
MINNESOTA
GEOLOGICAL SURVEY
1872
UNIVERSITY OF MINNESOTA

Bureau of Reclamation
Red River Valley Water Supply Study
THE PROBLEM

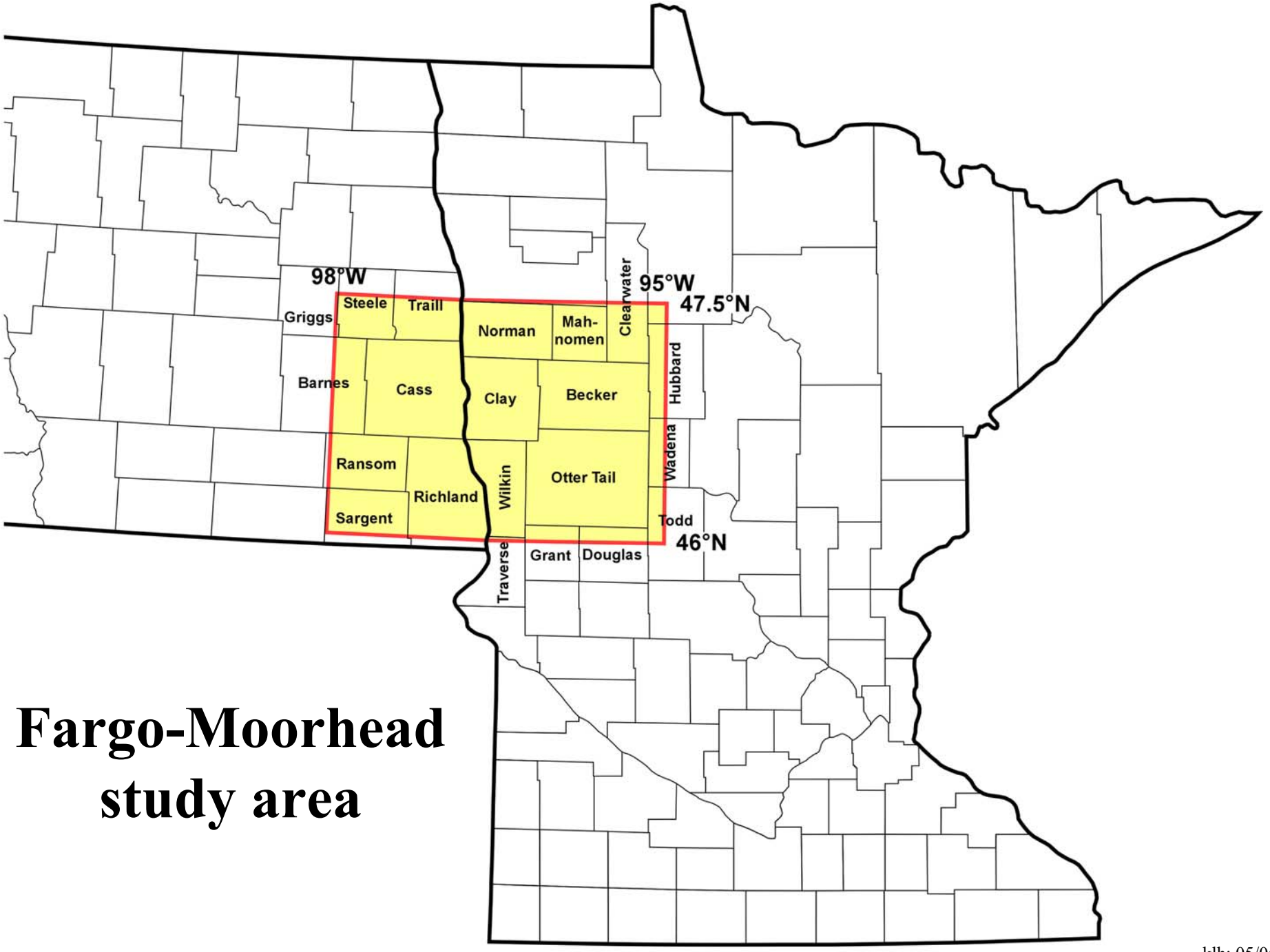
- **Limited surface water resources**
- **Limited groundwater resources**
- **Need to identify and evaluate alternative surface and groundwater resources**
- **Develop alternative basin water resources**

Bureau of Reclamation
Red River Valley Water Supply Study
COOPERATORS

- **Minnesota Geological Survey**
- **Minnesota Department of Natural Resources, Waters Division**
- **North Dakota Geological Survey**
- **North Dakota State Water Commission**
- **USGS, Water Resources Division (Minnesota and North Dakota)**

Bureau of Reclamation
Red River Valley Water Supply Study
TASKS

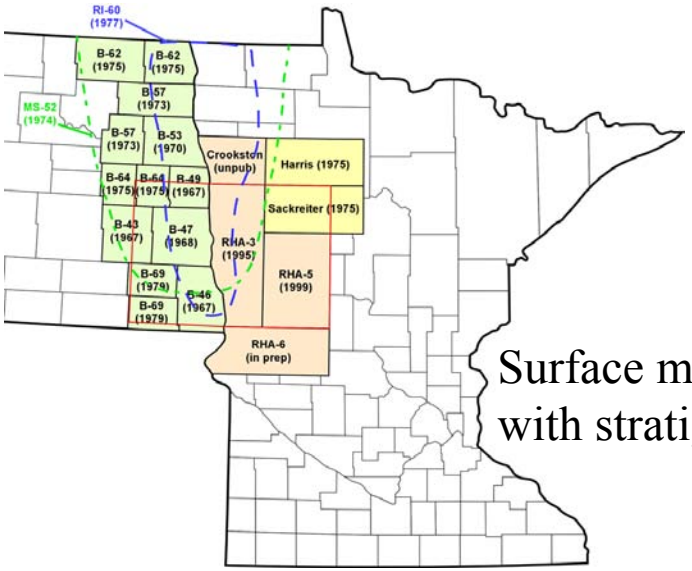
- Compile Existing Surficial Geology and Quaternary Stratigraphy
- Compile Existing Bedrock Geology and Stratigraphy
- Build a Waterwell Database and Cross Sections (5 km Spacing)
- Map detailed hydrostratigraphy where possible (~0.1 to 0.5 km Spacing)
- Build Three Dimensional Model of Geology
- Compile a regional groundwater flow literature review



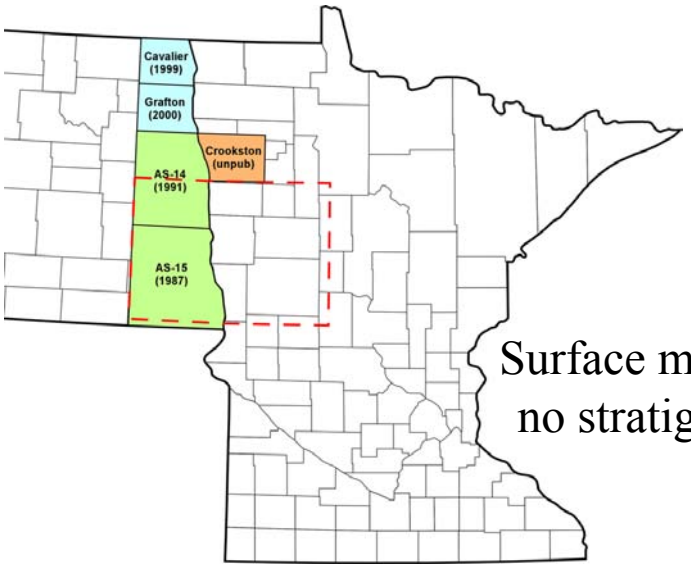
Fargo-Moorhead study area

klh; 05/05

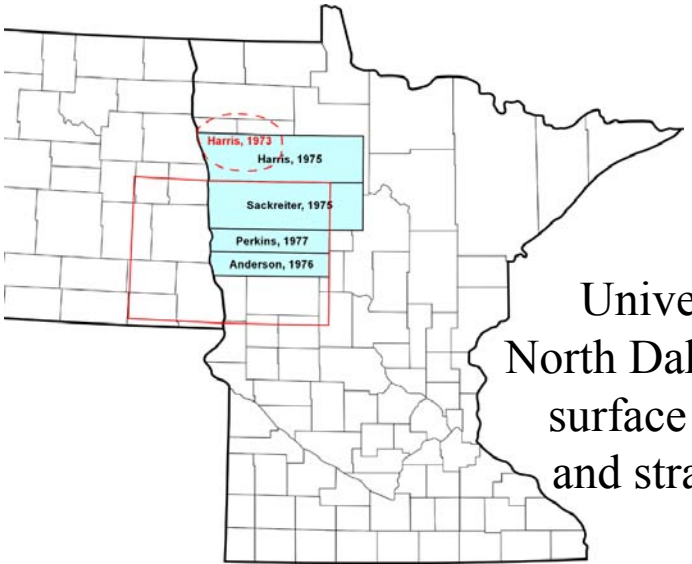
Previous mapping
Fargo-Moorhead study



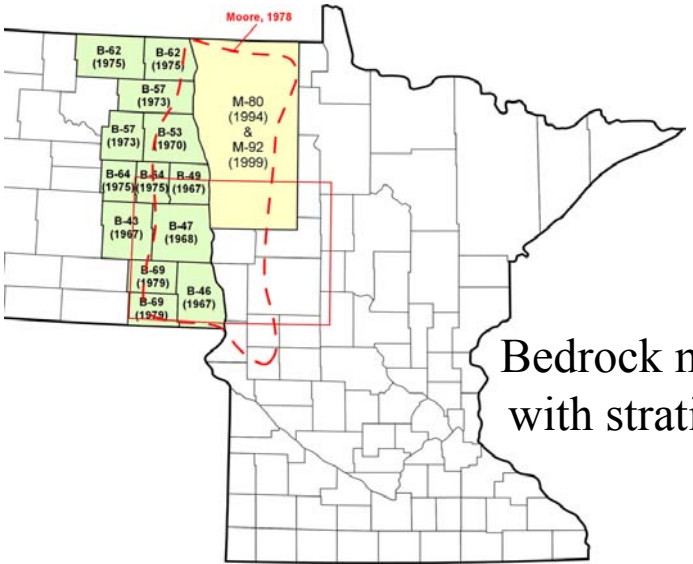
Surface mapping with stratigraphy



Surface mapping no stratigraphy

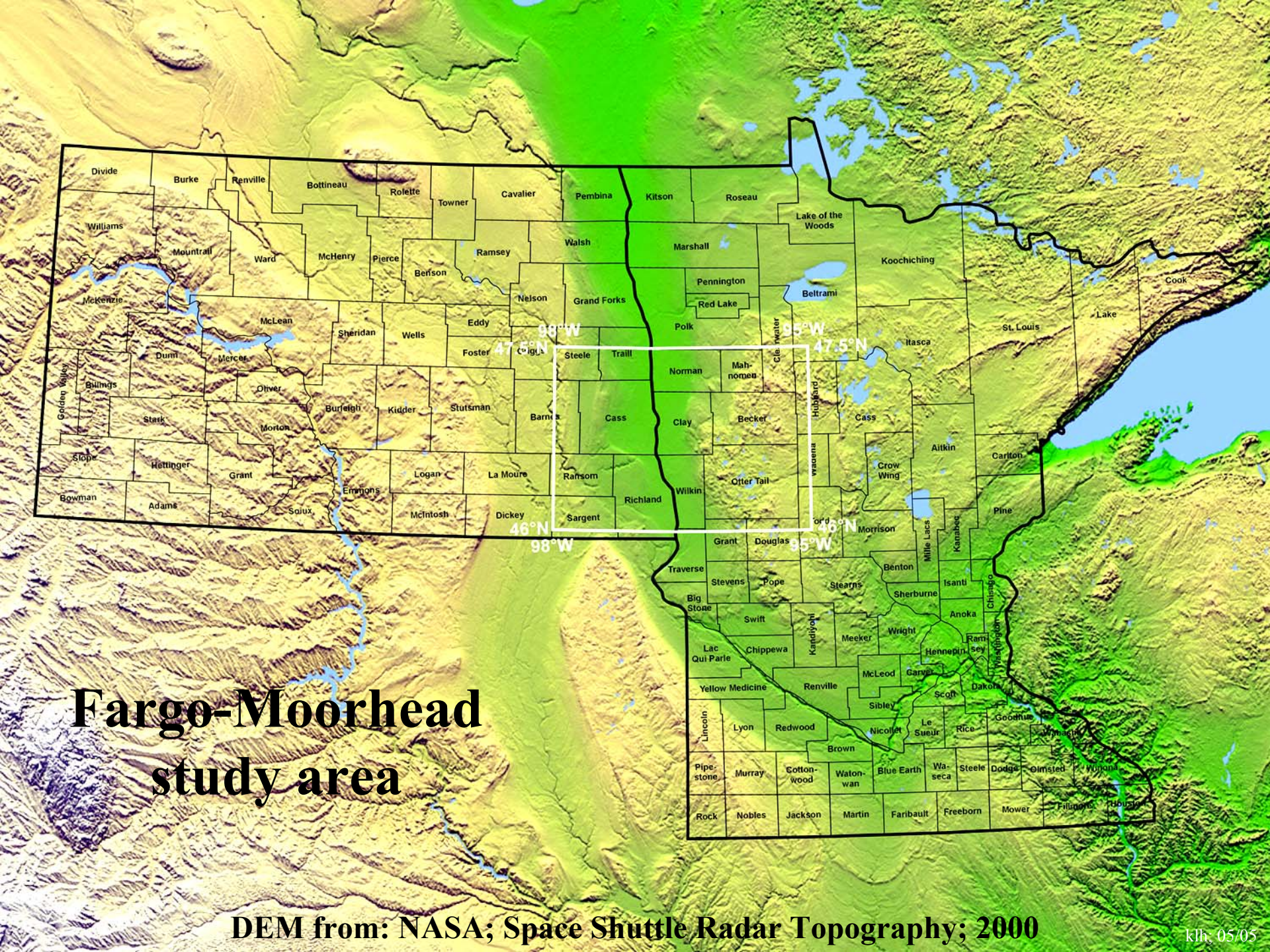


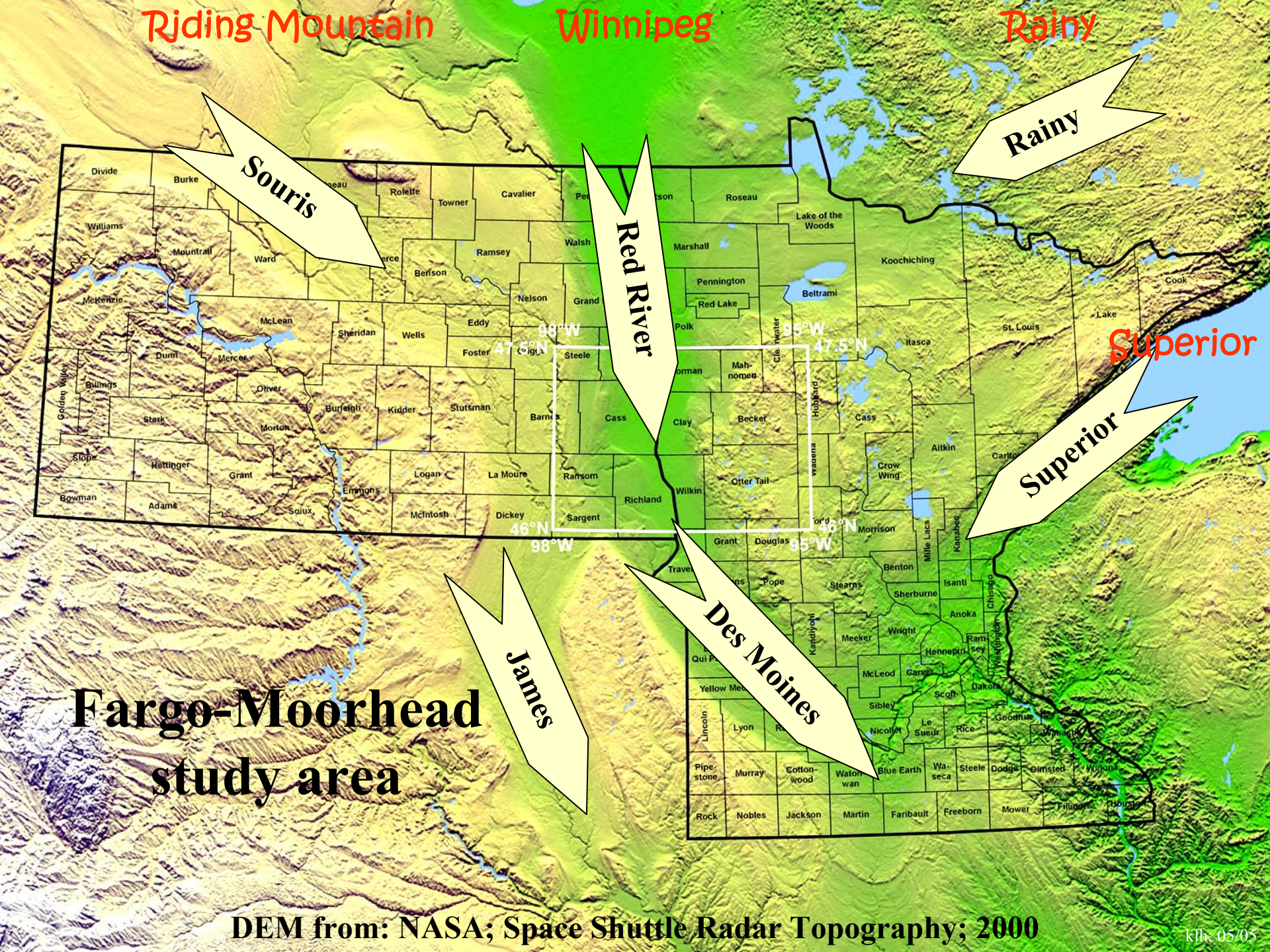
University of North Dakota theses; surface mapping and stratigraphy

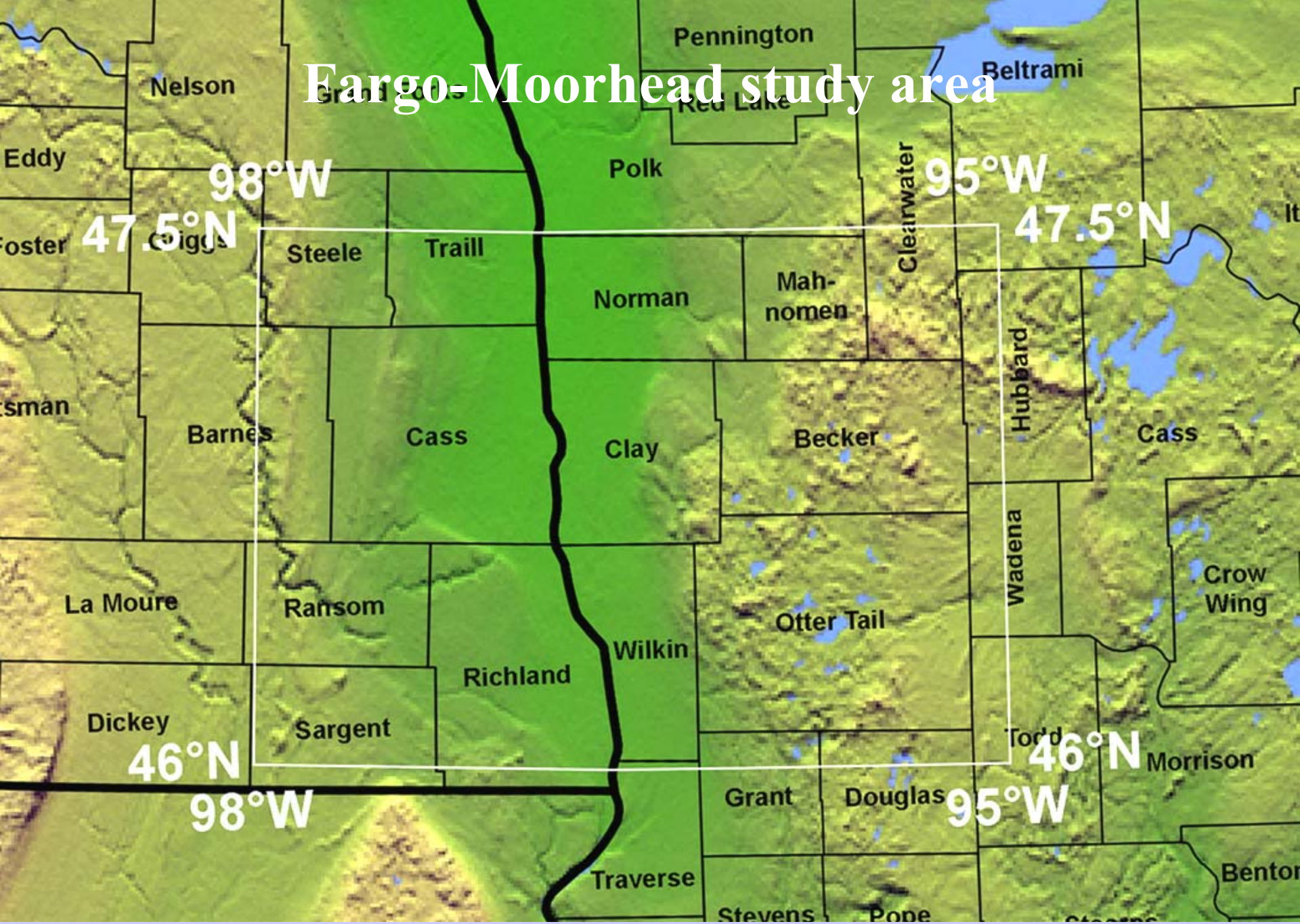


Bedrock mapping with stratigraphy

klh; 05/05


Fargo-Moorhead
study area
DEM from: NASA; Space Shuttle Radar Topography; 2000
klh, 05/05
Divide
Burke
Renville
Bottineau
Rolette
Towner
Cavalier
Pembina
Kitson
Roseau
Lake of the Woods
Williams
Mountrail
Ward
McHenry
Pierce
Benson
Ramsey
Walsh
Marshall
Koochiching
Cook
McKenzie
McLean
Sheridan
Wells
Eddy
Foster
Nelson
Grand Forks
Pennington
Red Lake
Beltrami
Polk
Clearwater
Lake
St. Louis
Itasca
Dunn
Mercer
Golden Valley
Billings
Oliver
Burleigh
Kidder
Stutsman
Barnes
Steele
Traill
Norman
Mahnomen
Hubbard
Cass
Clay
Becker
Stark
Morton
Slope
Hettinger
Grant
Bowman
Adams
Sioux
Logan
La Moure
Emmons
McIntosh
Dickey
Ransom
Sargent
Richland
Wilkin
Otter Tail
Wadena
Crow Wing
Aitkin
Carlton
Pine
Kanabec
Mille Lacs
Morrison
47.5°N
98°W
95°W
46°N
Grant
Douglas
Traverse
Stevens
Pope
Stearns
Benton
Isanti
Chisago
Big Stone
Swift
Kandiyohi
Meeker
Wright
Sherburne
Anoka
Ramsey
Hennepin
Washington
Lac Qui Parle
Chippewa
McLeod
Carver
Dakota
Yellow Medicine
Renville
Sibley
Scott
Goodhue
Lincoln
Lyon
Redwood
Nicollet
Le Sueur
Rice
Wabasha
Brown
Pipestone
Murray
Cottonwood
Watonwan
Blue Earth
Waseca
Steele
Dodge
Olmsted
Winona
Rock
Nobles
Jackson
Martin
Faribault
Freeborn
Mower
Fillmore
Houston


Riding Mountain
Winnipeg
Rainy
Souris
Red River
Rainy
Superior
Superior
James
Des Moines
Fargo-Moorhead
study area
DEM from: NASA; Space Shuttle Radar Topography; 2000
klh, 05/05

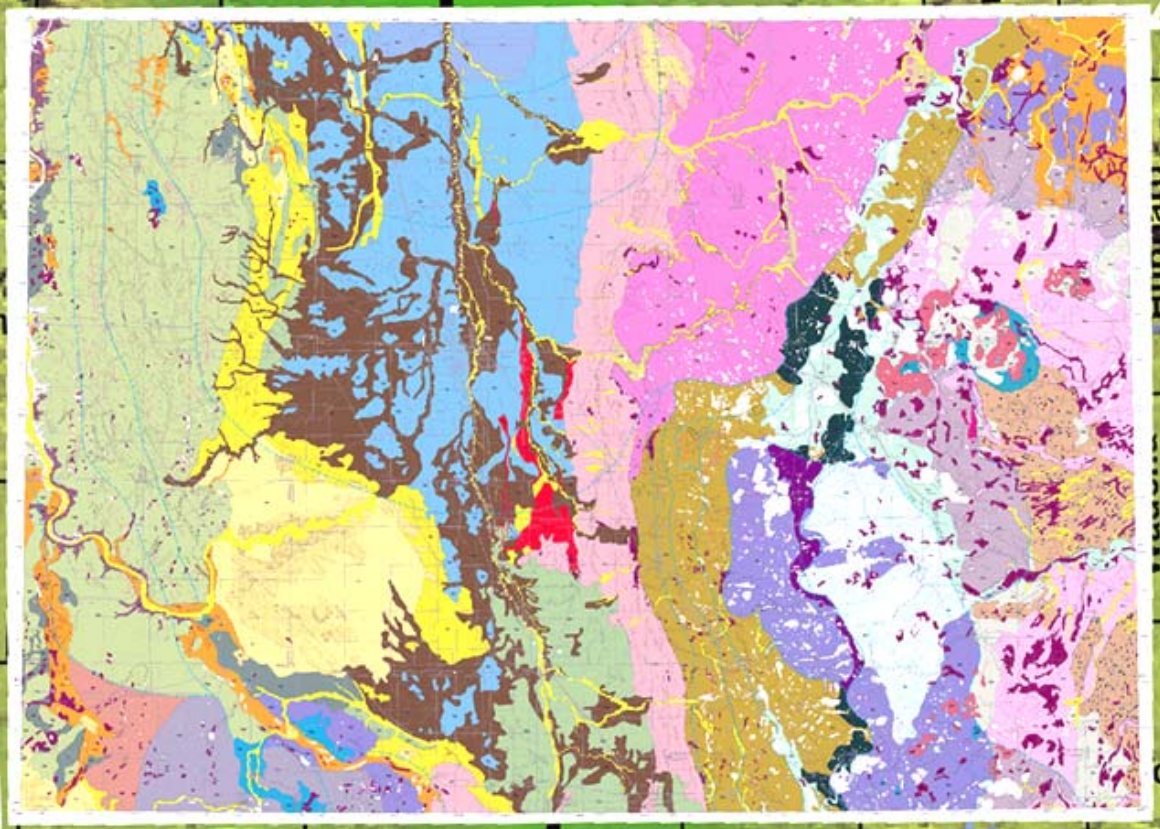


DEM from: NASA; Space Shuttle Radar Topography; 2000

klh; 05/05

Fargo-Moorhead study area

with lithostratigraphic map; Lusardi, Anderson, & Harris, 2005

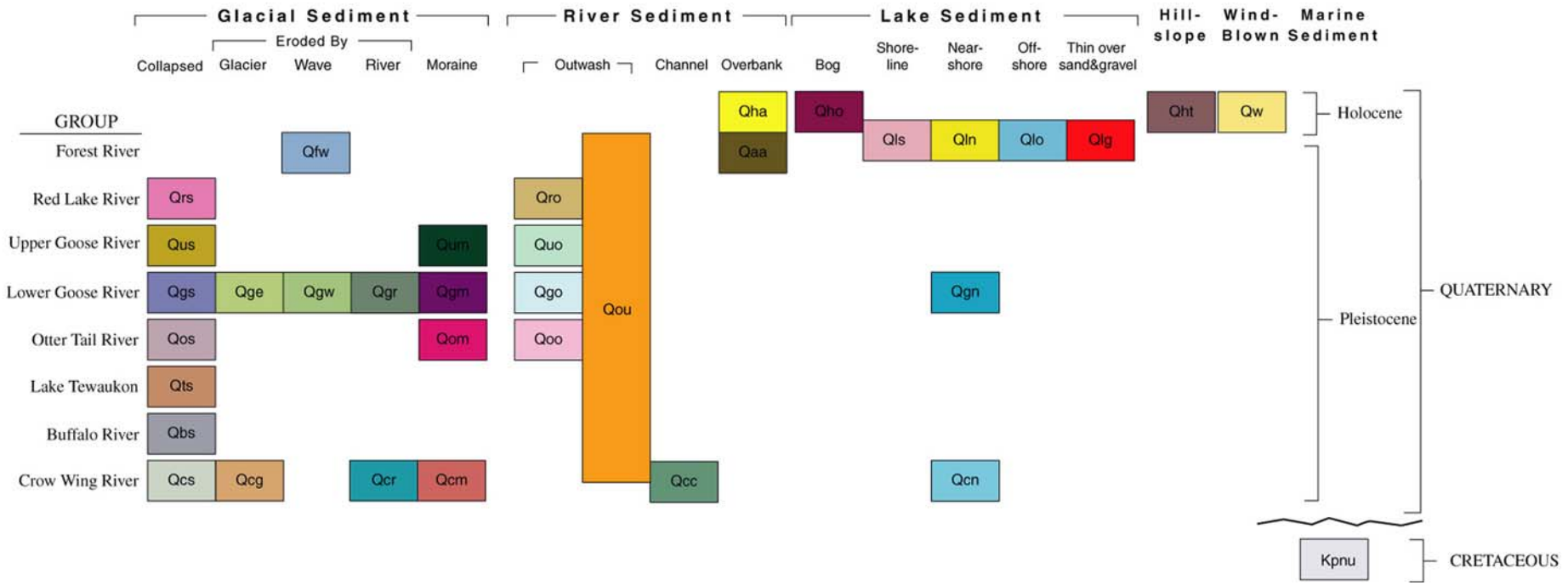


Pennington
Beltrami
Nelson
Grand Forks
Red Lake
Eddy
Polk
98°W
95°W
47.5°N
Foster
Barn
Cass
La Moure
Crow Wing
Dickey
46°N
Morrison
Grant
Douglas
Traverse
Stevens
Pope

DEM from: NASA; Space Shuttle Radar Topography; 2000

klh; 05/05

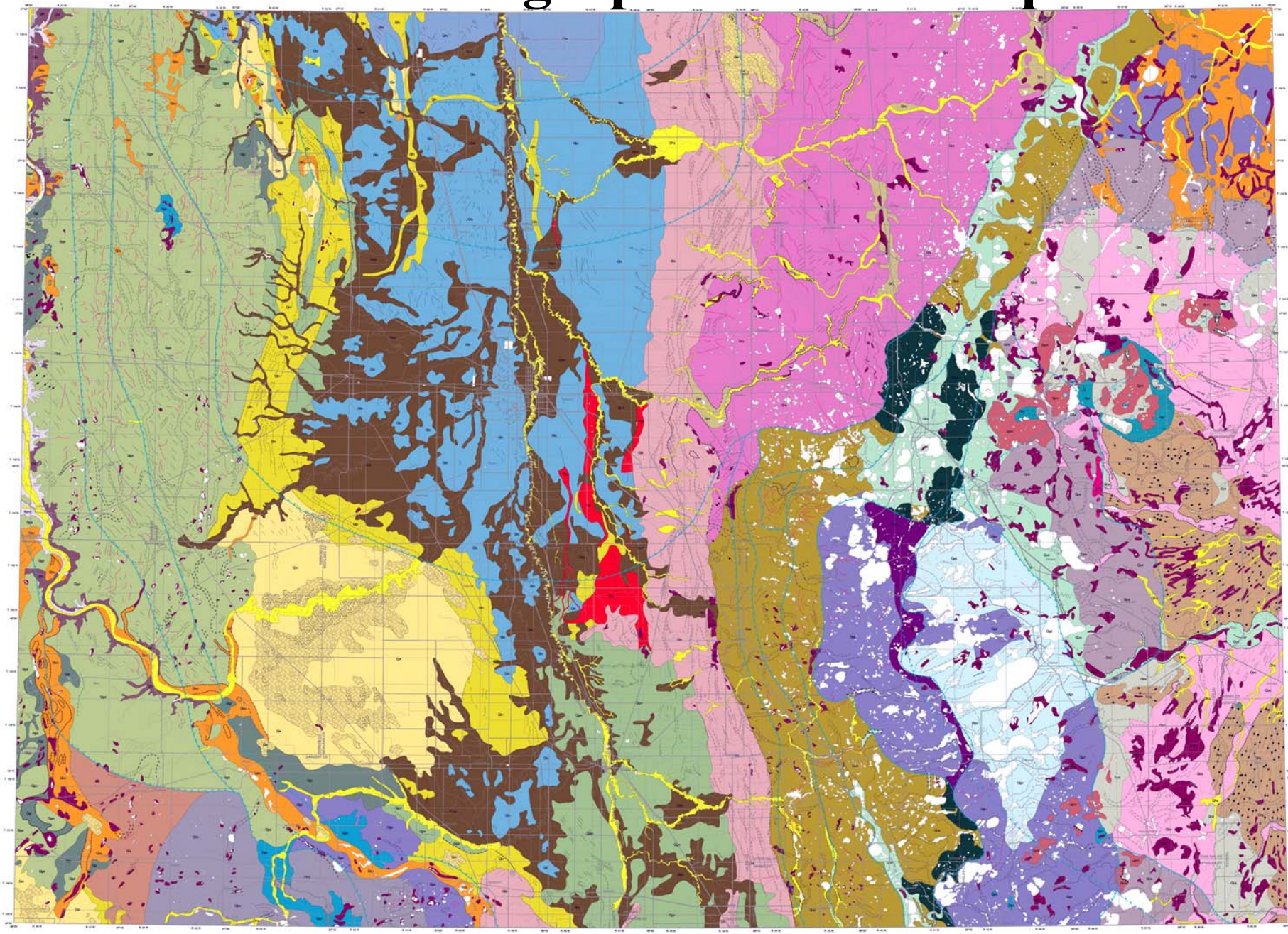
Lithostratigraphic surface map
Correlation of map units



Lusardi, Anderson, & Harris; 2005

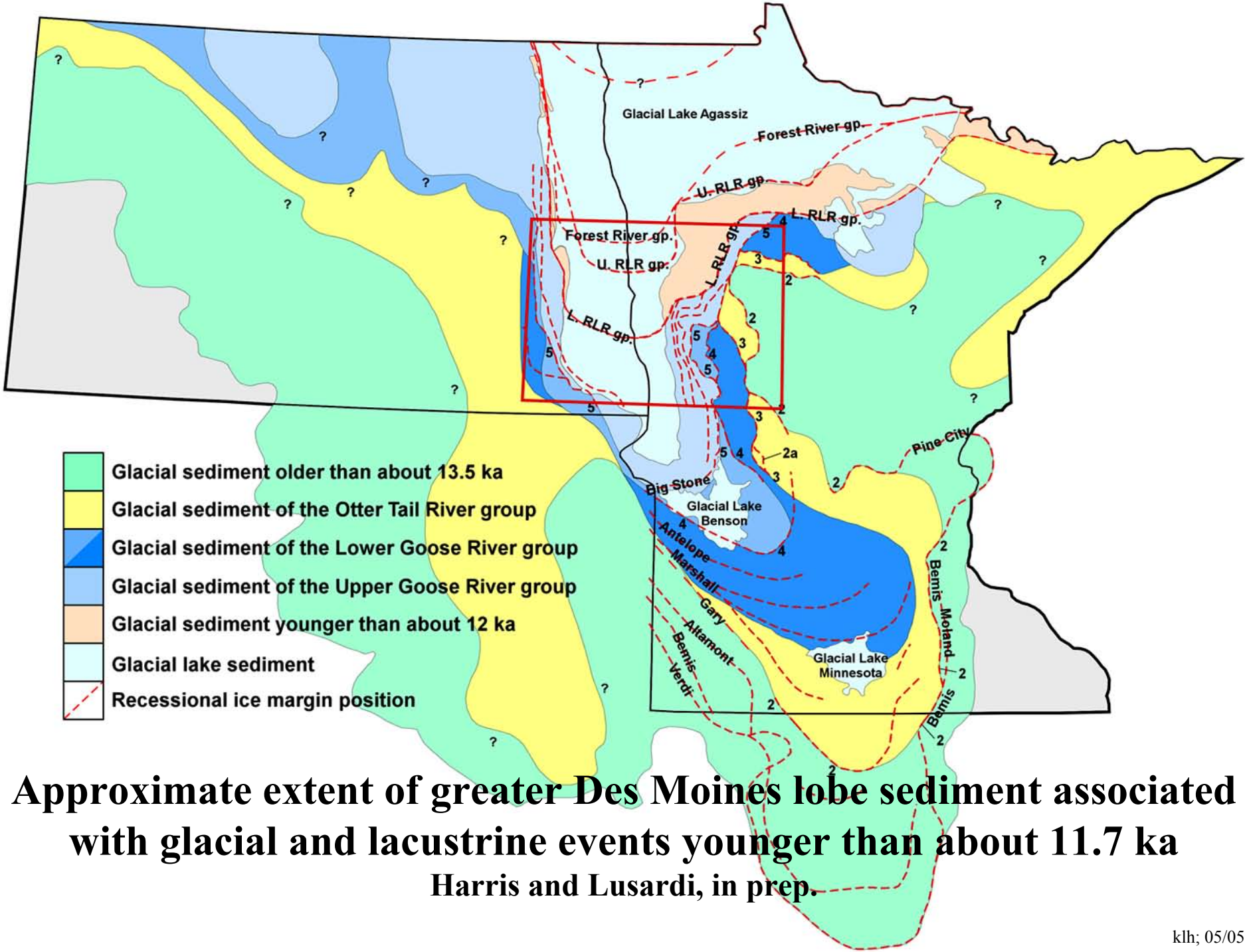
klh; 05/05

Lithostratigraphic surface map



Lusardi, Anderson, & Harris; 2005

klh; 05/05

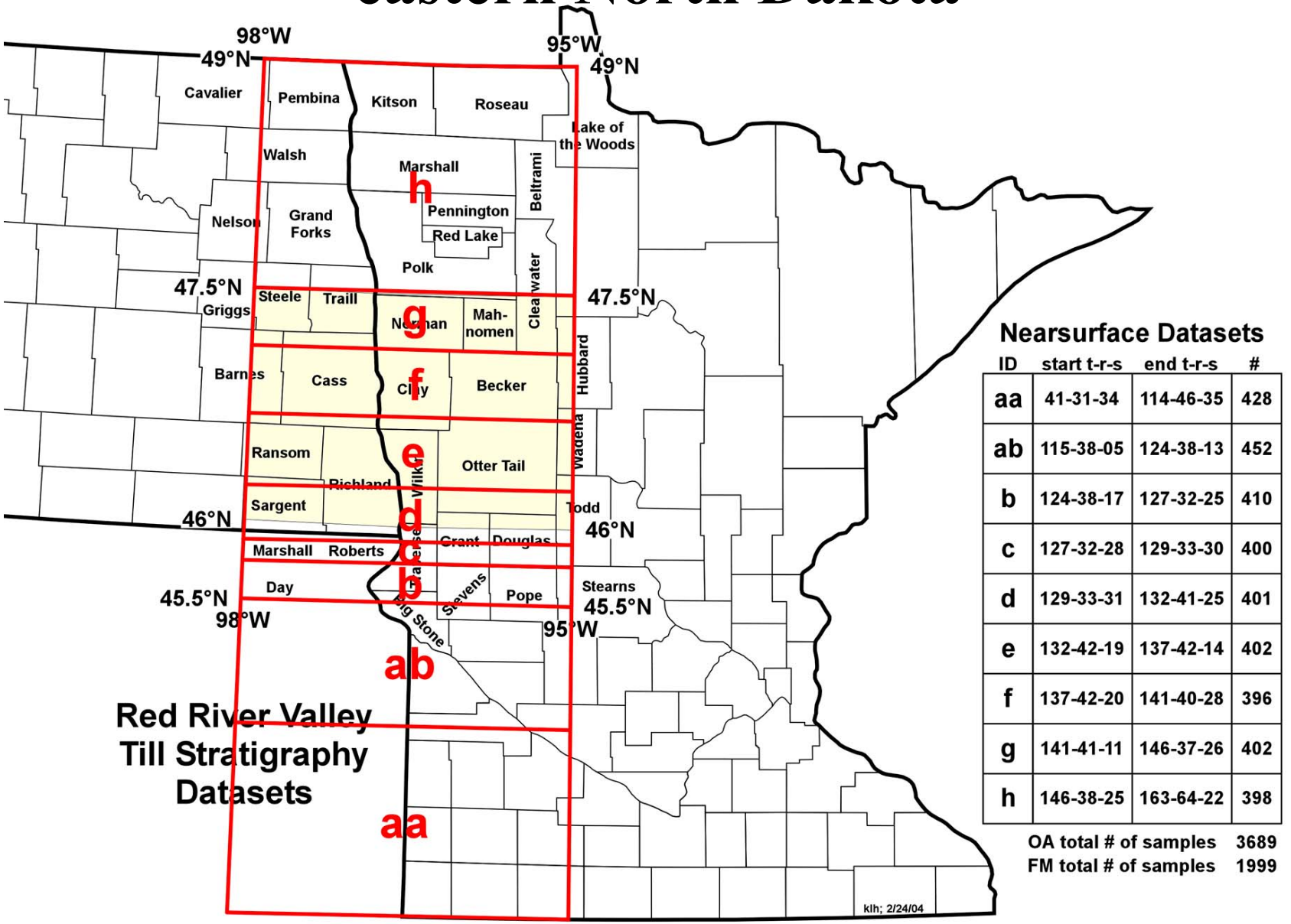


Approximate extent of greater Des Moines lobe sediment associated with glacial and lacustrine events younger than about 11.7 ka

Harris and Lusardi, in prep.

klh; 05/05

Nearsurface datasets in western Minnesota and eastern North Dakota



Nearsurface Datasets

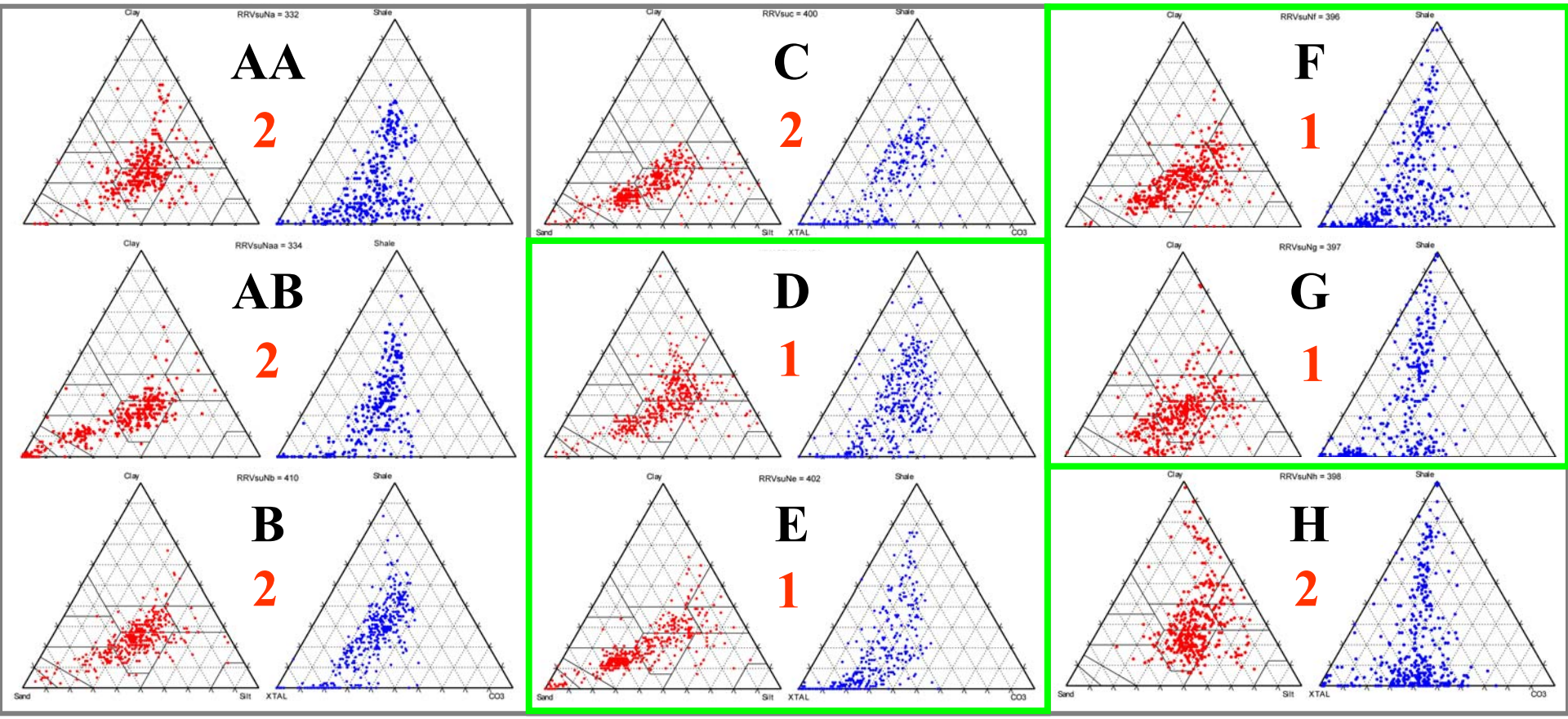
ID	start t-r-s	end t-r-s	#
aa	41-31-34	114-46-35	428
ab	115-38-05	124-38-13	452
b	124-38-17	127-32-25	410
c	127-32-28	129-33-30	400
d	129-33-31	132-41-25	401
e	132-42-19	137-42-14	402
f	137-42-20	141-40-28	396
g	141-41-11	146-37-26	402
h	146-38-25	163-64-22	398

OA total # of samples 3689
FM total # of samples 1999

klh; 05/05

Ternary plots of FM nearsurface data

south



north

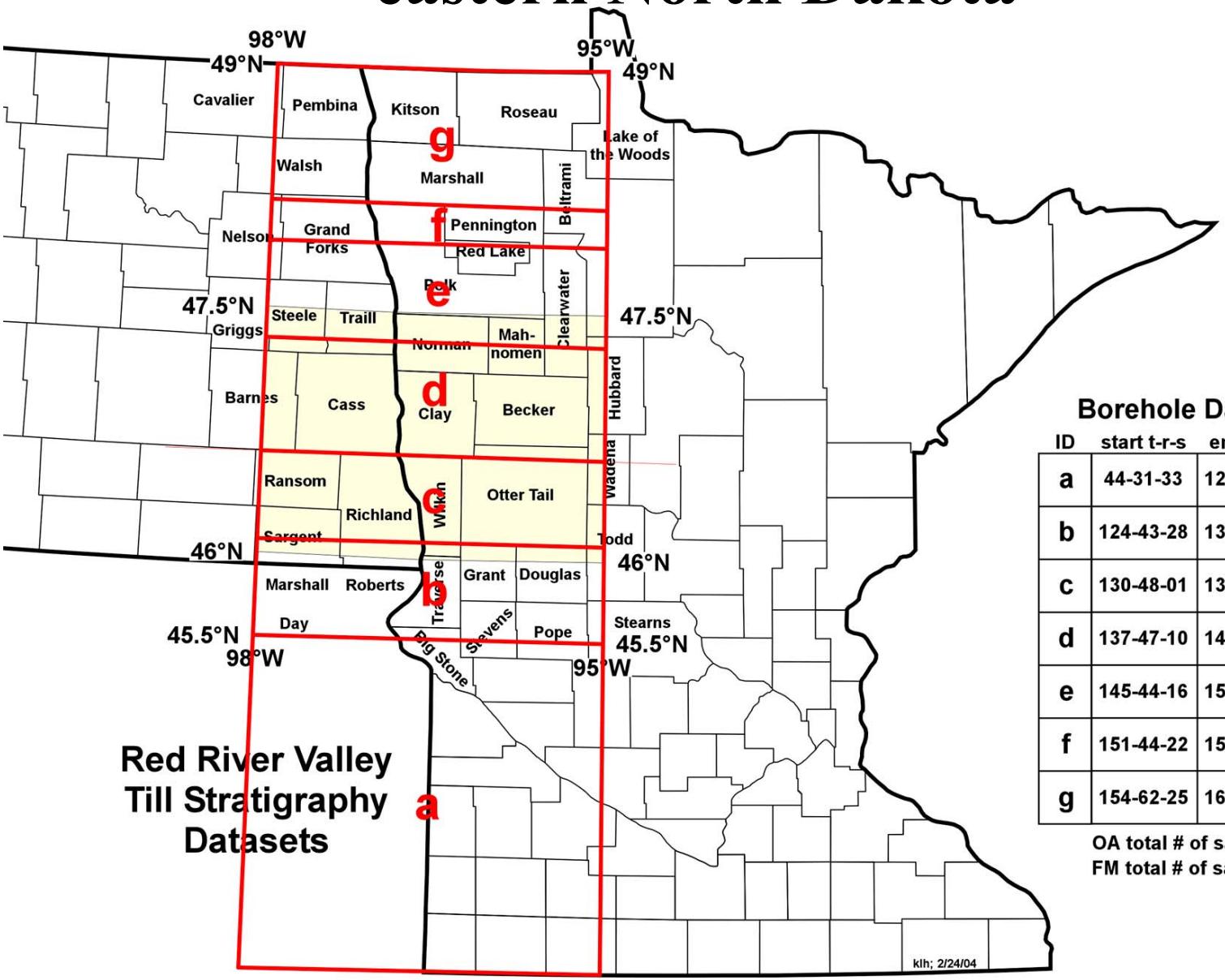
Red = Texture; **Blue** = 1-2 mm coarse-sand lithology

1 = datasets primarily located in the FM area

2 = datasets primarily located outside the FM area

klh; 05/05

Borehole datasets in western Minnesota and eastern North Dakota



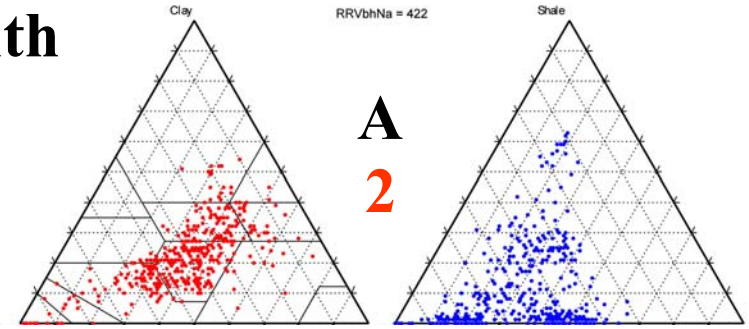
Borehole Datasets

ID	start t-r-s	end t-r-s	#
a	44-31-33	124-36-09	422
b	124-43-28	130-42-17	404
c	130-48-01	136-58-31	422
d	137-47-10	144-60-15	409
e	145-44-16	151-44-21	407
f	151-44-22	154-62-19	407
g	154-62-25	164-47-31	373

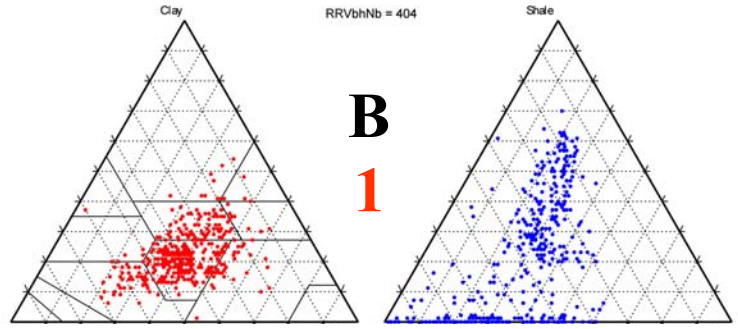
OA total # of samples 2844
FM total # of samples 1642

klh; 05/05

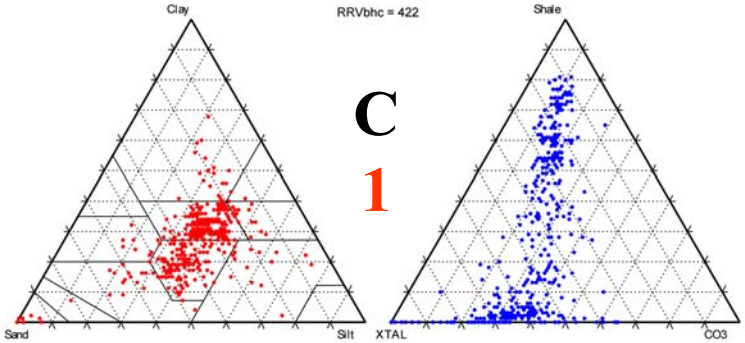
south



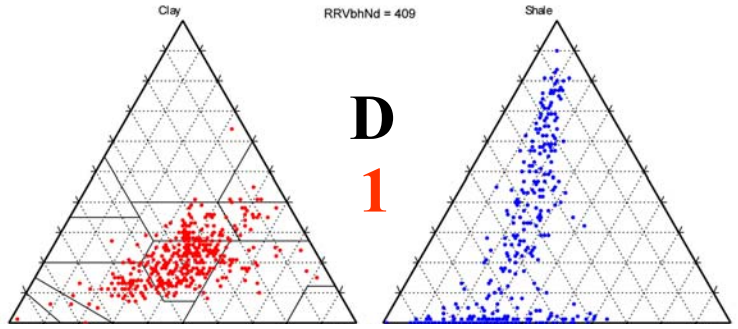
A
2



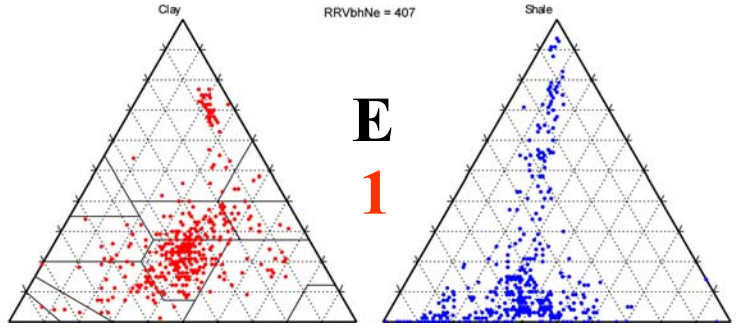
B
1



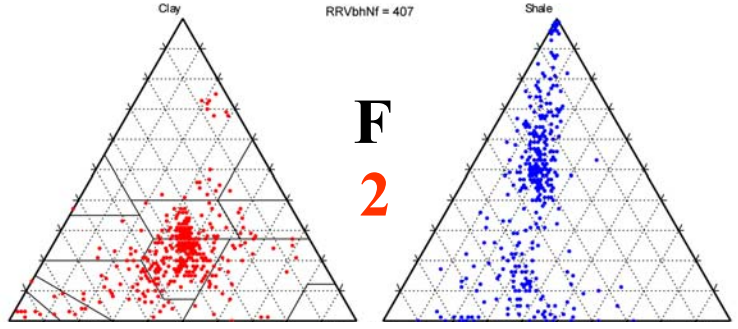
C
1



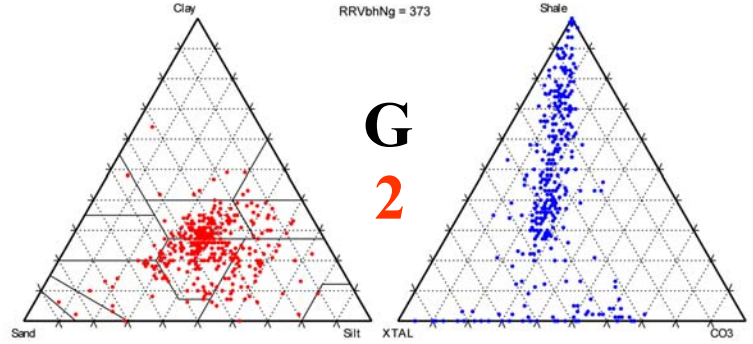
D
1



E
1



F
2



G
2

Ternary plots of FM borehole data

Red = Texture; **Blue** = 1-2 mm coarse-sand lithology

1 = datasets primarily located in the FM area

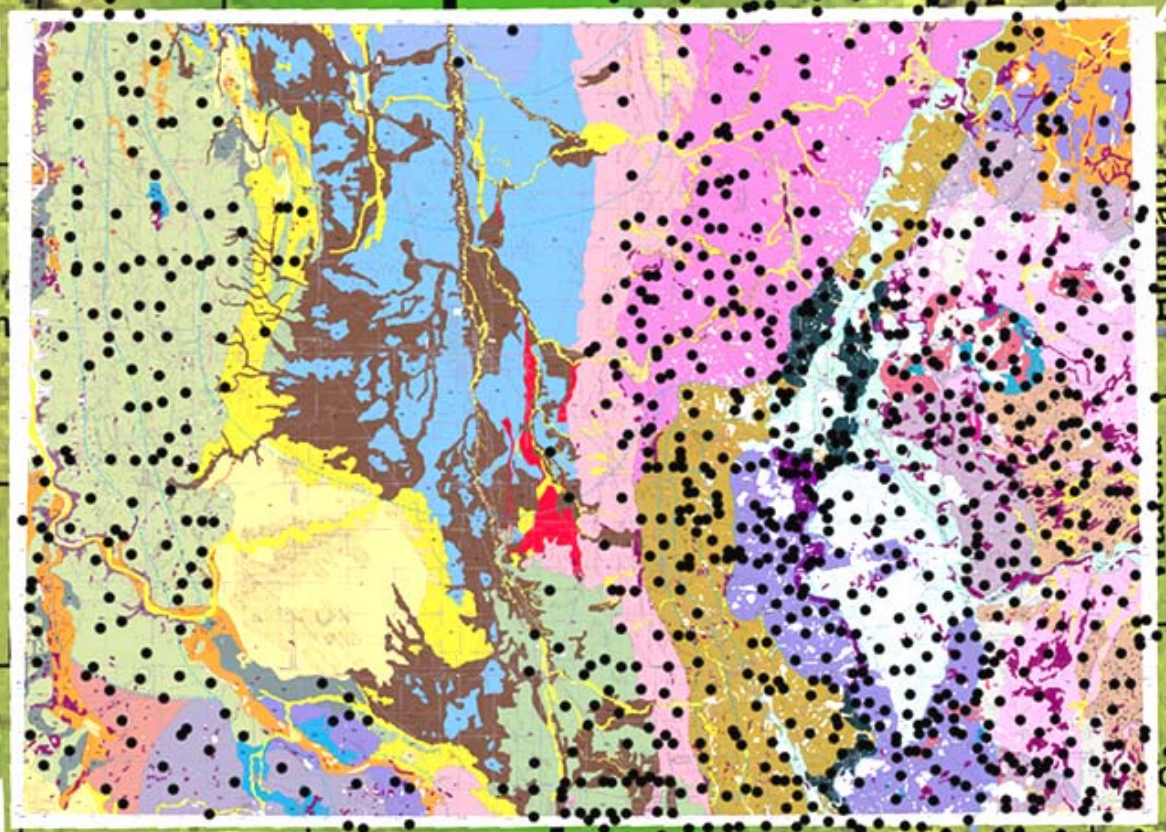
2 = datasets primarily located outside the FM area

klh; 05/05

north

Fargo-Moorhead study area

with surface geologic map; Lusardi, Anderson, & Harris, 2005



Pennington
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Crow Wing
Dickey
46°N
Morrison
Grant
Douglas
Traverse
Stevens
Pope

DEM from: NASA; Space Shuttle Radar Topography; 2000

klh; 05/05

Fargo-Moorhead area
Quaternary stratigraphic units
combined near-surface and borehole glacial units

updated = 04/20/05 — FMSBsummary.xls

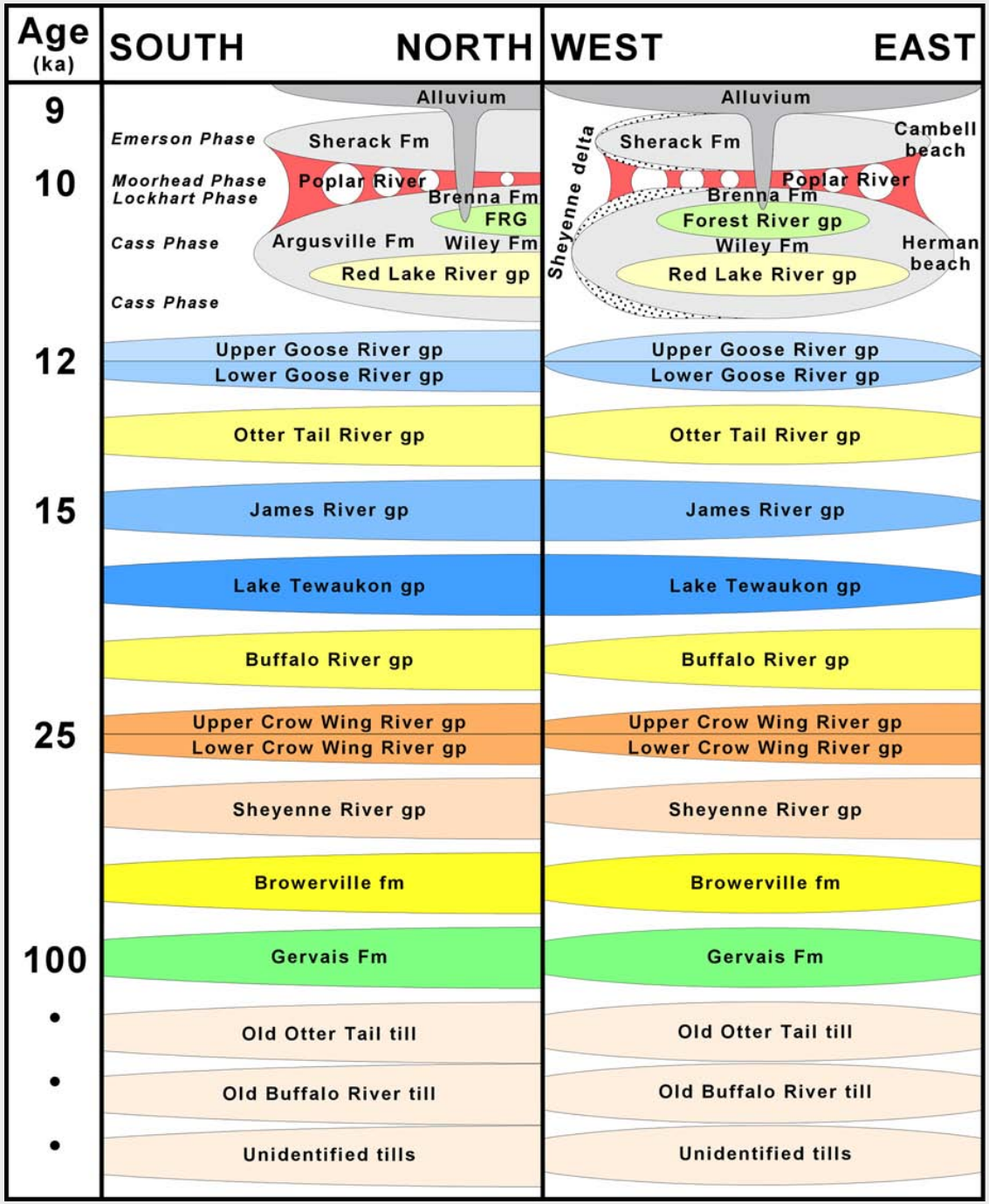
unit #	Group/Formation	Group/Formation	SD	SL	CL	Textural classification	XT	CO	SH	# of smpls	unit % of Tot	group % of Tot	labeled units	Labeled units
1	Forest River gp.	Huot Fm.	7	19	74	clay (C)	32	63	5	2	0.1%			
2	Forest River gp.	Falconer Fm.	11	35	54	clay (C)	39	35	26	10	0.4%	0.4%		
3	Red Lake River gp.	U. Red Lake Falls Fm.	37	40	23	loam (L)	58	29	13	26	0.9%			
4	Red Lake River gp.	L. Red Lake Falls Fm.	33	45	22	loam (L)	57	40	3	121	4.3%	5.2%		
5	U. Goose River gp.	Barnesville till	18	44	38	silty clay loam (SiCL)	44	44	12	67	2.4%			
6	U. Goose River gp.	St. Hilaire Fm.	27	44	29	clay loam (CL)	43	33	24	161	5.7%	8.1%		
7	L. Goose River gp.	Dahlen Fm.	30	42	28	clay loam (CL)	27	19	54	268	9.5%			
8	L. Goose River gp.	Heiberg fm.	32	40	28	clay loam (CL)	33	25	42	286	10.1%	19.6%		
9	Otter Tail River gp.	Hawley fm.	41	37	22	loam (L)	54	42	4	68	2.4%			
10	Otter Tail River gp.	New York Mills fm.	46	34	20	loam (L)	67	29	4	43	1.5%		**82.5%**	
11	Otter Tail River gp.	Villard fm.	42	37	21	loam (L)	49	28	23	239	8.5%	12.4%		
12	James River gp.	James till	45	35	20	loam (L)	45	24	31	64	2.3%	2.3%		
13	Lake Tewaukon gp	Gardar Fm.	27	44	29	clay loam (CL)	16	12	72	137	4.9%	4.9%		
14	Buffalo River gp.	Buffalo fm.	30	36	34	clay loam (CL)	64	32	4	103	3.6%	3.6%		**86.1%**
15	Crow Wing River gp.	U. Marcoux Fm.	57	28	15	sandy loam (SL)	85	15	0	266	9.4%			
16	Crow Wing River gp.	L. Marcoux Fm.	55	30	15	sandy loam (SL)	74	23	3	241	8.5%	18.0%		
17	Sheyenne River gp.	Sheyenne fm.	29	40	31	clay loam (CL)	50	36	14	48	1.7%	1.7%		
18	Browerville fm.	Browerville fm.	46	37	17	loam (L)	64	33	3	78	2.8%	2.8%		
19	Gervais Formation	Gervais Fm.	26	46	28	clay loam (CL)	48	49	3	102	3.6%	3.6%		
20	older till	Old Hawley till.	43	34	23	loam (L)	56	44	0	10	0.4%			
21	older till	Old New York Mills till	42	35	23	loam (L)	70	30	0	5	0.2%	0.5%		
22	older till	Old Buffalo till	37	37	26	loam (L)	62	30	8	5	0.2%	0.2%	**3.6%**	
23	older till	Old U. Marcoux till	36	44	20	loam (L)	85	14	1	36	1.3%			
24	older till	Old L. Marcoux till	38	42	20	loam (L)	74	24	2	45	1.6%	2.9%		
	no correlation									155	5.5%	5.5%		
	sd, sl, cl, sh dominant									238	8.4%	8.4%	**13.9%**	**13.9%**

Total samples =	**2824**	**100%**
Till samples =	**2431**	**86%**
Misc. samples =	**393**	**14%**

klh; 05/05

Time-distance diagram for the Fargo-Moorhead area

depicts stratigraphic position, geographic occurrence, and approximate age of Quaternary stratigraphic units encountered



klh; 05/05

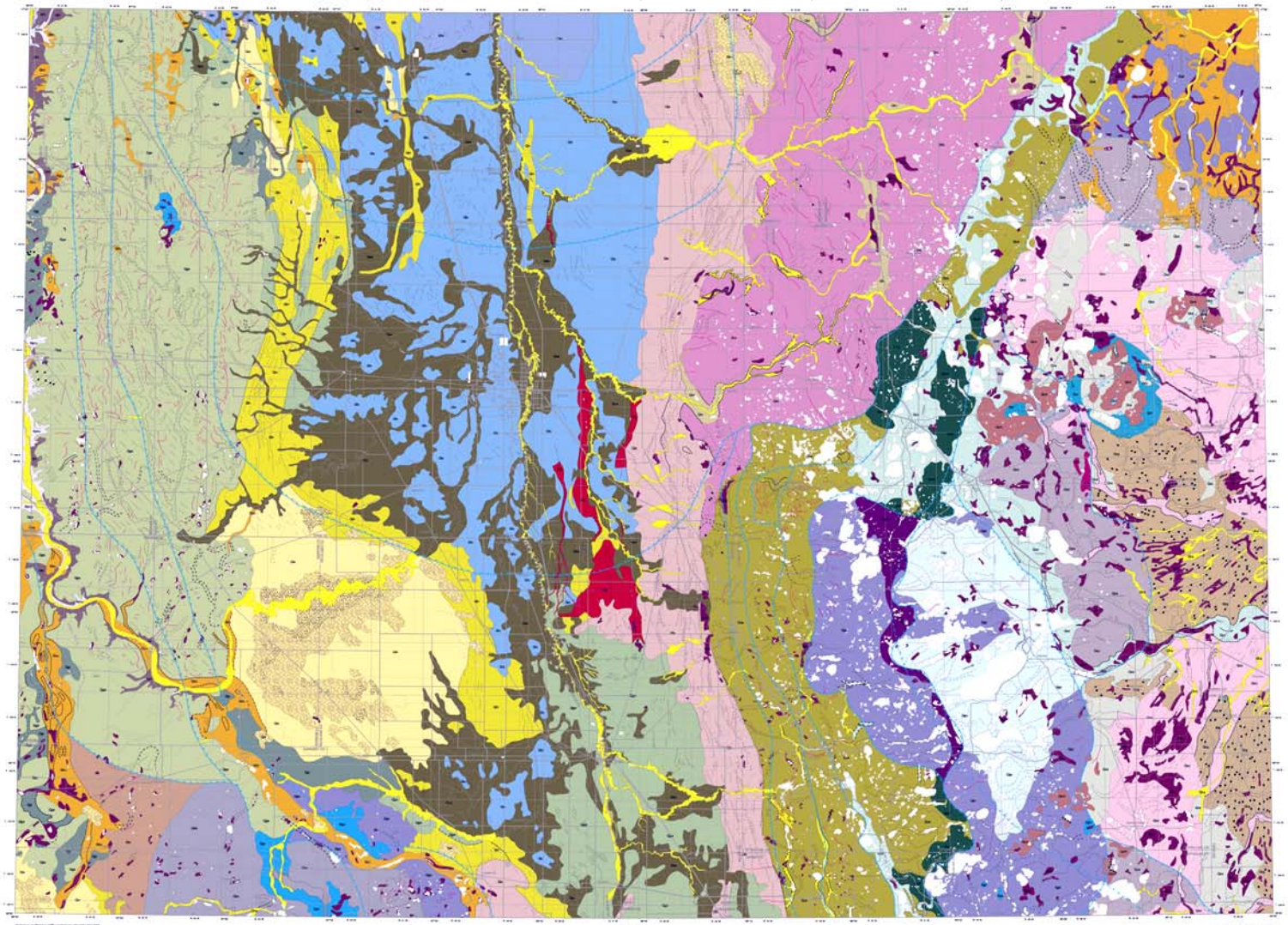
Fargo-Moorhead Regional Inventory of Groundwater Resources

RESULTS

- Map of Surficial Geology (1:200,000)
- Digital Drillhole Database (Project 3-D Database)
- Bedrock Geologic map (1:200,000)
- GIS Files of Subsurface Layer Extent (1:500,000)
- Database of "Tops" of Mapped Subsurface Layers (5 km Spacing)
- Modeled Surfaces of Each Mapped Subsurface Layer (~0.1 to 0.5 km Spacing)
- Review of available information regarding groundwater resources

Lithostratigraphic surface map

Lusardi, Anderson, and Harris, 2005



SURFICIAL GEOLOGY OF THE
FARGO-MOORHEAD AREA

By

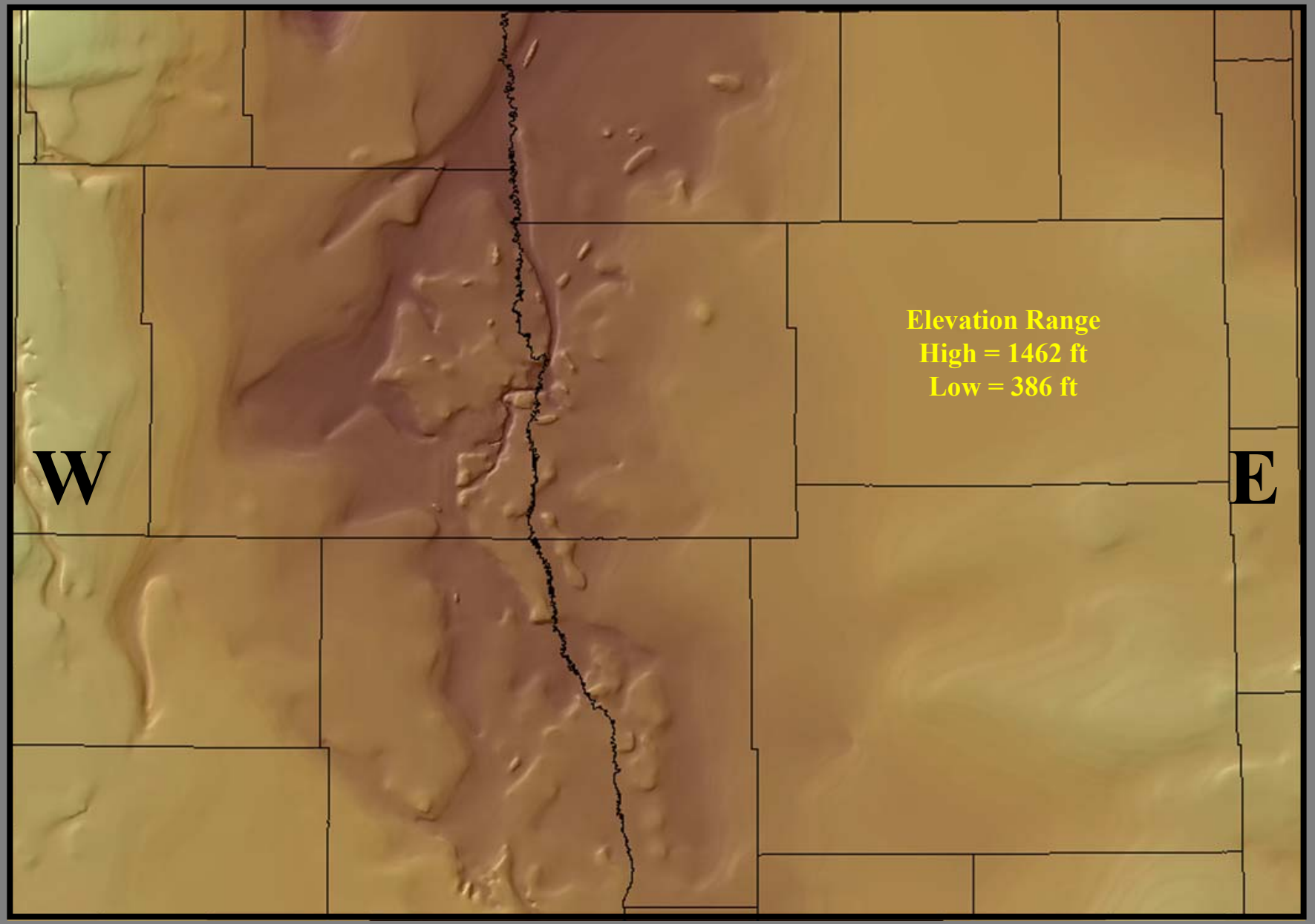
Barbara Lusardi (Minnesota Geological Survey),
Fred Anderson (North Dakota Geological Survey), and
Kenneth Harris (Minnesota Geological Survey)

2005

DESCRIPTION OF MAP UNITS

SURFICIAL GEOLOGY OF THE FARGO-MOORHEAD AREA, MINNESOTA AND NORTH DAKOTA

klh; 05/05



Bedrock digital elevation model

Setterholm and Anderson, October 2004

klh; 05/05

Summary of stratigraphic units in the FM study area

Harris, Lusardi, & Anderson, 2005

Age	Group/Formation	sediment type
HOLOCENE		
	Walsh Fm.	alluvium
	Oahe Fm.	wind-blown sand
	Lake Agassiz gp.	
	Sherack Fm.	lake sediment
	Poplar River Fm.	buried river sediment
	West Fargo Mbr.	channel sediment
	Harwood Mbr.	overbank sediment
PLEISTOCENE		
	Lake Agassiz gp.	lake sediment
	Brenna Fm.	
	Forest River gp.	glacial sediment
	Huot Fm	
	Falconer Fm.	
	Lake Agassiz gp.	lake sediment
	Wiley Fm.	
	Red Lake River gp.	glacial sediment
	Red Lake Falls Fm.	
	U. Red Lake Falls fm.	
	L Red Lake Falls fm.	
	Lake Agassiz gp.	river/deltaic sediment
	"Sheyenne Delta sediment"	
	Argusville Fm.	lake sediment
	Goose River gp.	glacial sediment
	U. Goose River gp.	
	Barnesville till	
	St Hilaire Fm.	
	L. Goose River gp.	
	Dahlen Fm.	
	Heiberg fm.	
	Otter Tail River gp.	
	Hawley fm.	
	New York Mills fm.	
	Villard fm.	
	James River gp.	
	James River fm.	

Age	Group/Formation	sediment type
	Lake Tewaukon gp.	glacial sediment
	Gardar Fm.	
	Buffalo River gp.	
	Buffalo River fm.	
	Crow Wing River gp.	
	U. Marcoux Fm.	
	L. Marcoux Fm.	
	Sheyenne River gp.	
	Sheyenne River fm.	
	Browerville gp.	
	Browerville fm.	
	Gervais gp.	
	Gervais Fm.	
	Old Otter Tail River gp.	
	Hawley II till	
	New York Mills II till	
	Old Buffalo River gp.	
	Buffalo River II till	
	Old Crow Wing River gp.	
	U. Marcoux Fm. II	
	L. Marcoux Fm. II	
CRETACEOUS		marine shale
	Montana Gp.	
	Pierre Fm.	
	Colorado Gp.	
	Niobrara Fm.	
	Carlile Fm.	
	Greenhorn Fm.	
	Bell Fouche/Skull Creek Fms.	
	Dakota Gp.	sandstone
	Inyan Kara Fm.	
ORDOVICIAN		dolomitic limestone
	Red River Fm.	
	Winnipeg gp	siltstone, sandstone, shale
PRECAMBRIAN (und)		igneous & metamorphic rocks

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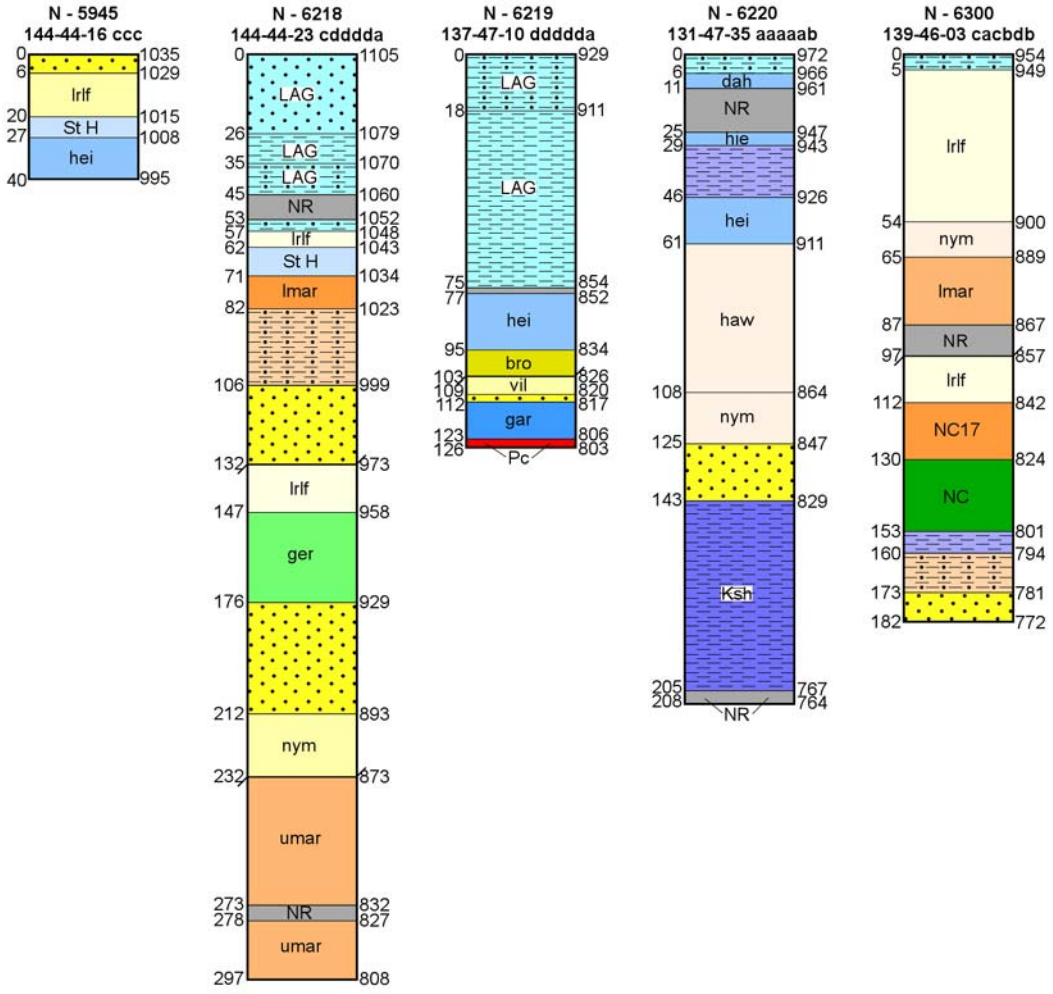
Informal group names (James River gp.) *Informal fromation names (James River fm.)* Formal F*romation* and Group names (*Wiley Fm. and* Dakota Gp.)

klh; 05/05

Examples of borehole summaries

used as control on regional cross sections



Fargo-Moorhead area cross section grid

- **Nine 30' X 60' Quadrangles (scale 1:100,000)**
- **142 mi by 103 mi (228 km by 166 km)**
- **14,626 square miles (37,848 square kilometers)**
- **5 km (~ 3 mi) grid spacing (34 E-W cross sections)**
- **1,625 grid points at a 5km grid spacing**

klh; 05/05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