OB-521**

Dark gray, very fine-grained rock with 0.5% deformed garnets (2 x 4 mm) exhibits greenschist-facies metamorphic assemblage with extensive epidote replacement near quartz veins. Biotite (up to 1 mm long) is abundant adjacent to a quartz vein at 318 feet. Two foliations are present where  $S_1$  ranges between  $50^\circ$  and  $60^\circ$  to CA and  $S_2$  is at  $75^\circ$  to CA. A quartz muscovite phyllonite at 302 to 304 feet is succeeded downward by an S-C tectonite. A fault breccia is intersected from 305 to 316 feet with 0.5 to 7 cm diameter breccia fragments in a chlorite-epidote matrix containing deformed quartz veins. Light gray, clear quartz veins and white crystalline calcite veins were rotated, segmented and brecciated during the faulting. Ductily deformed mafic volcanic breccia clasts are also found locally within the fault-gouge.

**Thin section description:** sample at 299 feet.

**Mineralogy:** chlorite, quartz, biotite, muscovite, plagioclase

**Texture:** A well developed S-C fabric is developed from the alignment of phyllosilicate minerals and lenses and pods of recrystallized quartz and untwined plagioclase. Grain size ranges from 0.1 to 0.3 mm for the phyllosilicates and 0.05 to 0.1 mm for the quartz and plagioclase.

**Lithology:** mylonite