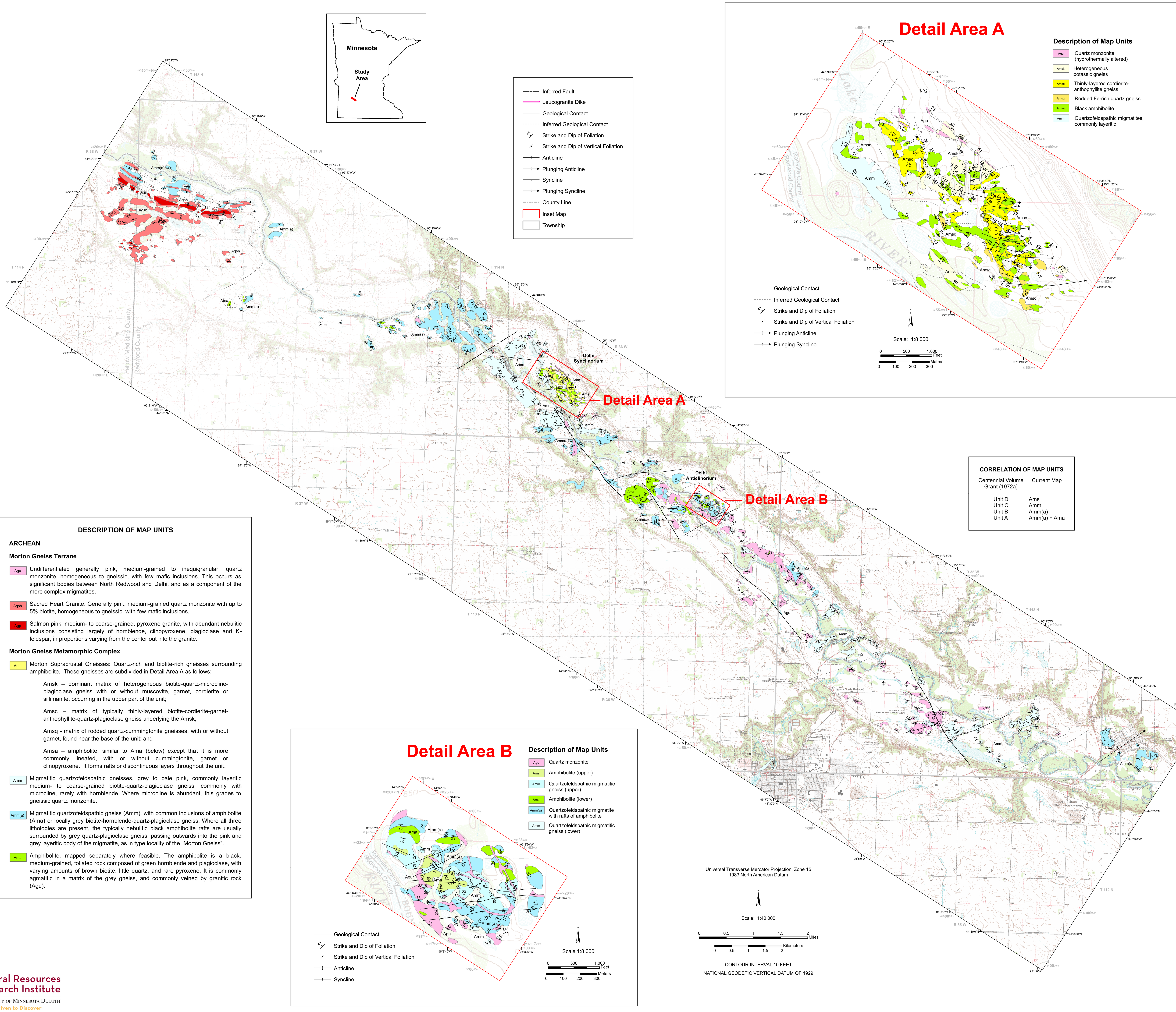
UNIVERSITY OF MINNESOTA DULUTH
NATURAL RESOURCES RESEARCH INSTITUTE
Rolf Weberg, Director

ECONOMIC GEOLOGY MAP SERIES
NRRI//EGG/MAP/2016-01
Project No. 1801-10416-20090
Project No. 1750-10416-20090-1000004145

Archean Geology of the Minnesota River Valley Sacred Heart to Morton

Geology by James A. Grant, 1965 - 1967



INTRODUCTION

James A. Grant

Dept. of Earth and Environmental Sciences

University of Minnesota Duluth

The Minnesota River has eroded through younger rocks to expose some of the oldest rock in the Canadian Shield. Modern mapping of these rocks started with E. H. Lund (1956). Lund mapped the Precambrian rocks from Ortonville to New Ulm. He concentrated on the Granite Falls area and the area of Cedar Mountain, near Franklin. He provided a most useful basis for later mapping. This mapping was carried out by G. L. Himmelburg (1968) in the Montevideo-Granite Falls area and by J. A. Grant (1972a, 1972b) in the Sacred Heart – Morton area, which is the work reported on here. I concentrated on this area, but provided structural data and some petrologic data on the rest of the Minnesota River Valley, as seemed necessary, for the Centennial Volume on the Geology of Minnesota (P. K. Sims and G. B. Morey, eds., 1972, p. 177-196). The mapping was underwritten by the Minnesota Geological Survey, but the maps were not published, probably due to a change in focus with change in the director of the Survey. Early digital versions of the mapping presented here were incorporated into maps of Renville and Redwood Counties (Jirsa et al, 2013; 2016). Although less detailed, these maps provide regional geologic context in and away from the Minnesota River valley, inferred largely from geophysical and drill hole data.

The geology on which the present maps are based is from field work and petrology done from 1965-1967. The mapping was carried out on aerial photographs from the 1950s to early 1960s. The base layer for the current map comprises portions of nine 1:24,000 Digital Raster Graphic USGS topo maps, current as of 2003. Thus, the base available for mapping has improved dramatically since the original work was done. The hiatus between work and publication has not improved my memory or the mapping, but nevertheless, this makes available detailed mapping of this major area of outcrop, which can be read in conjunction with the text in the Centennial Volume referenced above. The correlation between the units used in the map and in the text is shown in the chart to the left, and it should be noted that the two amphibolite layers in “Unit A” may extend to “Agp” in the Sacred Heart Granite.

Lund located the major areas of outcrop and distinguished the granitic bodies, such as the Ortonville Granite and the Sacred Heart Granite, the Montevideo Gneiss and the Morton Gneiss, and the mafic rocks, Lund’s “gabbro gneiss”, intermixed with them. Once one tries to subdivide these units further, the major question is just what can be mapped. When I started mapping, from near Sacred Heart southeast towards Morton, I found that neither color nor composition nor structure nor thickness remained constant very far; of these, simple color was the most useful criterion. I mapped pink quartz monzonitic rocks including the “Sacred Heart Granite”, gray and pink quartzofeldspathic migmatites with and without black amphibolite rafts or layers, and black amphibolite on its own where scale permitted. Even this work could be a challenge, as the grey and pink rock of the migmatites may merge into pink due to the actual formation of migmatites, whether by the intrusion of magma or not, or by the weathering of the quartzofeldspathic rocks to a pale pink surface. (An area near North Redwood is the location of Goldich’s (1938) classic study of weathering.) One cannot map on a thin section basis or visit every outcrop; one has to try to map on what can be seen from some way off.

I tried to illustrate some of the variation in the Morton Complex by mapping two areas near Delhi in greater detail than the bulk of the region. “Detail Area A” shows the geology of Lund’s largest area of “gabbro gneiss” in some detail because it is underlain by supracrustal rocks not previously reported. “Detail Area B” illustrates the possibility of defining stratigraphy, or at least layered order, in the “Morton Gneiss”.

In the exposed Sacred Heart – Morton area, the “Morton Gneiss Metamorphic Complex” consists of an upper unit of supracrustal rocks only exposed in the vicinity of Delhi, overlying a migmatitic complex, the typical Morton Gneiss. This complex is composed of pink rocks, grey rocks, and black rocks in a variety of migmatitic structures, commonly layered, in rafts (schollen) or as breccia (agmatitic). Generally, the amphibolite is in agmatitic rafts or layers. Grey tonalitic rock occurs as layers in pink and grey quartzofeldspathic gneiss, as rafts in more monzonitic gneiss, and also heals fractures in agmatitic amphibolite. Pink quartz monzonitic rock occurs as a component of the quartzofeldspathic migmatites, as relatively homogeneous bodies, and as sills and dikes and veinlets. Late granite and pegmatite dikes are common, especially northwest of Morton.

In west Delhi, the supracrustal rocks vary from iron-rich quartz-cummingtonite-gneisses to biotite-garnet-cordierite-anthophyllite-gneisses to K feldspar-sillimanite-bearing rocks, all with amphibolite rafts. The quartzitic rocks may be early iron-formation, and the quartz may be largely hydrothermal. (The quartzofeldspathic migmatites north of Beckendorf Lake are unusually quartz-rich and are approximately on strike with these rocks, on the west side of the Delhi Synclinorium (Detail Area A).) The cordierite-anthophyllite rocks may be residual from partial melting of greywackes and the aluminous rocks may be residual from partially melted more aluminous muds (Grant, 1968; Grant and Weiblen, 1971; Grant, Himmelburg, and Goldich, 1972).

These rocks have a long eventful history starting about 3.6 Ga to the end of the Archean – about one billion years later. Their history includes the combined results of igneous, sedimentary, and metamorphic events, and brittle and ductile deformation. I would emphasize the latter: differential flow is probably the major mode of deformation whose results we see, so ductility matters as much as composition.

Acknowledgements

I am most grateful for the opportunity to bring closure to this work, given to me initially by Steve Hauck and later by George Hudak, both of NRRI. It would not have come to fruition without the competence, hard work and patience of Julie Oreskovich, also of NRRI, to whom I owe immeasurable thanks. So when you consider this work, remember that the errors of omission and commission are mine, and that Julie is the person who has brought the 50-year old work to be, I hope, a useful addition to the geology of the Minnesota River Valley.

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CORRELATION OF MAP UNITS

Centennial Volume Grant (1972a)	Current Map
Unit D	Ams
Unit C	Amm
Unit B	Amm(a)
Unit A	Amm(a) + Ama

DESCRIPTION OF MAP UNITS

ARCHEAN

Morton Gneiss Terrane

Agu Undifferentiated generally pink, medium-grained to inequigranular, quartz monzonite, homogeneous to gneissic, with few mafic inclusions. This occurs as significant bodies between North Redwood and Delhi, and as a component of the more complex migmatites.

Agsh Sacred Heart Granite: Generally pink, medium-grained quartz monzonite with up to 5% biotite, homogeneous to gneissic, with few mafic inclusions.

Agp Salmon pink, medium- to coarse-grained, pyroxene granite, with abundant nebulitic inclusions consisting largely of hornblende, clinopyroxene, plagioclase and K-feldspar, in proportions varying from the center out into the granite.

Morton Gneiss Metamorphic Complex

Ams Morton Supracrustal Gneisses: Quartz-rich and biotite-rich gneisses surrounding amphibolite. These gneisses are subdivided in Detail Area A as follows:

Amsk – dominant matrix of heterogeneous biotite-quartz-microcline-plagioclase gneiss with or without muscovite, garnet, cordierite or sillimanite, occurring in the upper part of the unit;

Amsc – matrix of typically thinly-layered biotite-cordierite-garnet-anthophyllite-quartz-plagioclase gneiss underlying the Amsk;

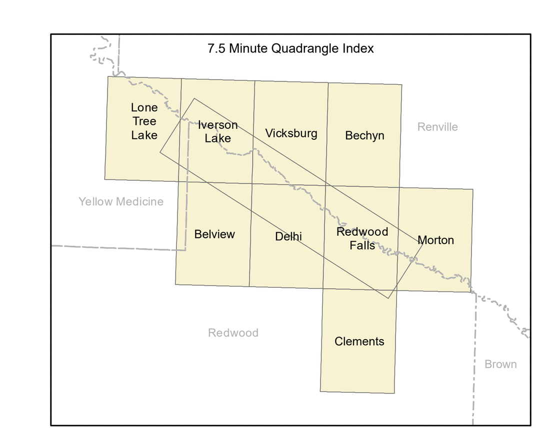
Amsq - matrix of rodded quartz-cummingtonite gneisses, with or without garnet, found near the base of the unit; and

Amsa – amphibolite, similar to Ama (below) except that it is more commonly lineated, with or without cummingtonite, garnet or clinopyroxene. It forms rafts or discontinuous layers throughout the unit.

Amm Migmatitic quartzofeldspathic gneisses, grey to pale pink, commonly layeritic medium- to coarse-grained biotite-quartz-plagioclase gneiss, commonly with microcline, rarely with hornblende. Where microcline is abundant, this grades to gneissic quartz monzonite.

Amm(a) Migmatitic quartzofeldspathic gneiss (Amm), with common inclusions of amphibolite (Ama) or locally grey biotite-hornblende-quartz-plagioclase gneiss. Where all three lithologies are present, the typically nebulitic black amphibolite rafts are usually surrounded by grey quartz-plagioclase gneiss, passing outwards into the pink and grey layeritic body of the migmatite, as in type locality of the “Morton Gneiss”.

Ama Amphibolite, mapped separately where feasible. The amphibolite is a black, medium-grained, foliated rock composed of green hornblende and plagioclase, with varying amounts of brown biotite, little quartz, and rare pyroxene. It is commonly agmatitic in a matrix of the grey gneiss, and commonly veined by granitic rock (Agu).



Base from U.S. Geological Survey 1:24,000 quadrangles, 2003.

Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover

GIS and cartography by Julie A. Oreskovich
December, 2016