Use of SSURGO Data in developing a model for the source and distribution of loess on the Green Bay Lobe land surface

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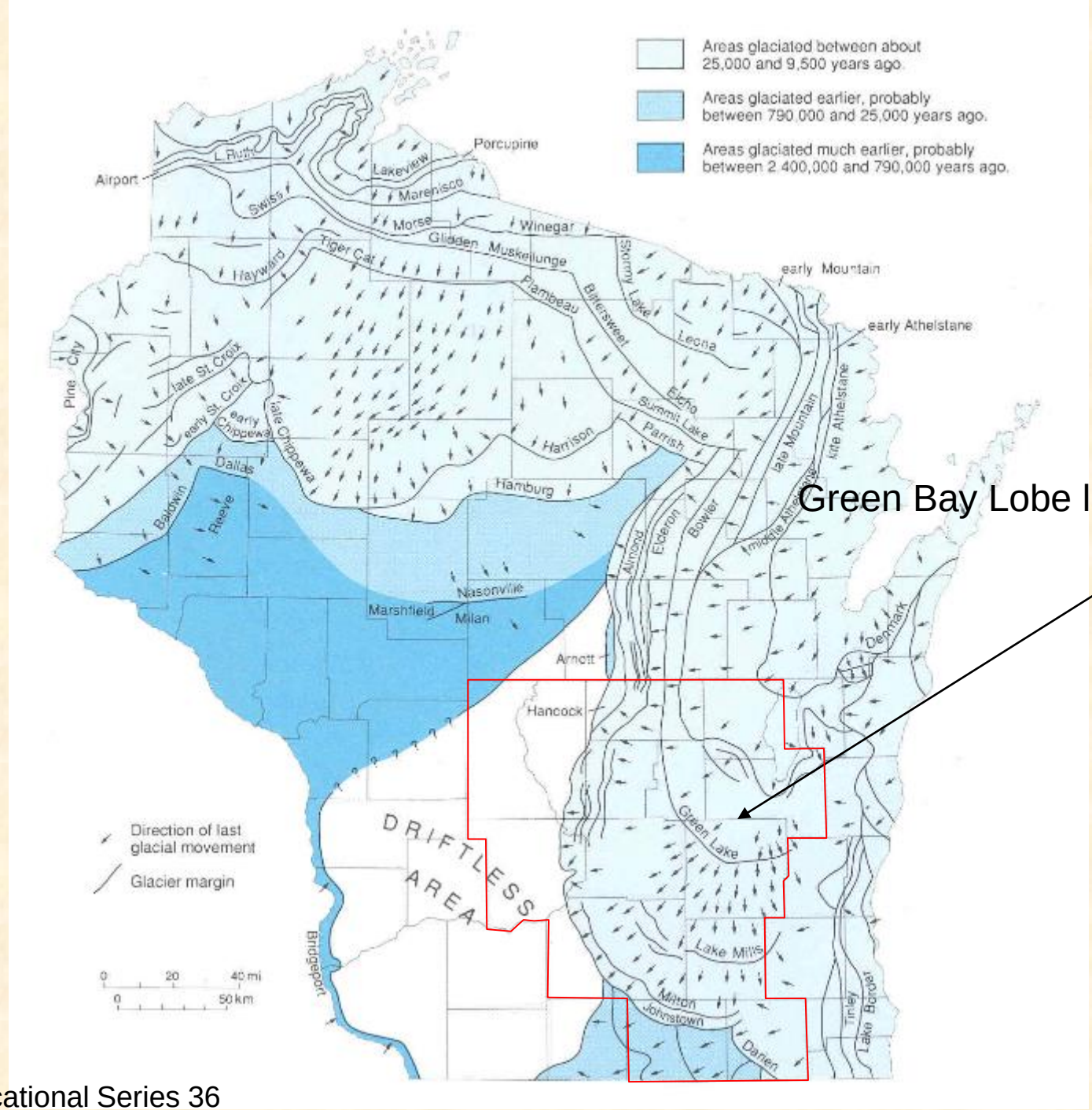
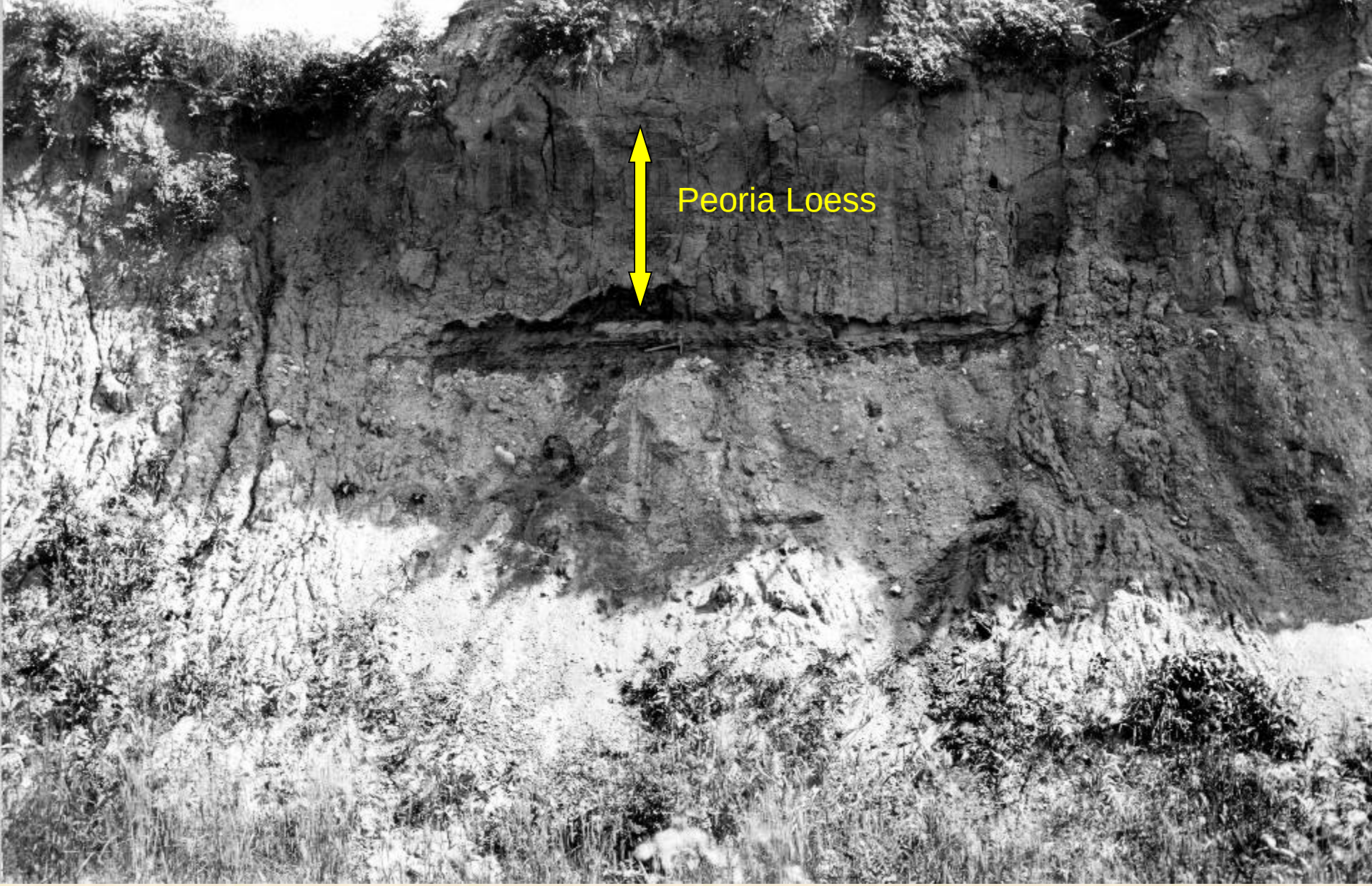
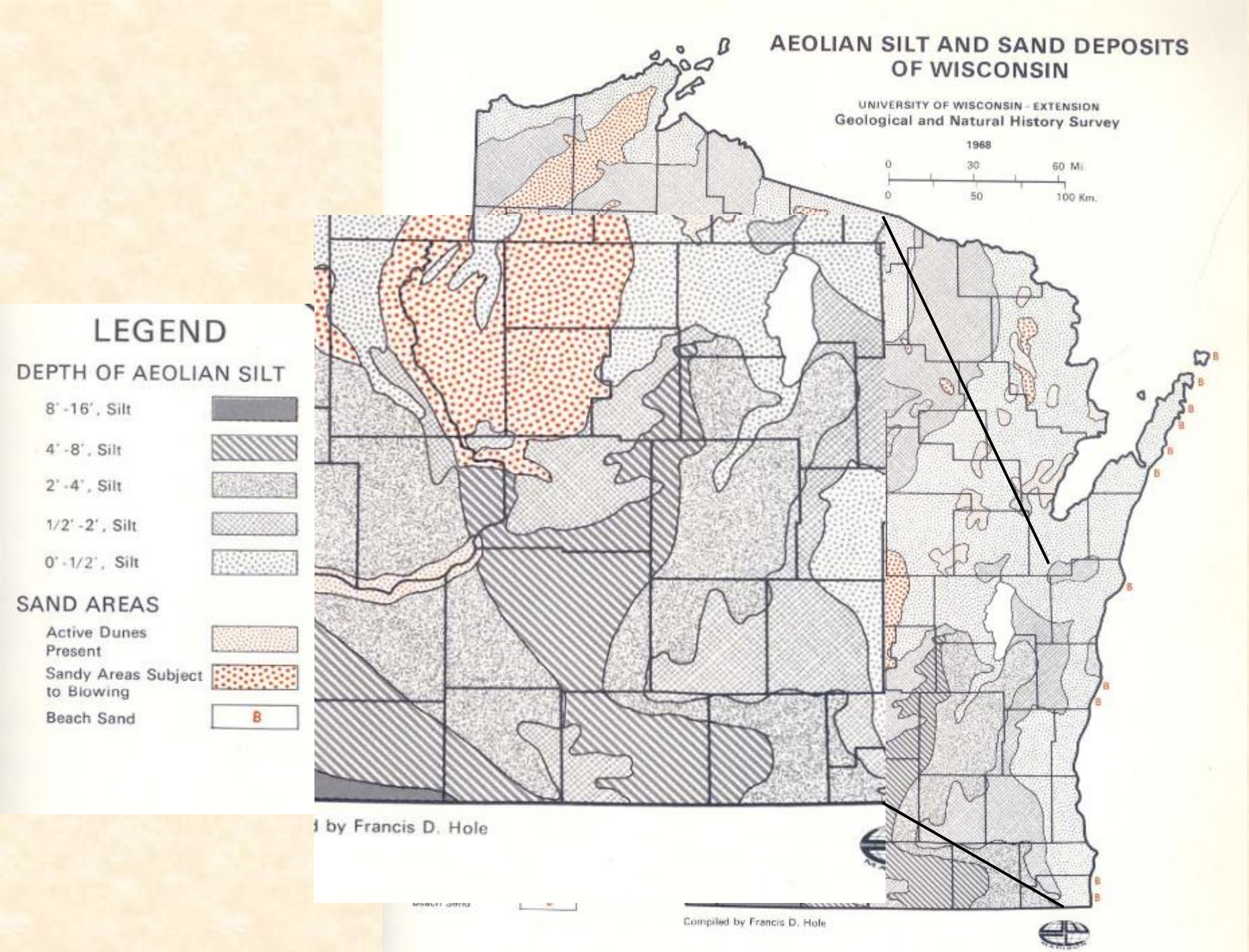

Areas glaciated between about 25,000 and 9,500 years ago.
Areas glaciated earlier, probably between 790,000 and 25,000 years ago.
Areas glaciated much earlier, probably between 2,400,000 and 790,000 years ago.
Porcupine
Airport
L. Rusty
Lakeview
Marenisco
Swiss
Morse
Winegar
Glidden
Muskellunge
Tiger Cat
Hayward
Stormy Lake
Plambeau
Bittersweet
Leona
early Mountain
early Athelstane
late St. Croix
early St. Croix
early Chippewa
late Chippewa
Pine City
Echo
Summit Lake
Parrish
Harrison
Dallas
Hamburg
Baldwin
Reeve
late Mountain
late Athelstane
Middle Athelstane
Almond
Elderon
Bowler
Nasonville
Marshfield
Milan
Arnott
Denmark
Hancock
Green Lake
Lake Mills
Milton
Johnstown
Darien
Tinley
Lake Bordet
Bridgeport
DRIFTLESS AREA
Direction of last glacial movement
Glacier margin
0 20 40 mi
0 50 km
Green Bay Lobe land surface

Background to Loess on the GB Lobe land surface

- Loess recognized on GBL surface for 100 yrs, but little research on dist'n and source.
- Hole (1950, 1968) mapped eolian deposits based on soil survey efforts.
- Fanning & Jackson (1966) suggested local stream sources for thick loess on GBL surface.
- Hole, 1976 described soil associations with loess, but no explanation of patterns or origin of loess.



Loess overlying glacial till of the Wisconsin stage, Chicago, Milwaukee & St. Paul railway cut 3 miles northwest of Fall River; Sec. 20, T. 11 N., R. 12 E. Columbia County, Wisconsin. June 29, 1909. Plate 35-B in U.S. Geological Survey. Professional paper 106. 1918.


AEOLIAN SILT AND SAND DEPOSITS OF WISCONSIN
UNIVERSITY OF WISCONSIN - EXTENSION
Geological and Natural History Survey
1968
0 30 60 Mi.
0 50 100 Km.
LEGEND
DEPTH OF AEOLIAN SILT
8'-16', Silt
4'-8', Silt
2'-4', Silt
1/2'-2', Silt
0'-1/2', Silt
SAND AREAS
Active Dunes Present
Sandy Areas Subject to Blowing
Beach Sand
B
by Francis D. Hole
Compiled by Francis D. Hole

Mapping the Distribution of Loess on the GBL surface

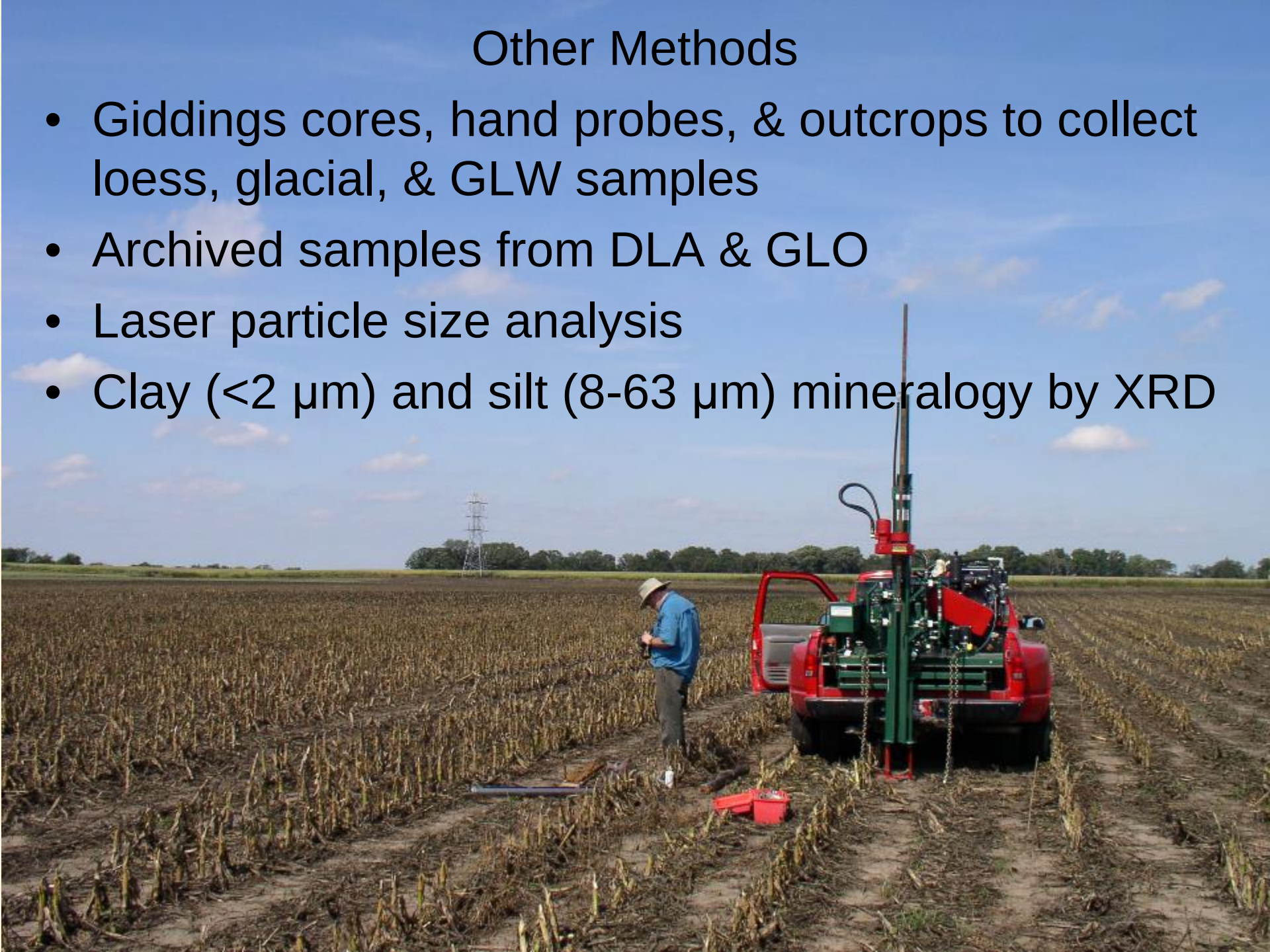
- SSURGO data to map the distribution.
- Eolian sediment thickness of map units interpreted from Official Series Description in the Soil Survey of each county.
- In ArcMap, soil map units were extracted based on potential loess thickness in categories of <50, 50 -100, and >100 cm, along with soils formed in eolian sand or a fine sand mantle.

Mapping the Distribution of Loess on the GBL surface

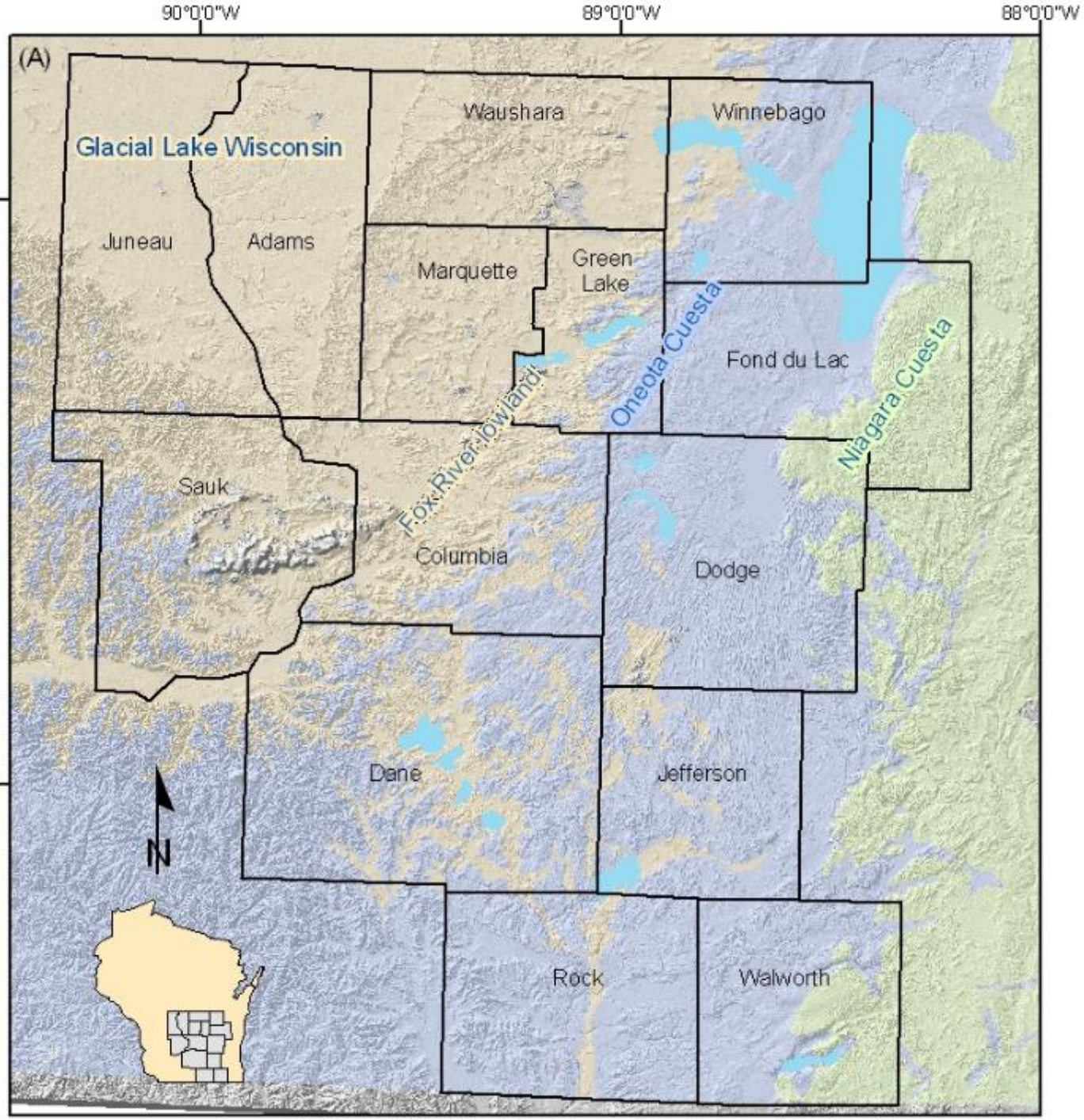
- Overlay on 30 m DEM from WI DNR
- Ice margins positions from Colgan (1993)
- BR Geology overlay from WGNHS

Other Methods

- Giddings cores, hand probes, & outcrops to collect loess, glacial, & GLW samples
- Archived samples from DLA & GLO
- Laser particle size analysis
- Clay (<2 μm) and silt (8-63 μm) mineralogy by XRD



Eolian Deposits of the Green Bay Lobe



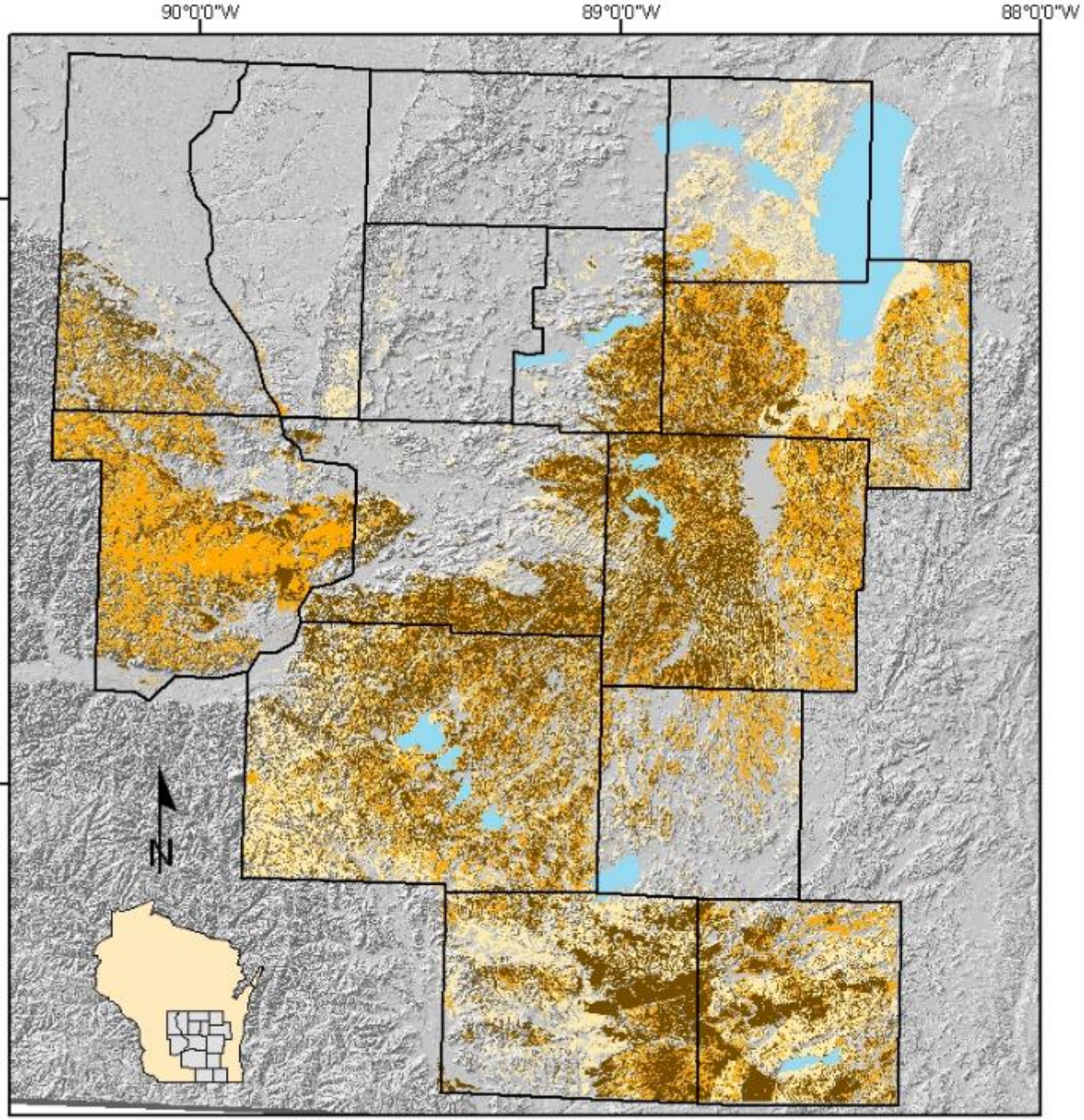
Bedrock

- Cambrian
- Ordovician
- Silurian

Kilometers
0 25 50

1:1,000,000

Eolian Deposits of the Green Bay Lobe



Quaternary

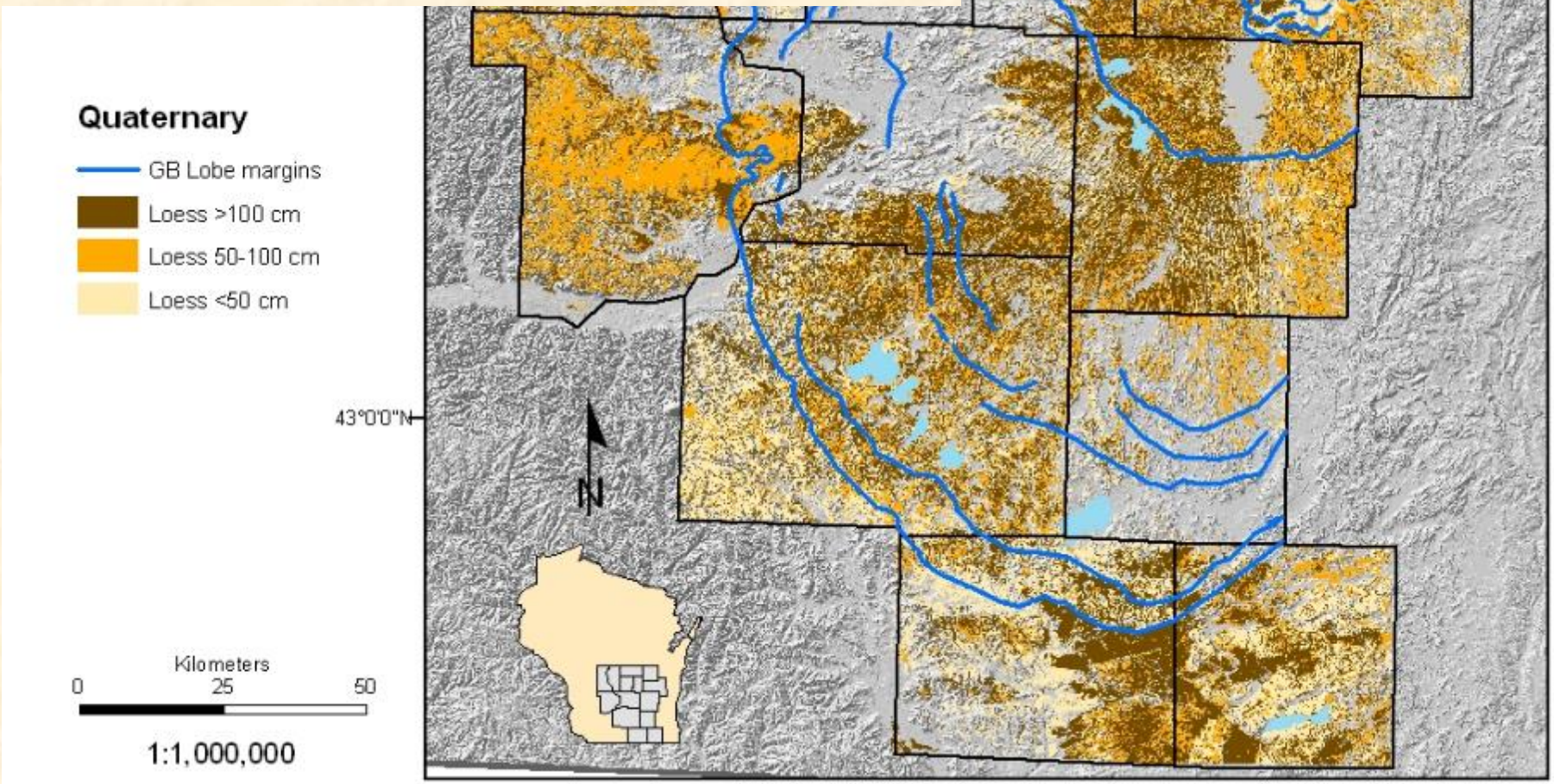
- Loess >100 cm
- Loess 50-100 cm
- Loess <50 cm

Kilometers
0 25 50

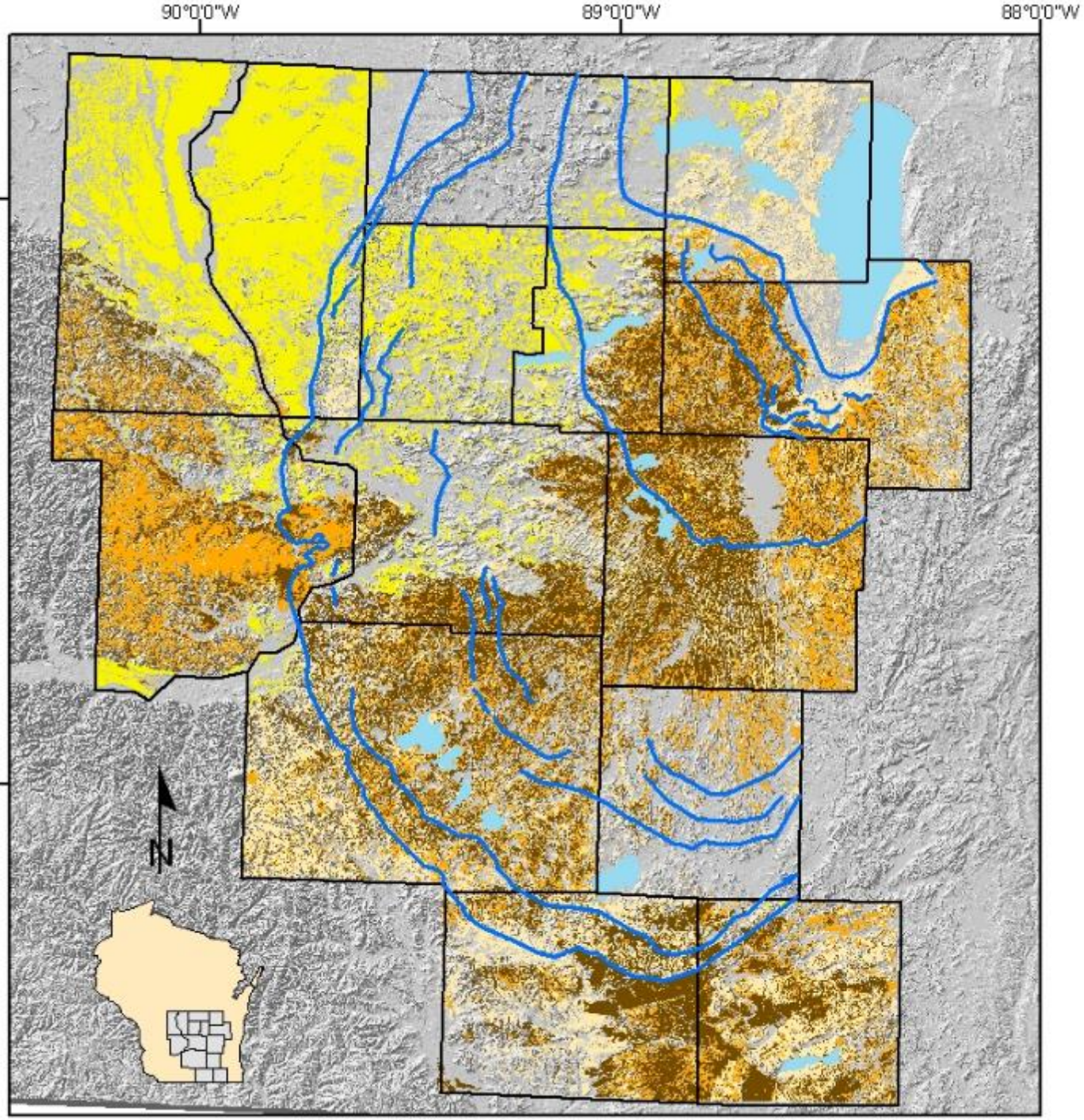
1:1,000,000

Questions

- Why thicker N & E of terminus?
- What explains SW-NE trending pattern?
- Why such a sharp loess border?
- Why minimal loess on GL Oshkosh surface?
- Where did the loess come from?



Eolian Deposits of the Green Bay Lobe



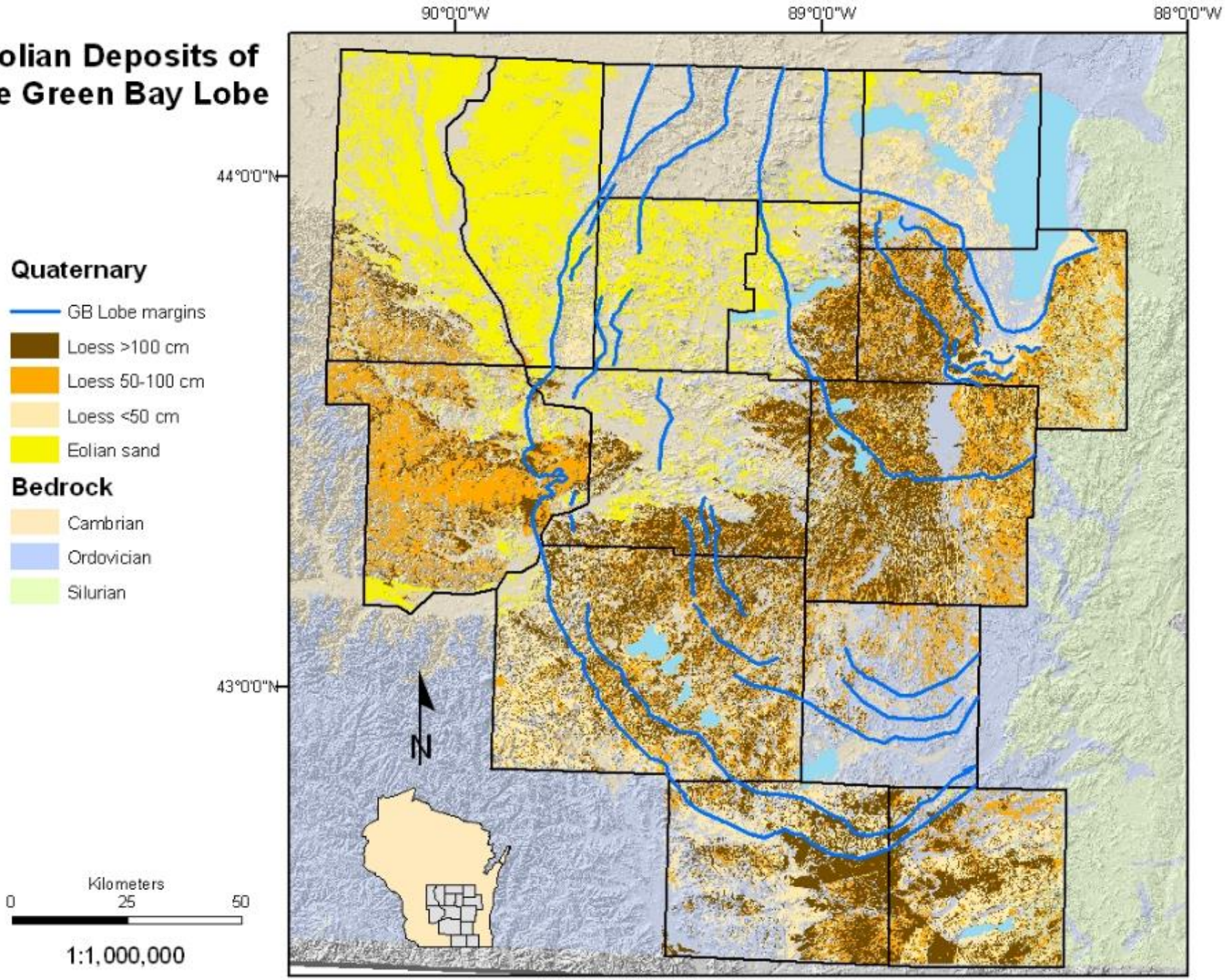
Quaternary

- GB Lobe margins
- Loess >100 cm
- Loess 50-100 cm
- Loess <50 cm
- Eolian sand

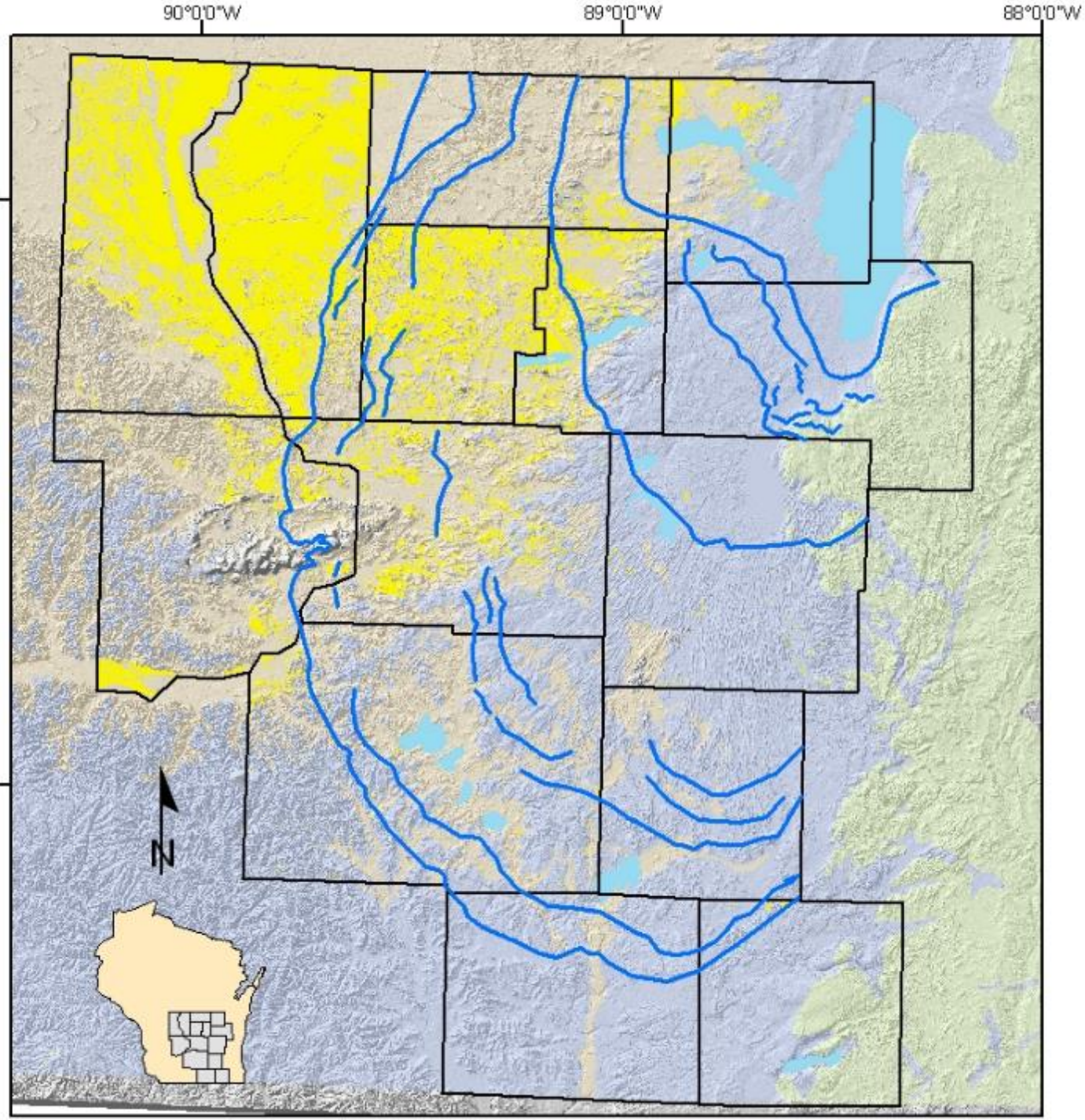
Kilometers
0 25 50

1:1,000,000

Eolian Deposits of the Green Bay Lobe



Eolian Deposits of the Green Bay Lobe



Quaternary

- GB Lobe margins
- Eolian sand

Bedrock

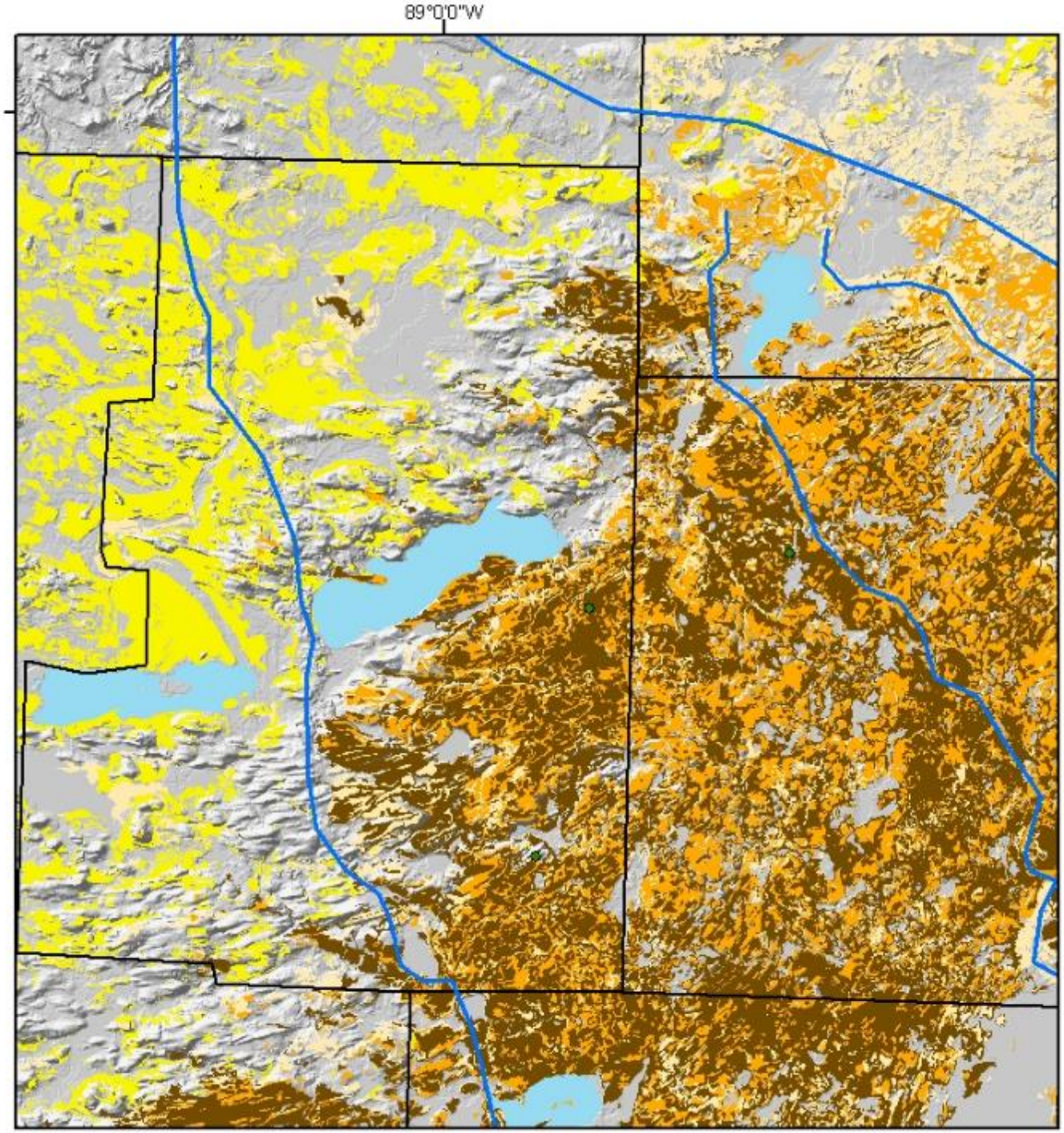
- Cambrian
- Ordovician
- Silurian

Kilometers
0 25 50

1:1,000,000

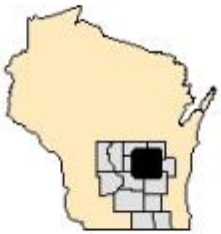
Eolian Deposits of the Green Bay Lobe

Green Lake Area



Quaternary

- GB Lobe margins
- Loess >100 cm
- Loess 50-100 cm
- Loess <50 cm
- Eolian sand



Kilometers

0 5 10

N

1:250,000

Eolian Deposits of the Green Bay Lobe

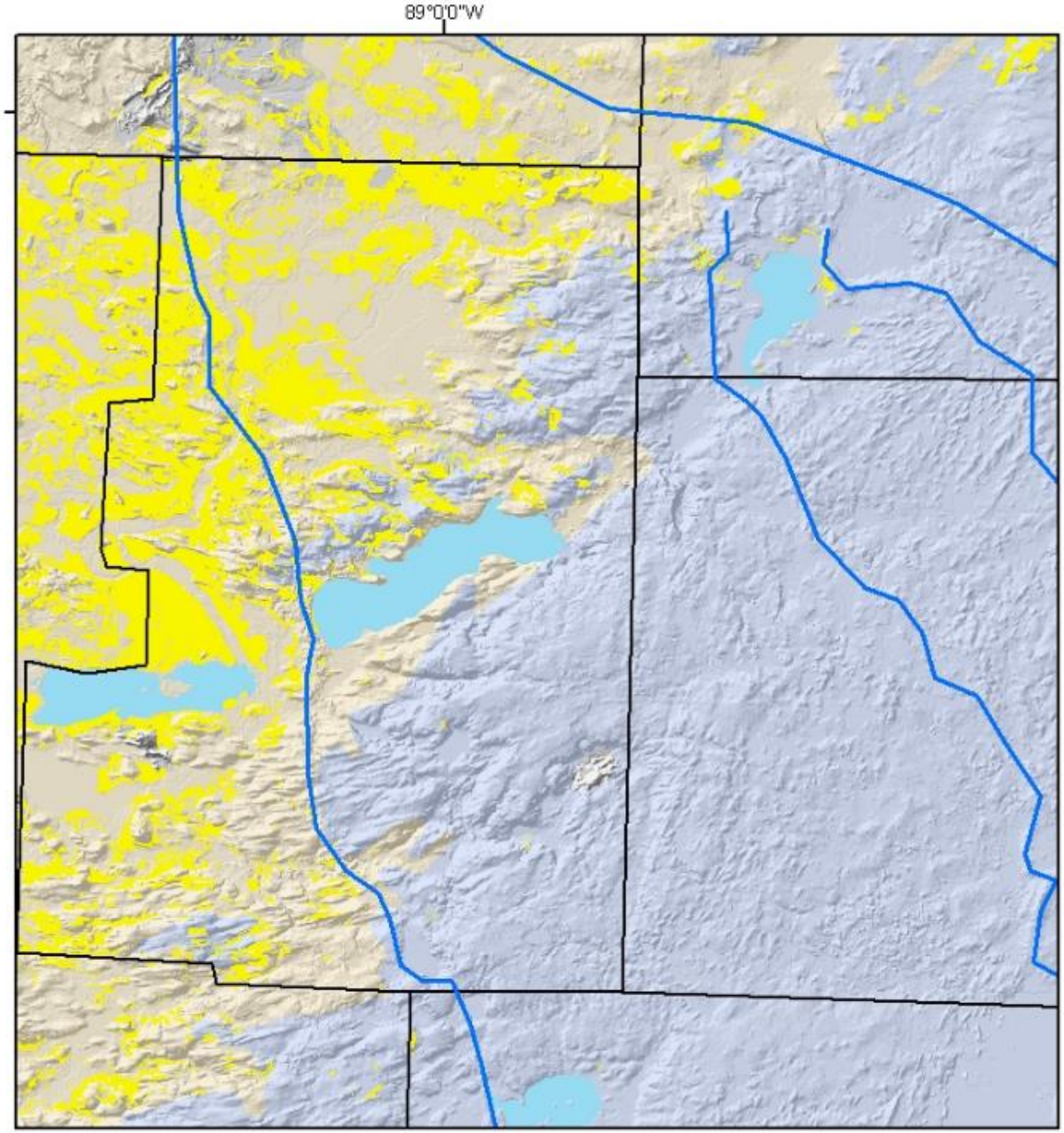
Green Lake Area

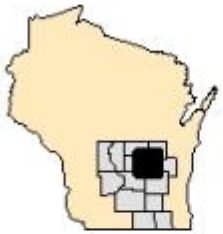
Quaternary

- GB Lobe margins
- Eolian sand

Bedrock

- Cambrian
- Ordovician
- Silurian





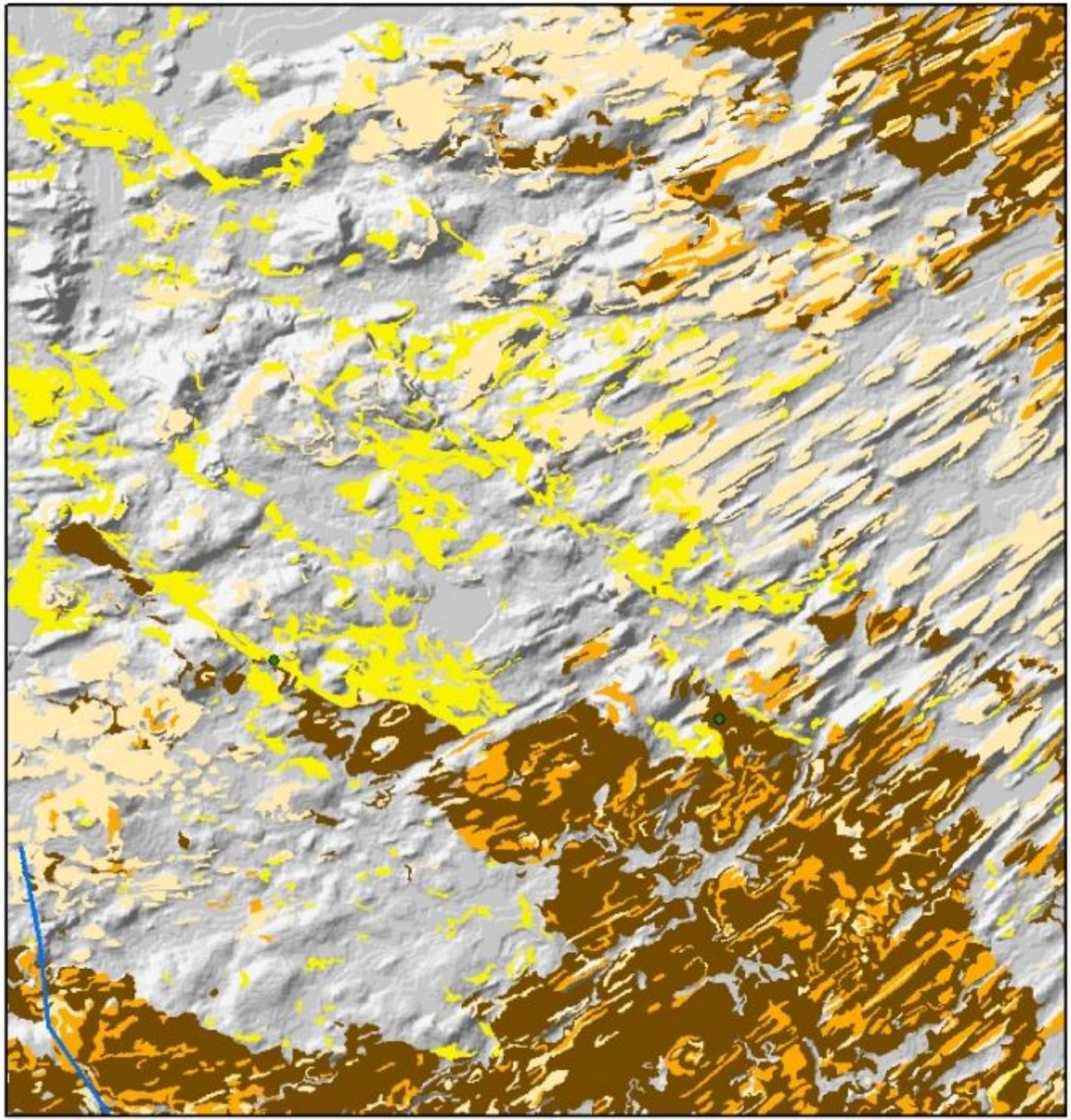
Kilometers
0 5 10

N

1:250,000

Eolian Deposits of the Green Bay Lobe

Eastern Columbia Co.



Quaternary

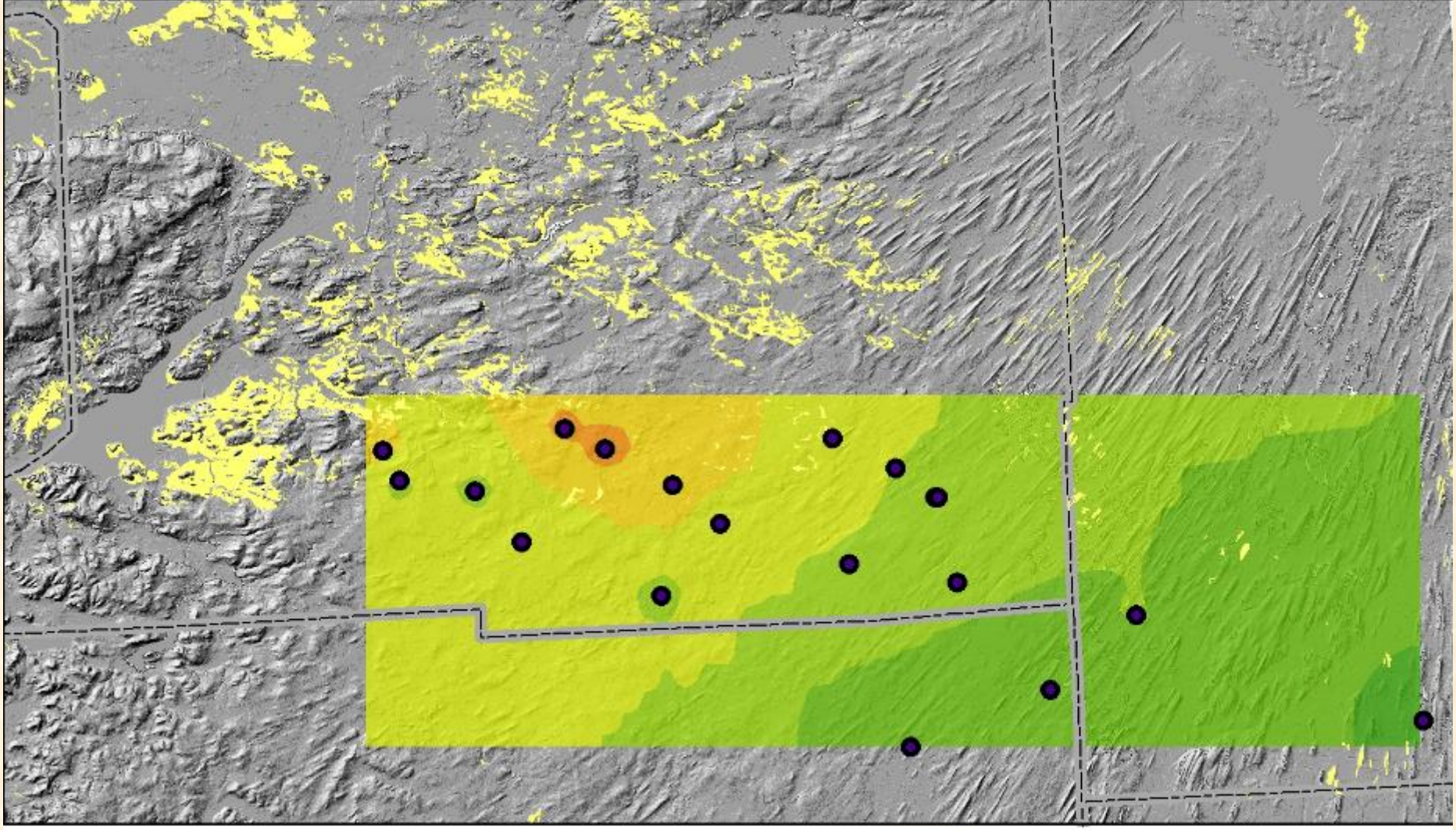
- GB Lobe margins
- Loess >100 cm
- Loess 50-100 cm
- Loess <50 cm
- Eolian sand

Kilometers

0 2 4

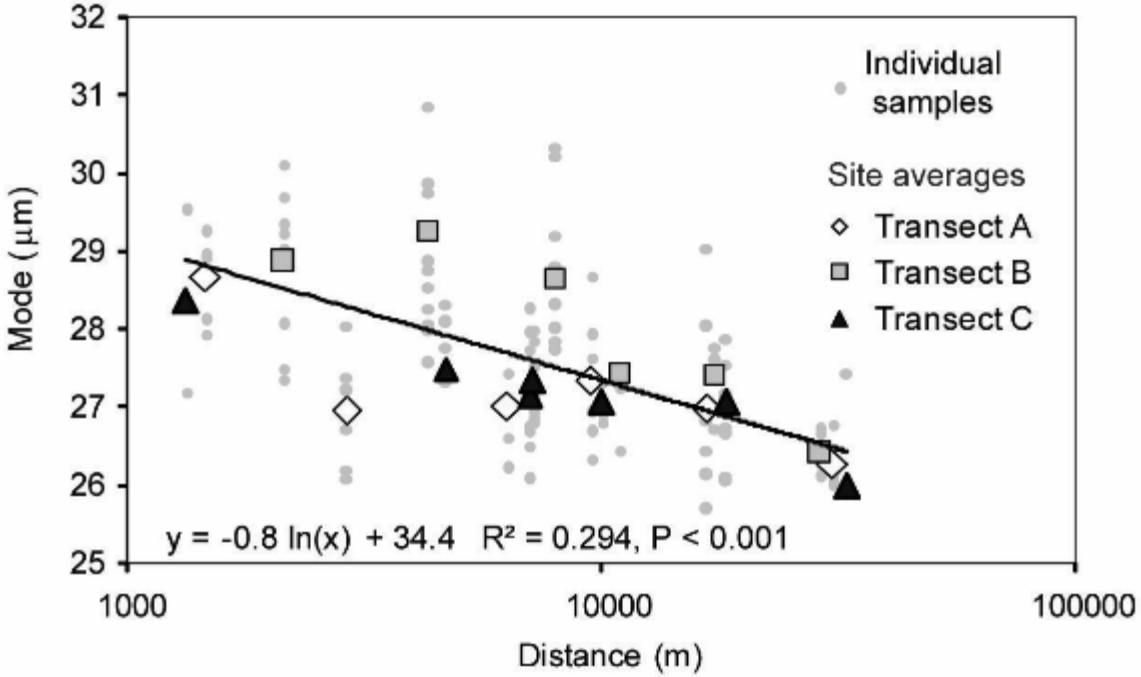
N

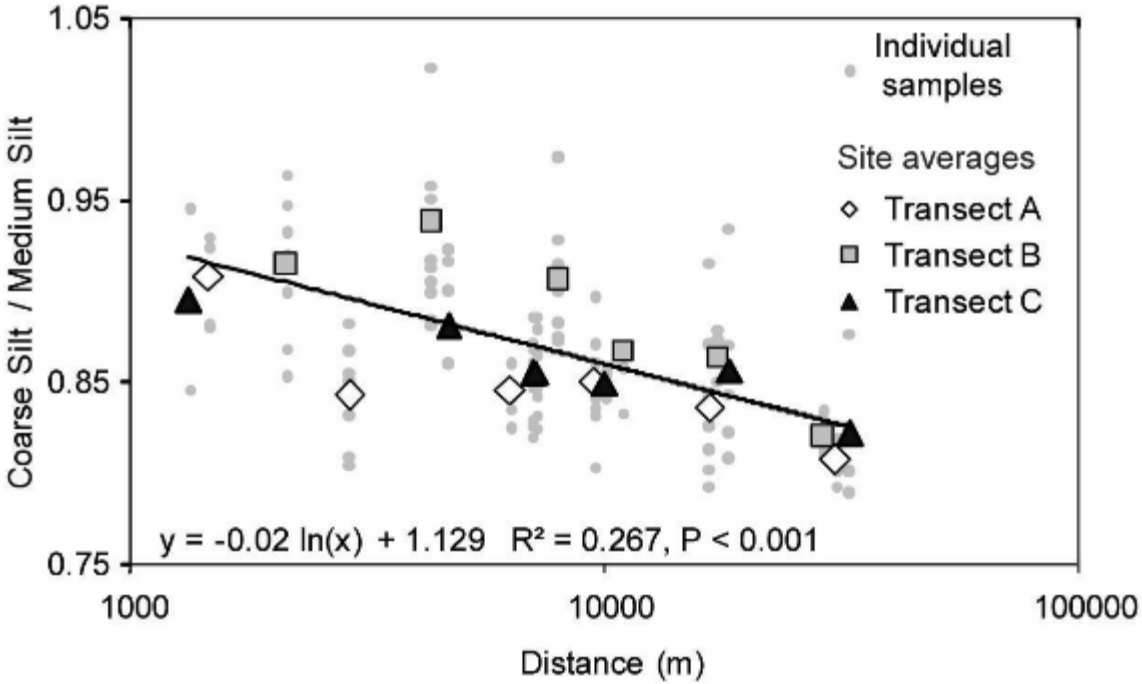
1:100,000



Average Modal Diameter

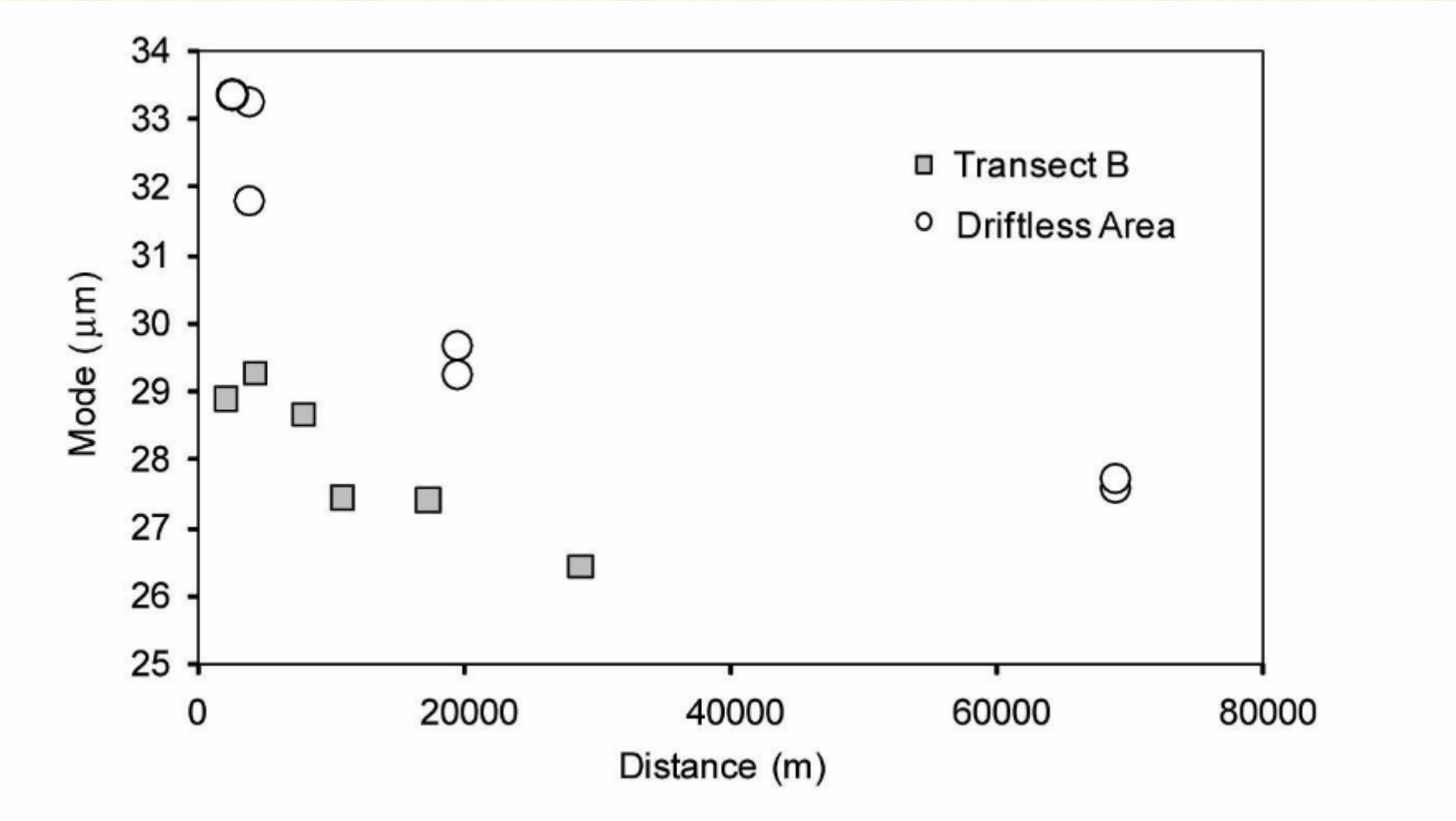
- 26-26.5
- 26.5-27
- 27-27.5
- 27.5-28
- 28-28.5
- 28.5-29
- 29-29.5
- 29.5-30



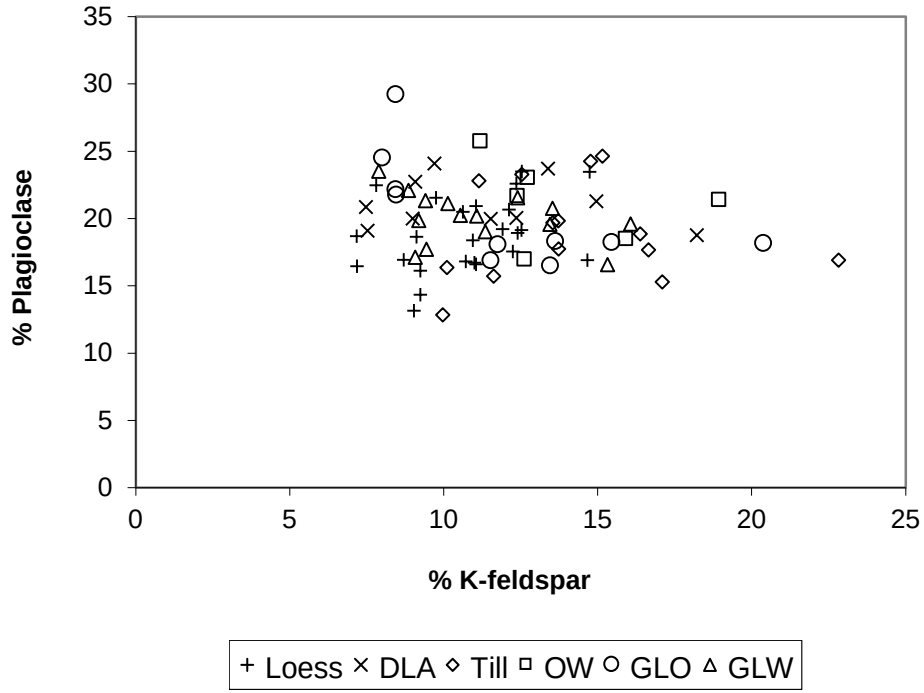


Trends in particle size with distance along 3 parallel transects.

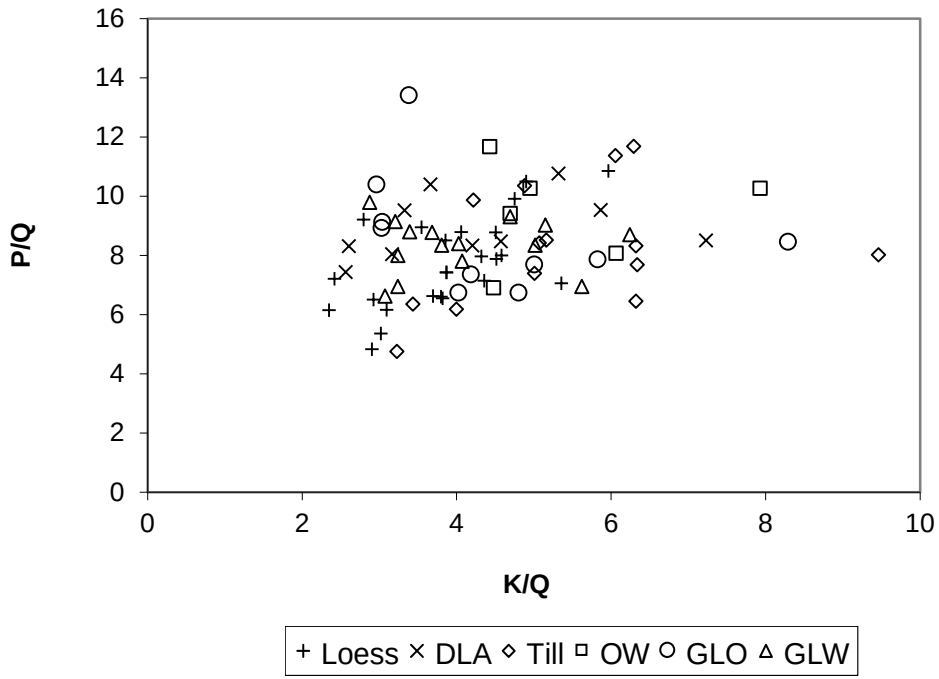
Note both mode & silt-size ratio both decrease with distance from edge of loess.



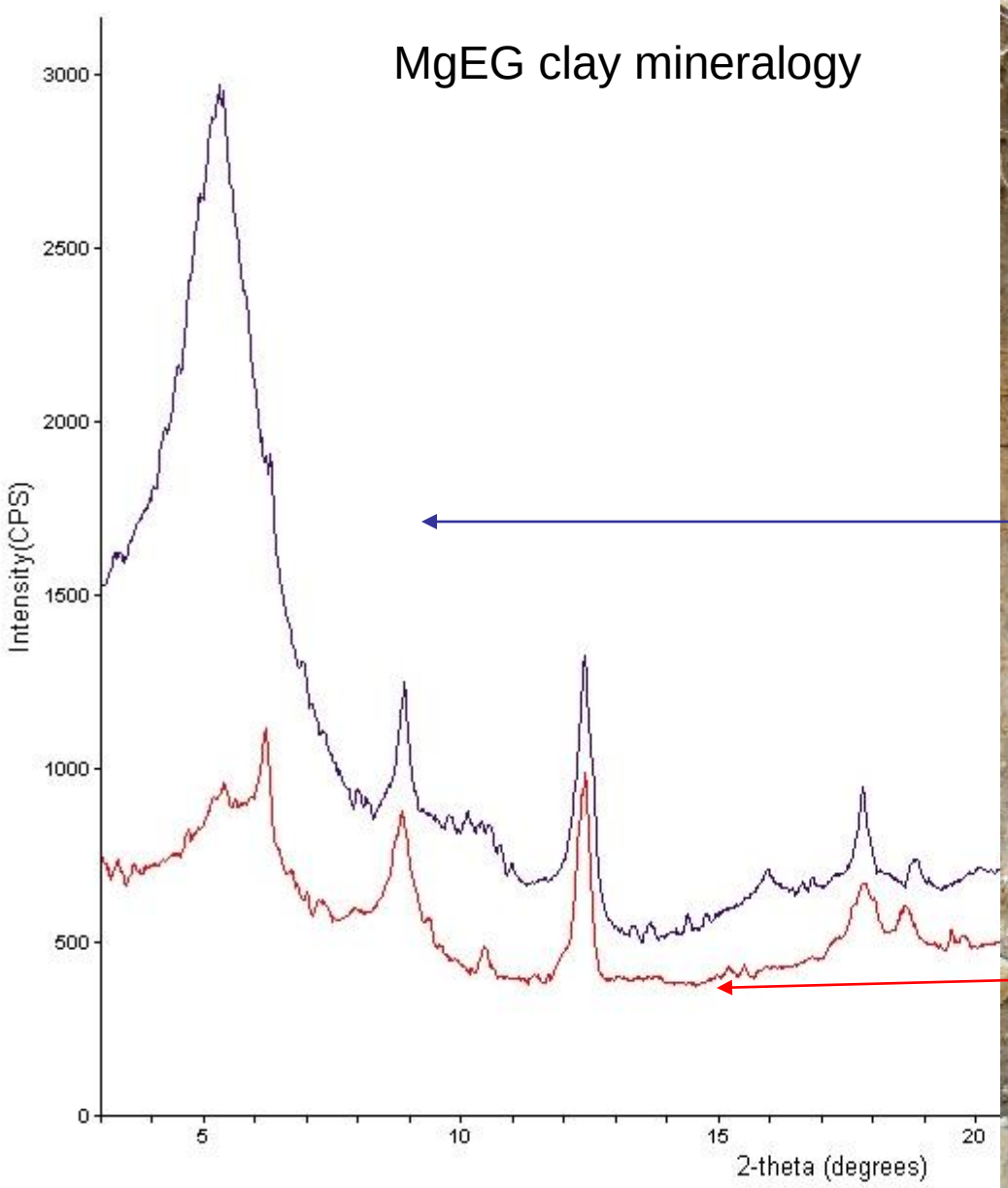
Distance trend of decreasing particle-size mode for loess on the Green Bay Lobe land surface compared to upland loess of the Driftless Area. Note finer mode on GBL, but similar slopes.

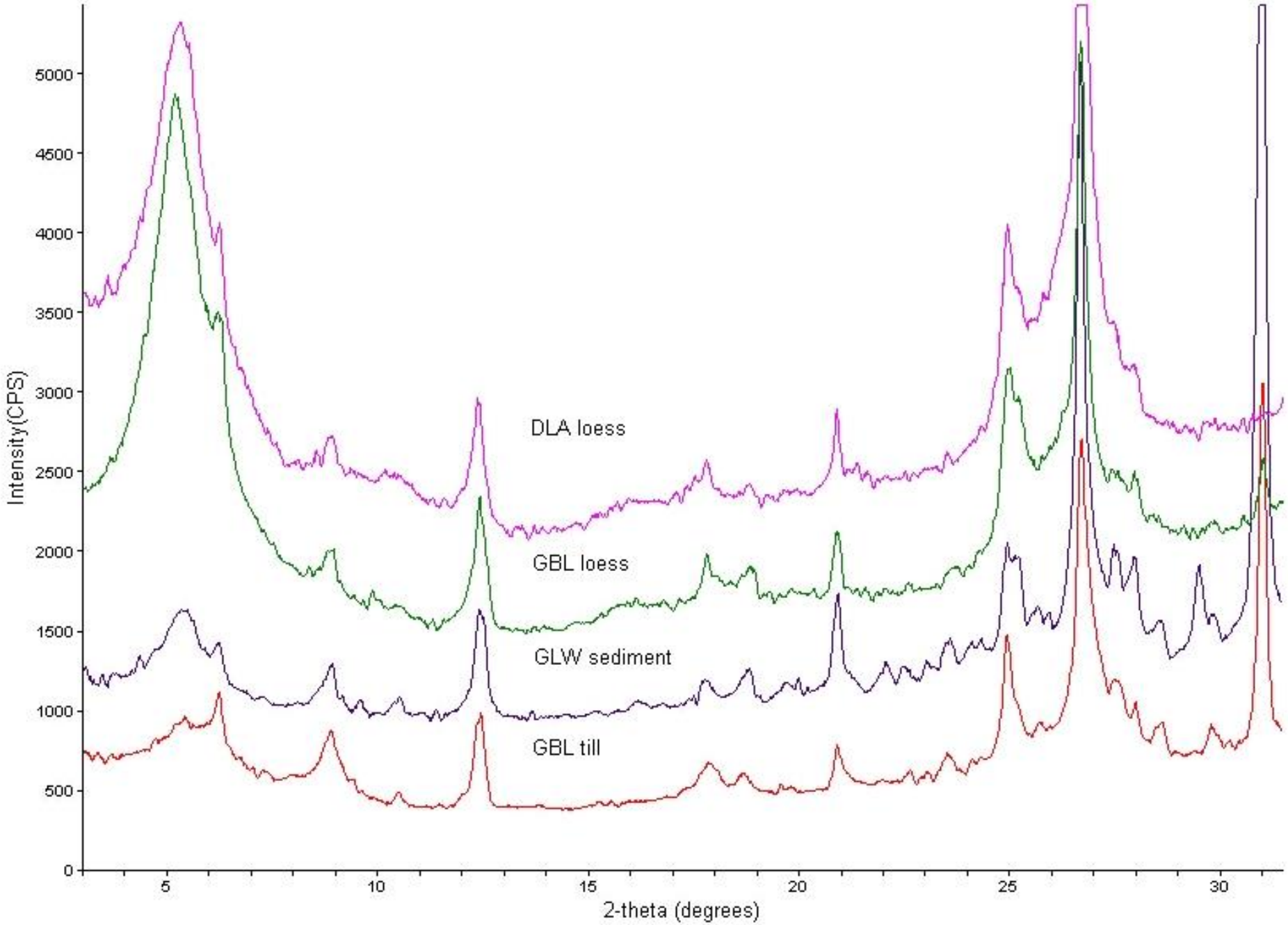


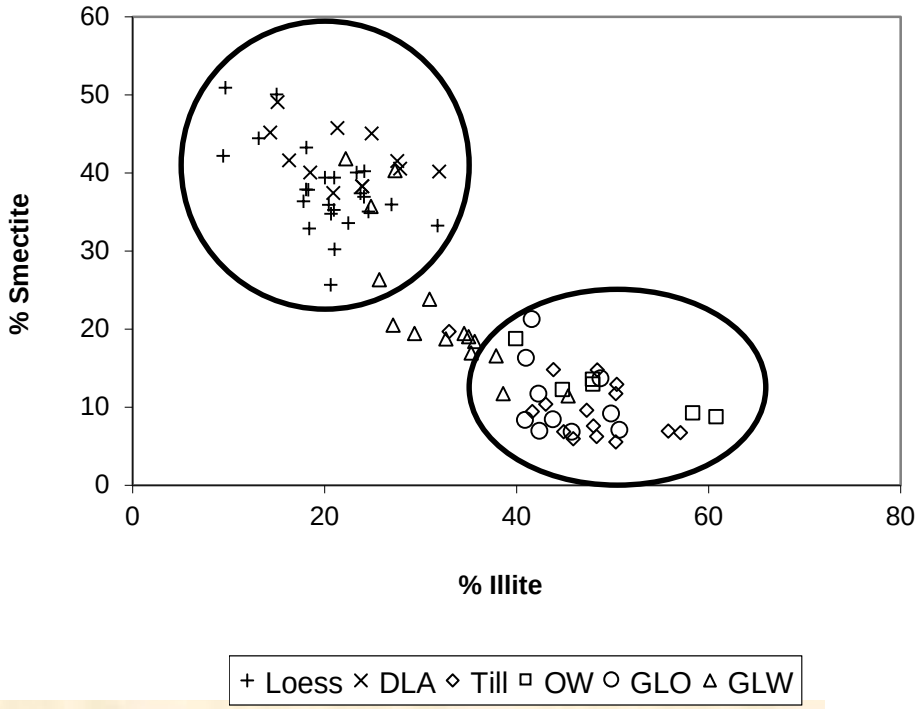
Silt (8-63 µm) is mineralogically similar across sediment types and sources.



MgEG clay mineralogy




Intensity(CPS)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5
10
15
20
25
30
2-theta (degrees)
DLA loess
GBL loess
GLW sediment
GBL till

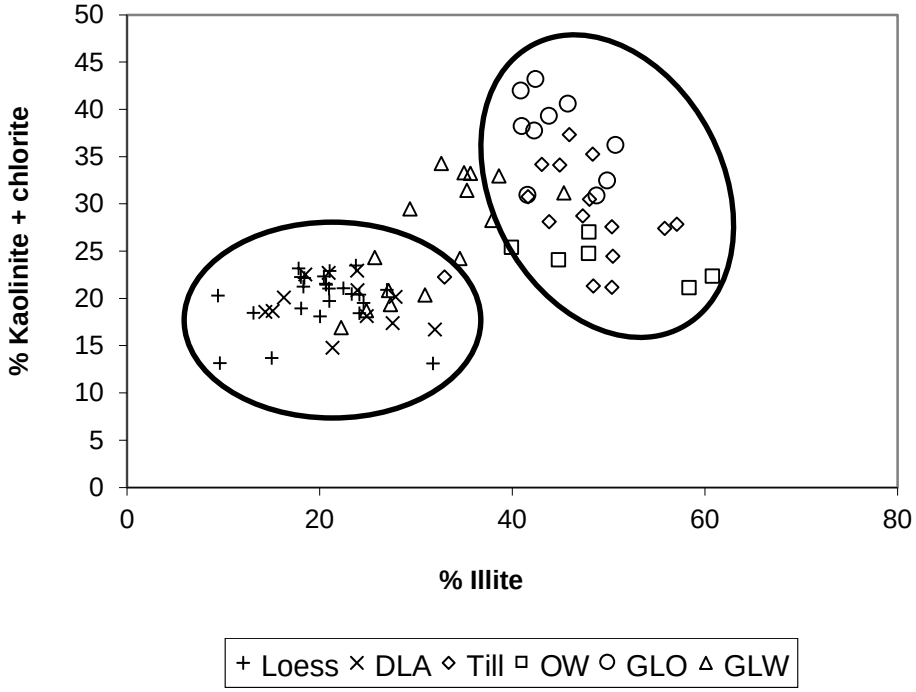


Note grouping of:

1) loess and DLA,
2) Till, OW, & GLO,
3) GLW trends intermediate.

ANOVA results of clay mineralogy.

	Loess	DLA	Till	OW	GLO
DLA	V	–	–	–	–
Till	SVIK	SIK	–	–	–
OW	SVIK	SIK		–	–
GLO	SVIK	SVIK	VK	VK	–
GLW	SIK	SIK	SI	SI	SVIK



Model for origin and distribution

- Eolian activity on deglaciated terrain, the basin of glacial lakes, & river valleys.
  - Sandy landscapes north and east of DLA uplands acted as surface of transport, with migrating sand acting to re-entrain silt.
- Dunes confined to topographic lowlands.
- Loess accumulated on upland of Oneota Cuesta, thinning & fining to E & S.
  - Silt minerals similar in all lithologic units.
  - Clay minerals indicate western source of loess; silt & clay migrate together.
  - Particle size finer than DLA loess, indicates distal end of sedimentary system & likely lake sediment storage.

Elements of the Model

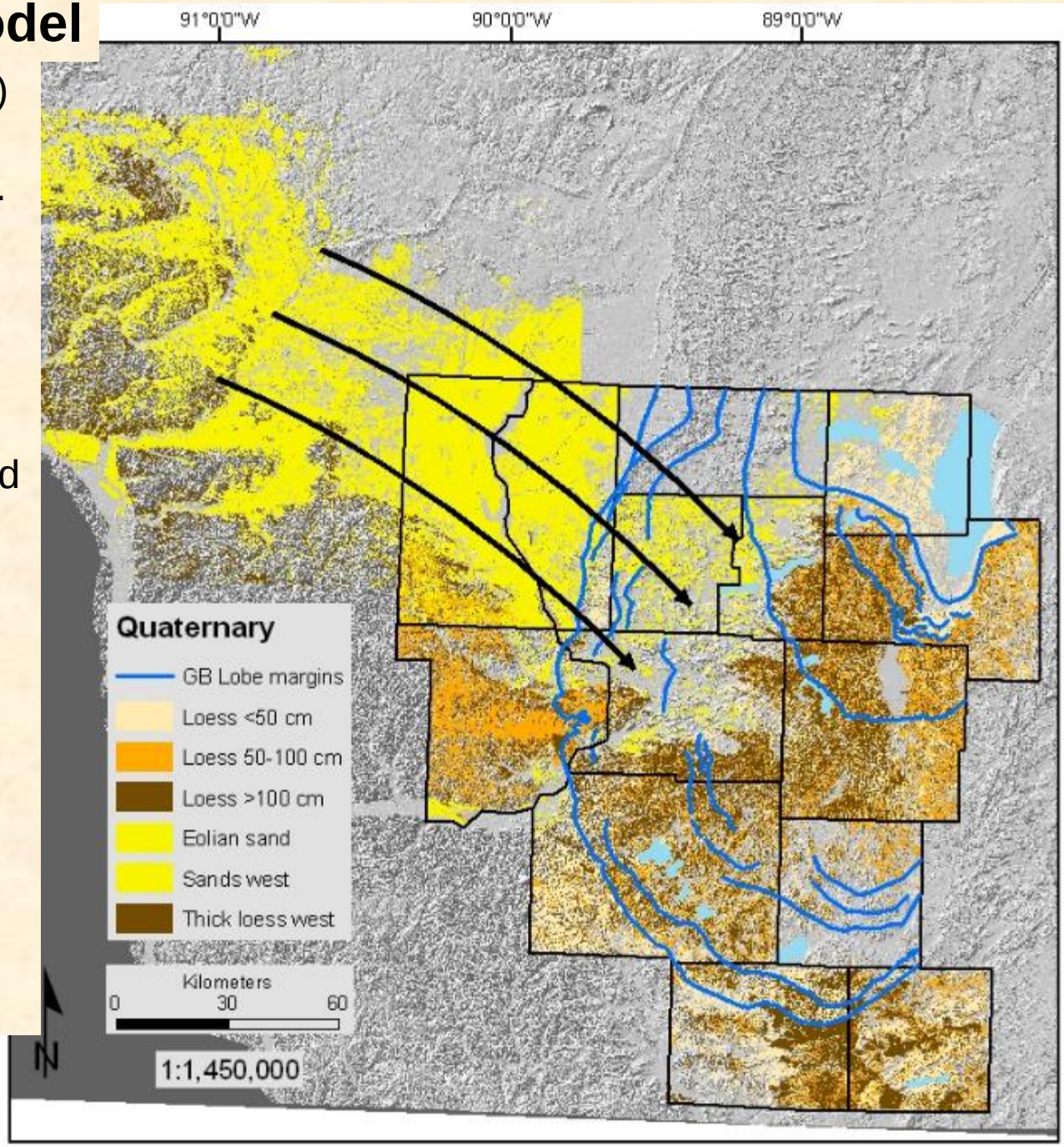
Western source (smectitic) loess transported to E-SE during Wisconsin Episode.

Drainage of GLW & exposure of glaciated land surface.

Eolian reworking of the bed of GLW into sandsheet provide a surface of transport to SE.

Loess accumulated on topographic highs protected from migrating sand.

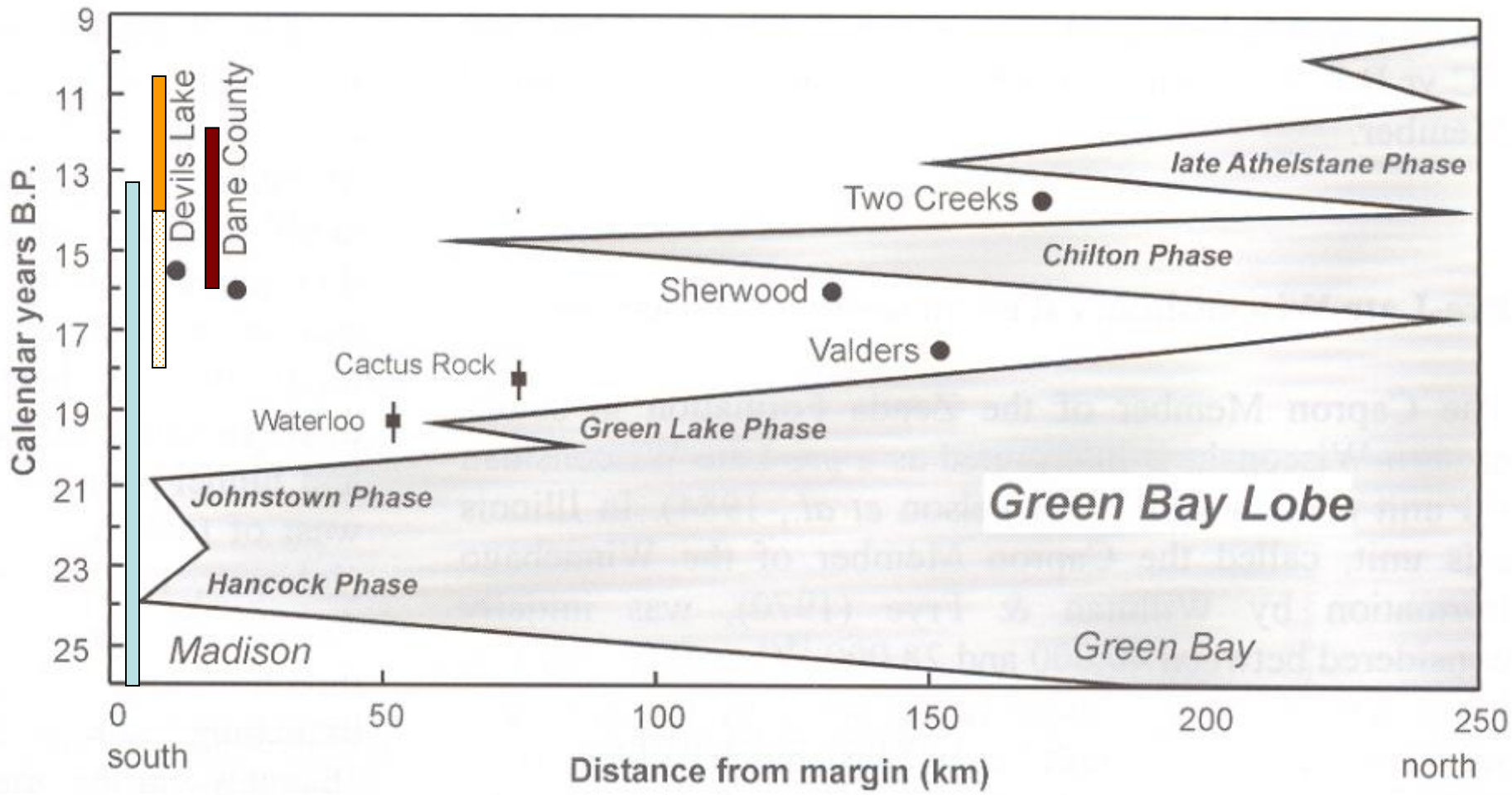
Loess remained on flat landscapes.



Age Control

- GL Oshkosh chronology (Hooyer, 2007)
  - Glacial land surface exposed progressively between 24,000 - 18,700 yrs.
  - GL Oshkosh drainage – S part exposed periodically, final exposure by 13,000 yrs.
  - Minimal loess on Lake Oshkosh surface behind Eureka Moraine – suggests loess deposition largely occurred before 13,000 yrs.
  - Wolf River dunes active between 13,400 to 9800 yrs.
- Drainage of GL Wisconsin 16-15,000 yrs; eolian activity until 12,000 yrs (Beauchaine, 2008)
- GL Wisconsin eolian activity by W-NW winds between 14-10,600 yrs (Rawling et al., 2008) + older sand sheet and dune ages unpublished.

Time-distance diagram for the Green Bay Lobe with calibrated radiocarbon ages (●) and cosmogenic isotope ages from Syverson and Colgan (2004).

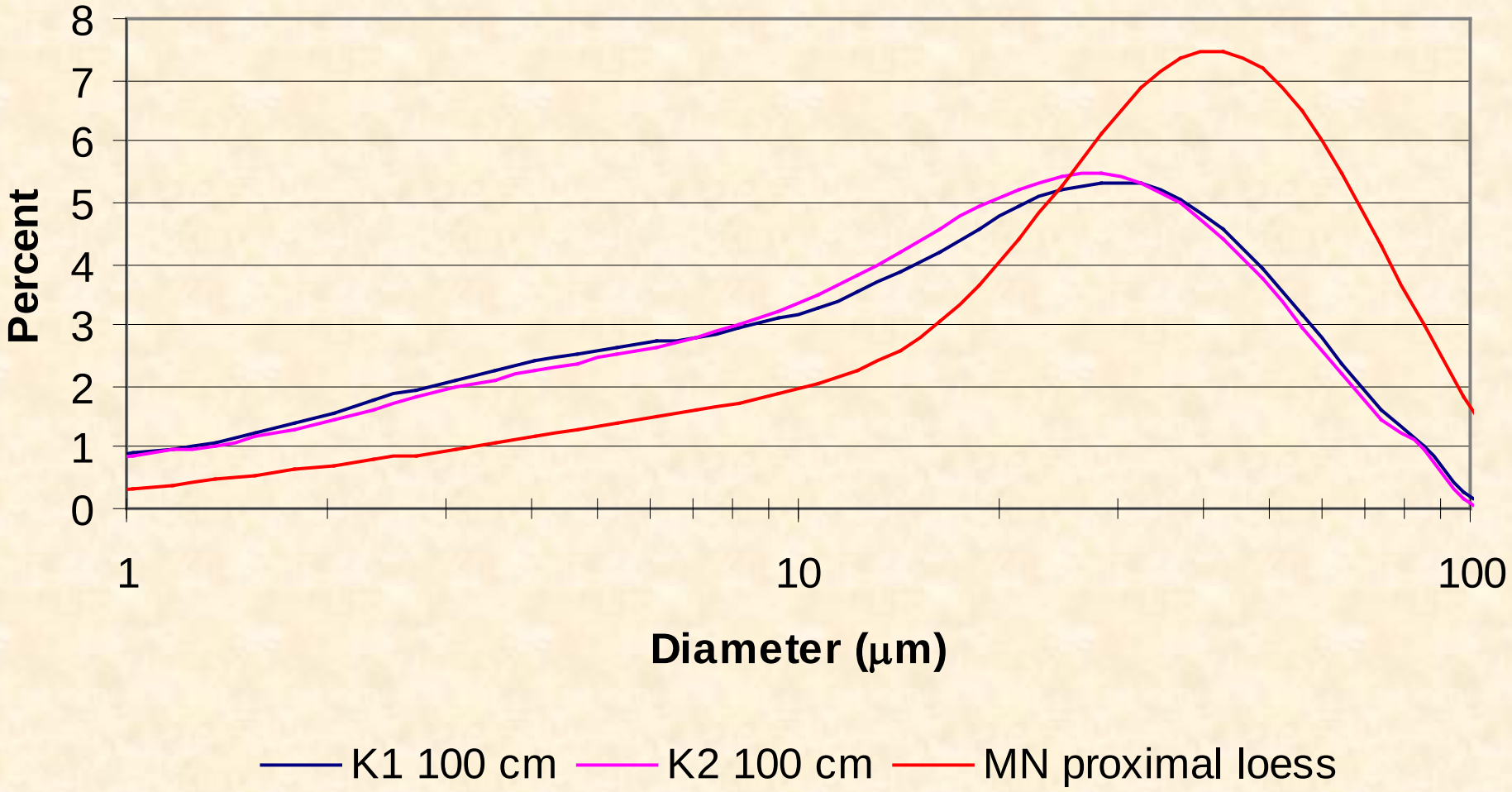


Deposition of Mississippi Valley loess (Bettis et al., 2003)

WI river eolian activity (Beauchaine, 2008)

GLW big dunes (Rawling et al., 2008)

GLW eolian activity (Rawling & Hanson unpublished)


8
7
6
5
4
3
2
1
0
Percent
1
10
100
Diameter (μm)
K1 100 cm
K2 100 cm
MN proximal loess

Full Disclosure

Quaternary Research 78 (2012) 149–151

Contents lists available at SciVerse ScienceDirect

Quaternary Research

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Letter to the Editor

Mississippi Valley Regional Source of Loess on the Southern Green Bay Lobe Land Surface, Wisconsin—Comment to the paper published by Jacobs et al., Quaternary Research 75 (3), 574–583, 2011

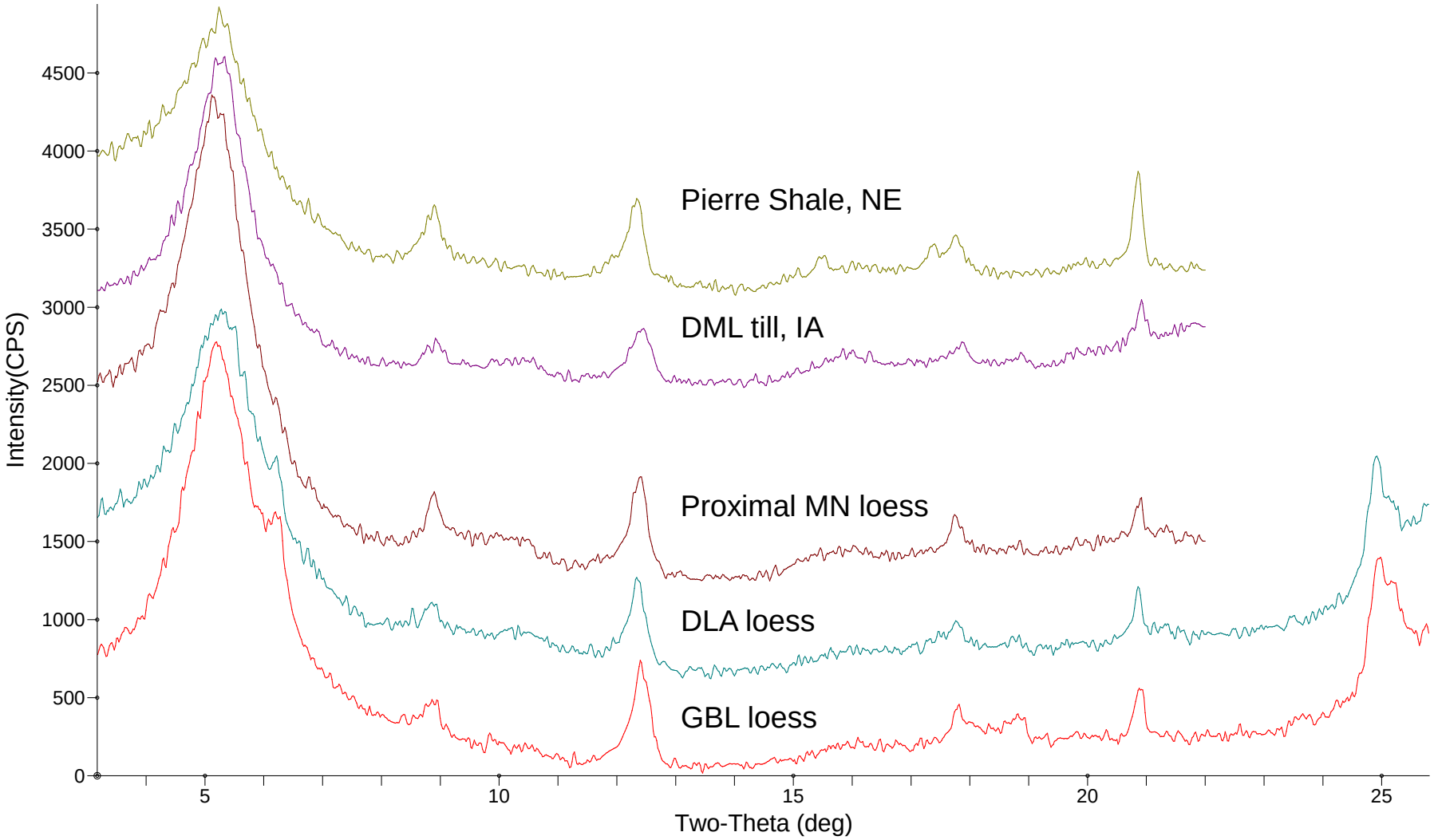
In this article, Jacobs et al. (2011) discuss the possible origins of a thin (75–125 cm) loess mantle on a bedrock upland in southeastern Wisconsin, last glaciated by the Green Bay Lobe (GBL) of the Wisconsin glacier (Fig. 1A). They argue that the ultimate source of this loess was Mississippi River Valley (MRV) glacial outwash—a long-established

mismatches) among samples that have such varying depositional histories and differing geographies.

Lastly, Jacobs et al. (2011) rely on the assumption that MRV loess was transported to GLW plain and then remobilized by migrating dunes. Although dunes exist on the GLW plain (Rawling et al., 2008), most of the lake plain is flat, wet, and lacks obvious dune fields (Fig. 1B). Indeed, the nearest dune field is ≈75 km northwest of the GBL study area. Contrary to what was asserted by Jacobs et al. (2011), between GLW and the Oneota escarpment, few dunes—and no dune fields—occur that could have transported eolian sediment

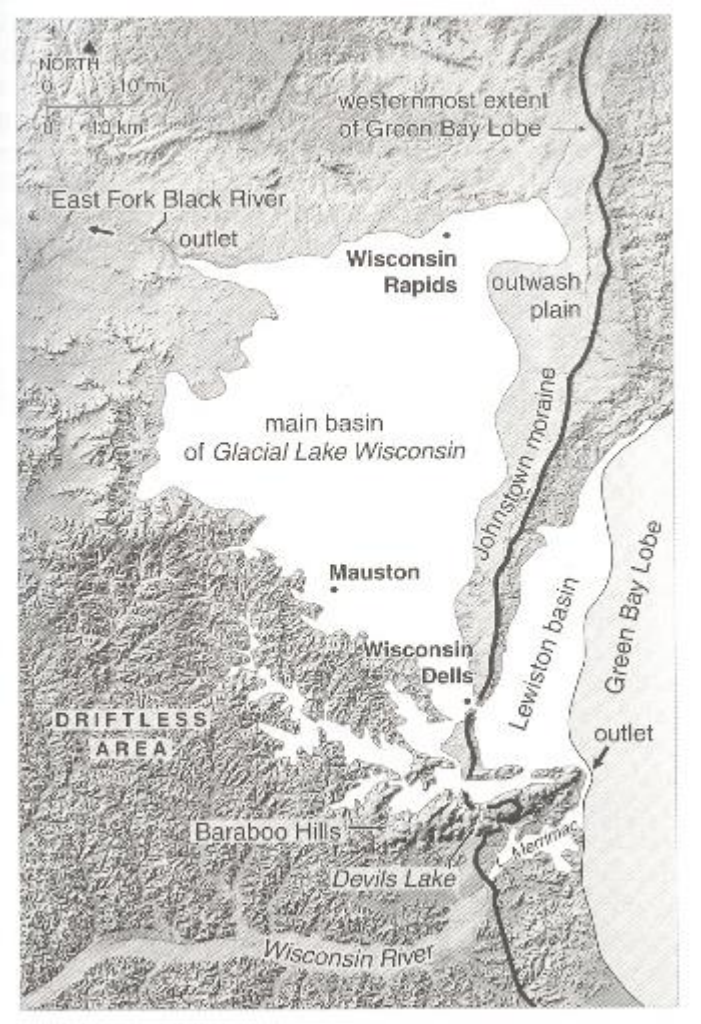
Randy Schaetzl, Michigan State University, challenged our proposal along the lines of:

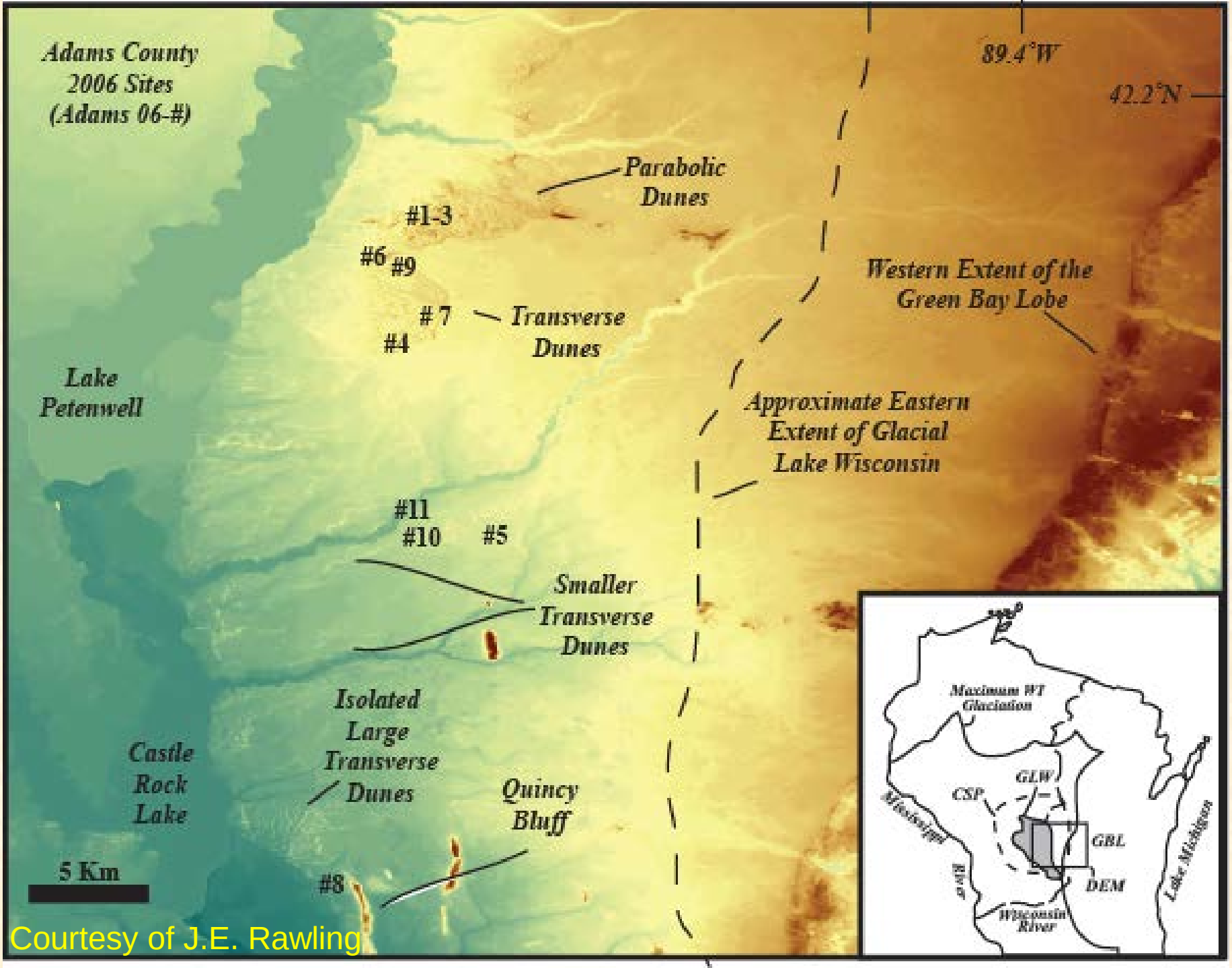
1) Source of smectitic clays, and
2) Lack of dunes to transport dust to escarpment.


Intensity(CPS)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5
10
15
20
25
Two-Theta (deg)
Pierre Shale, NE
DML till, IA
Proximal MN loess
DLA loess
GBL loess

Glacial Lake Wisconsin

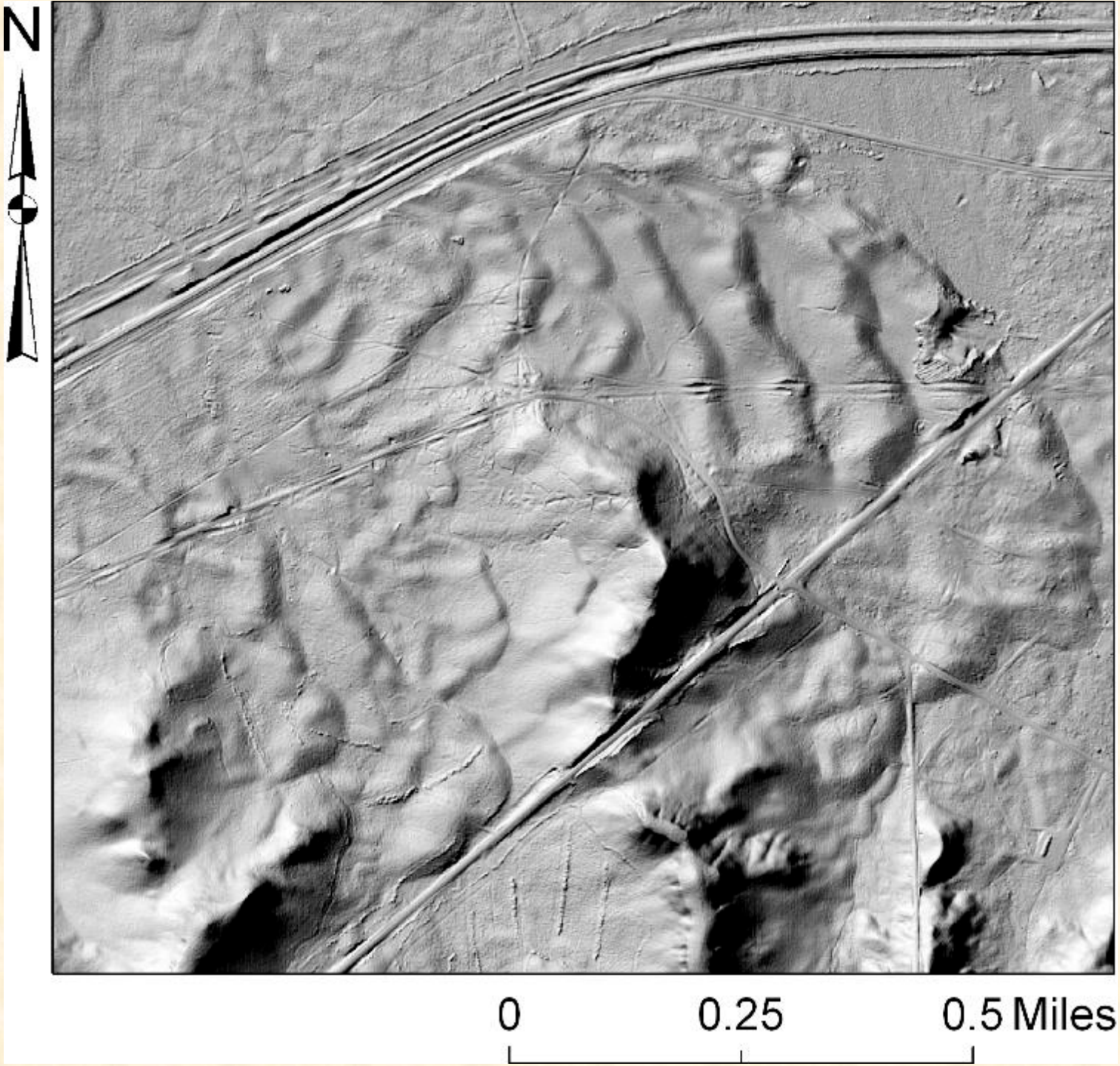
- Following drainage of GLW late glacial eolian activity reworked lake sediments into sandsheet and dunes





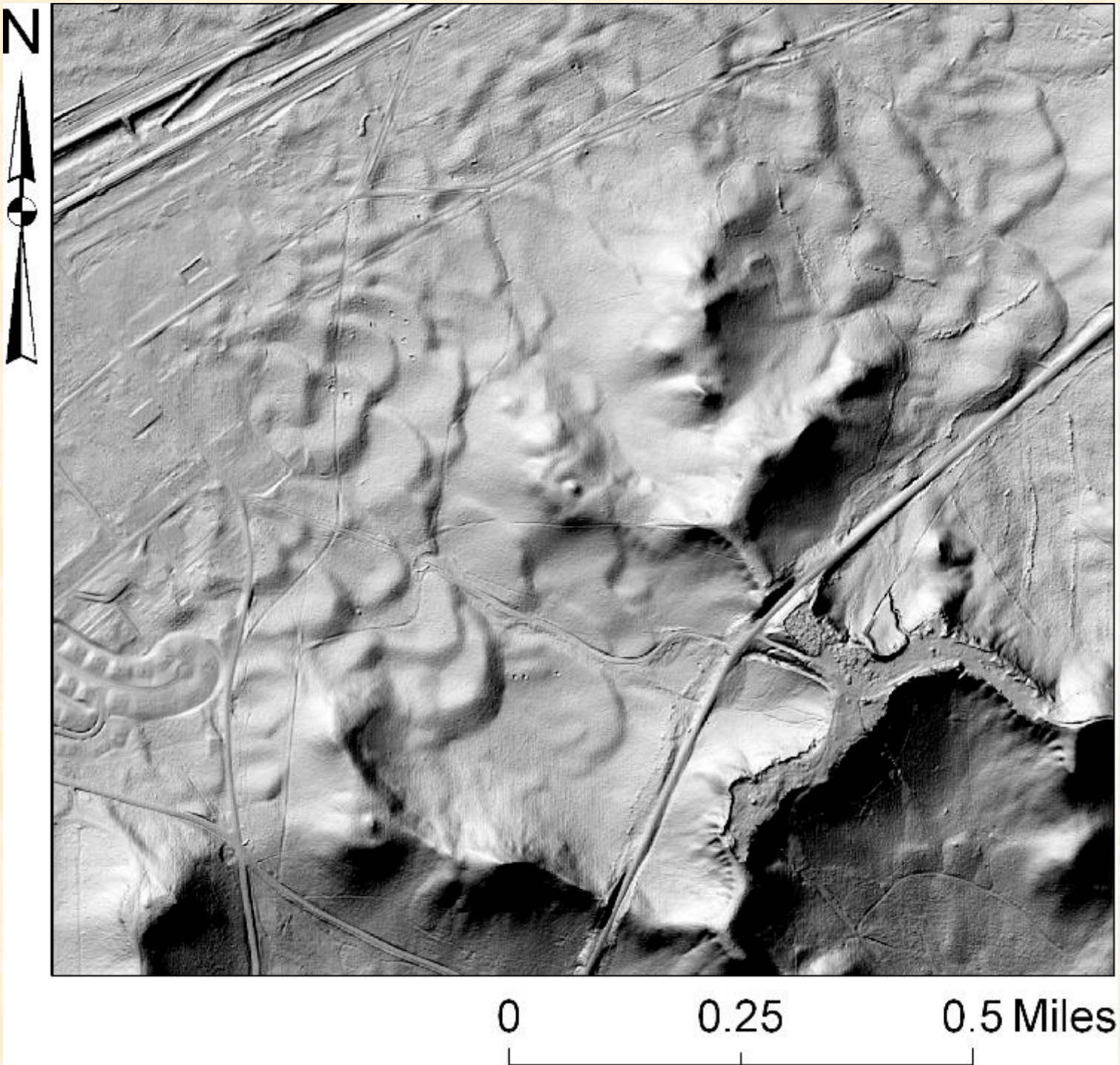
Courtesy of J.E. Rawling

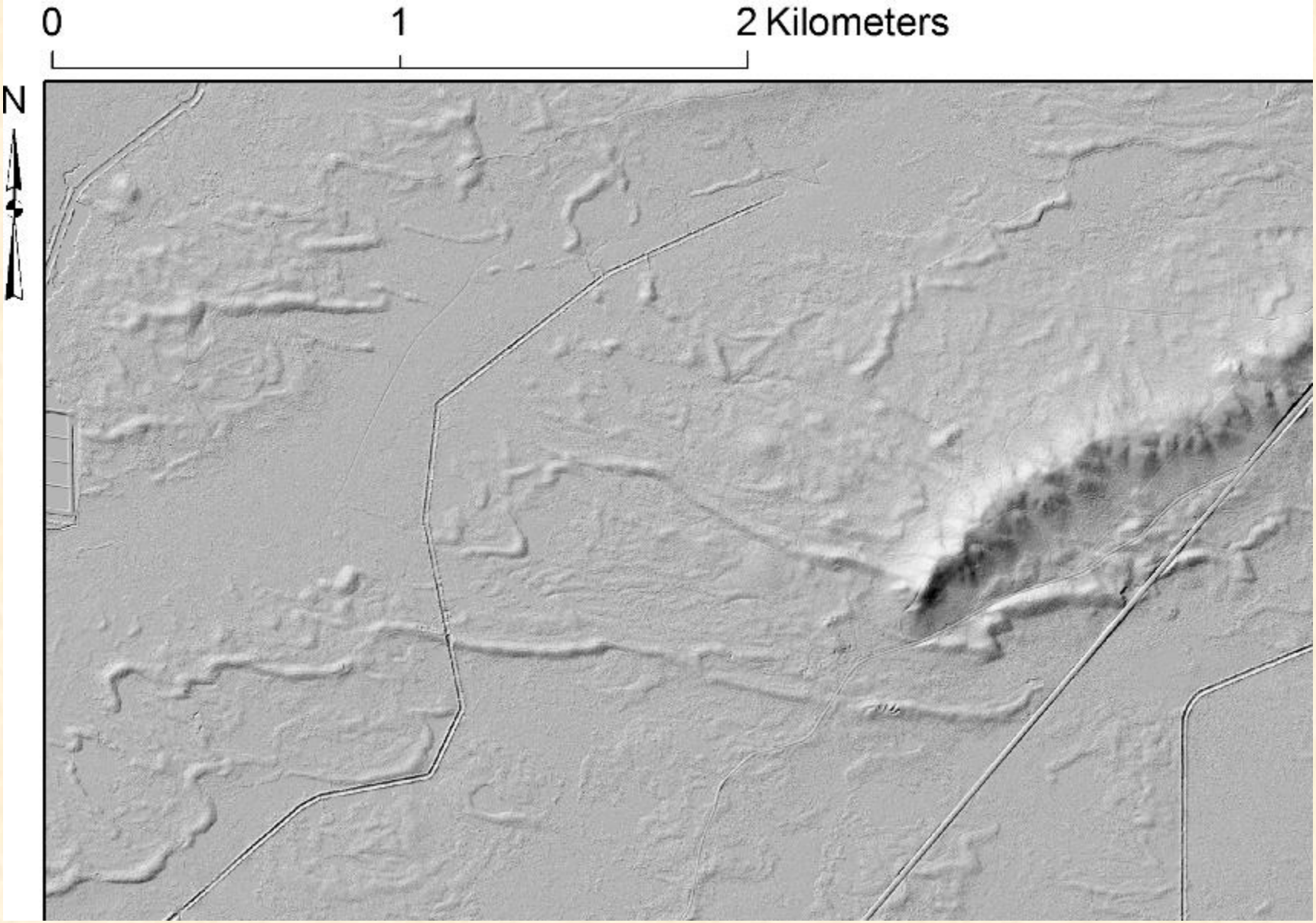
- Large dunes in GLW formed 14-10.6 ka; sandsheet ages extend back to 18 ka.



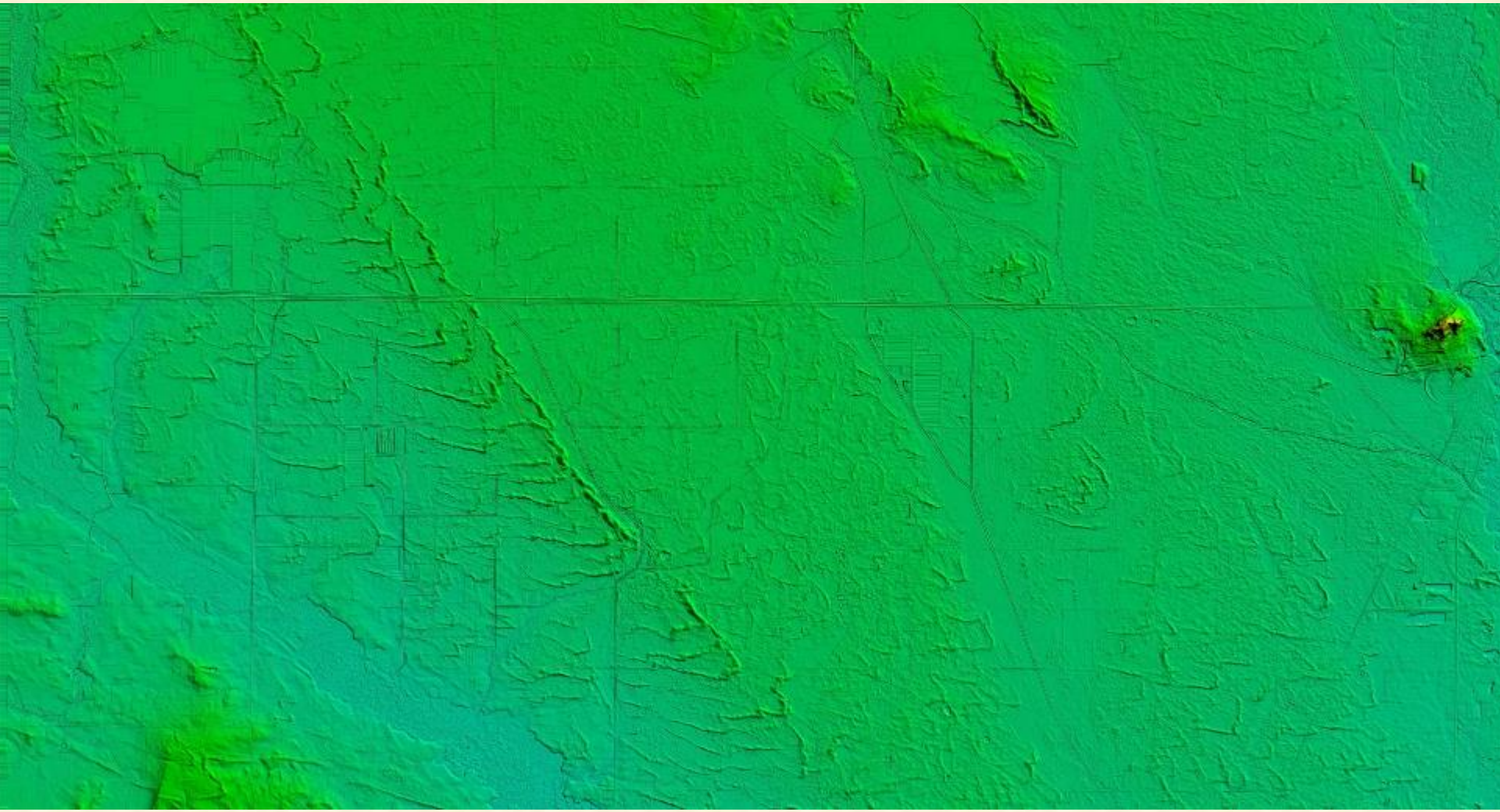
Fort McCoy
at Sparta

Sparta

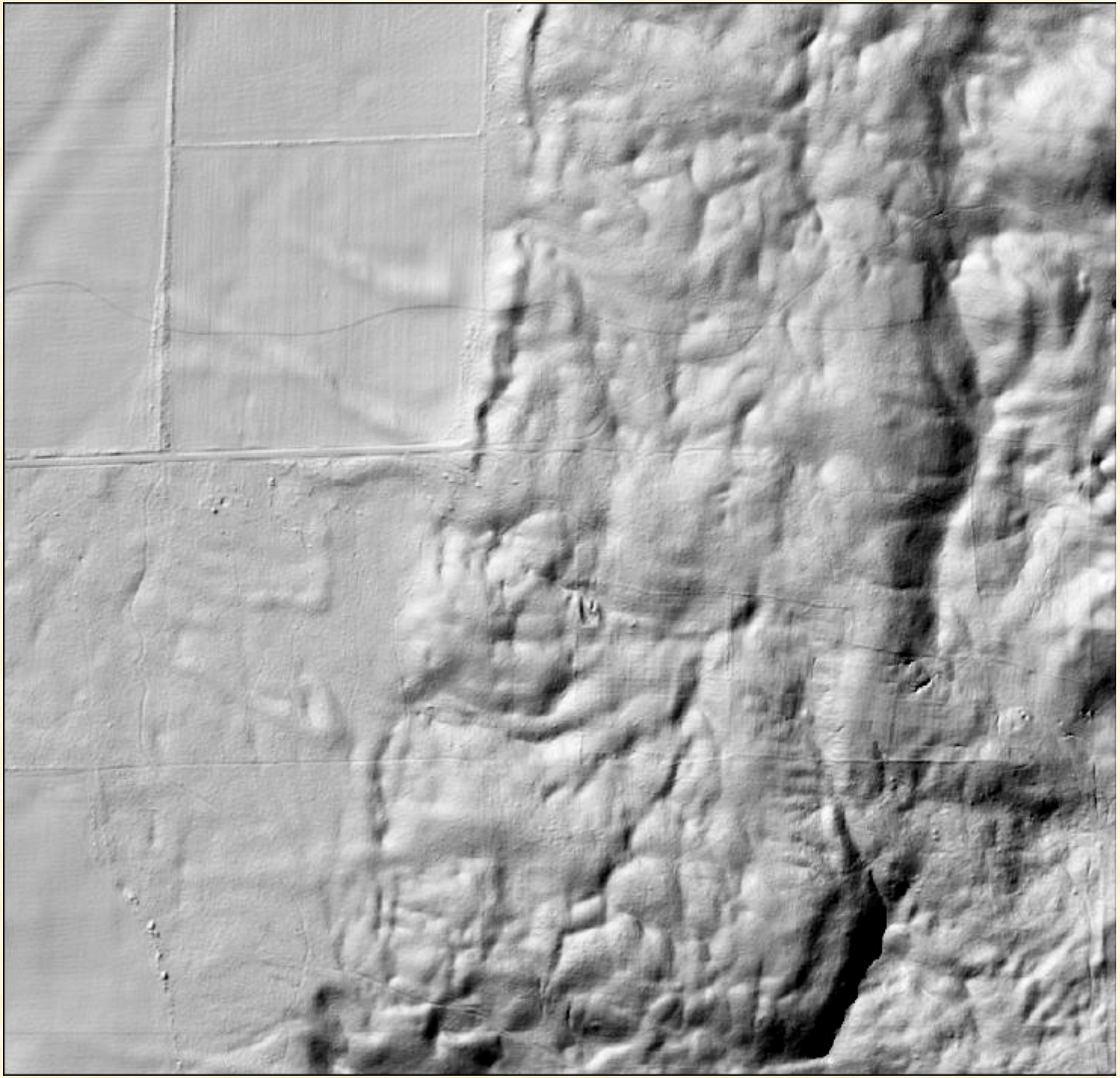




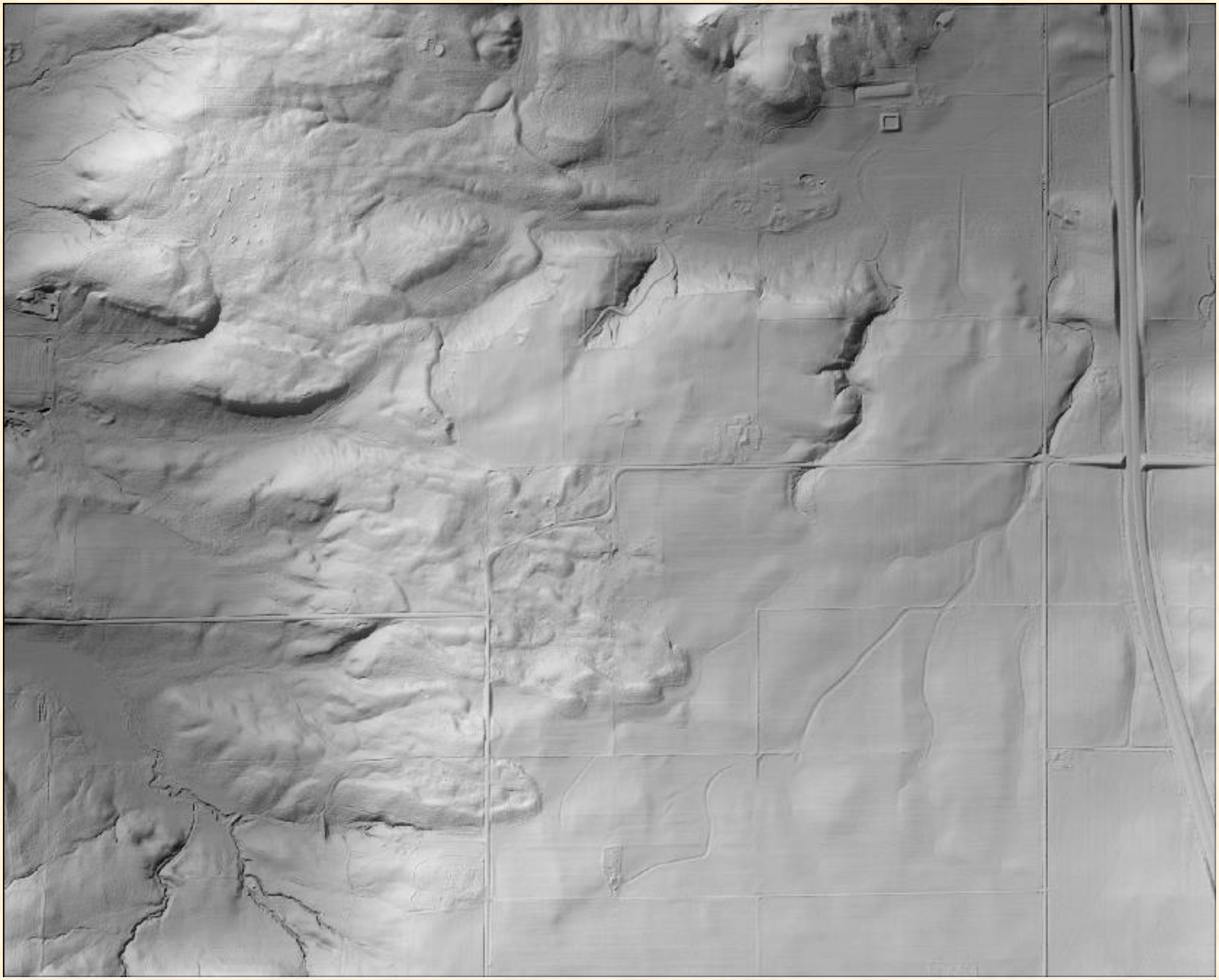
Tomah



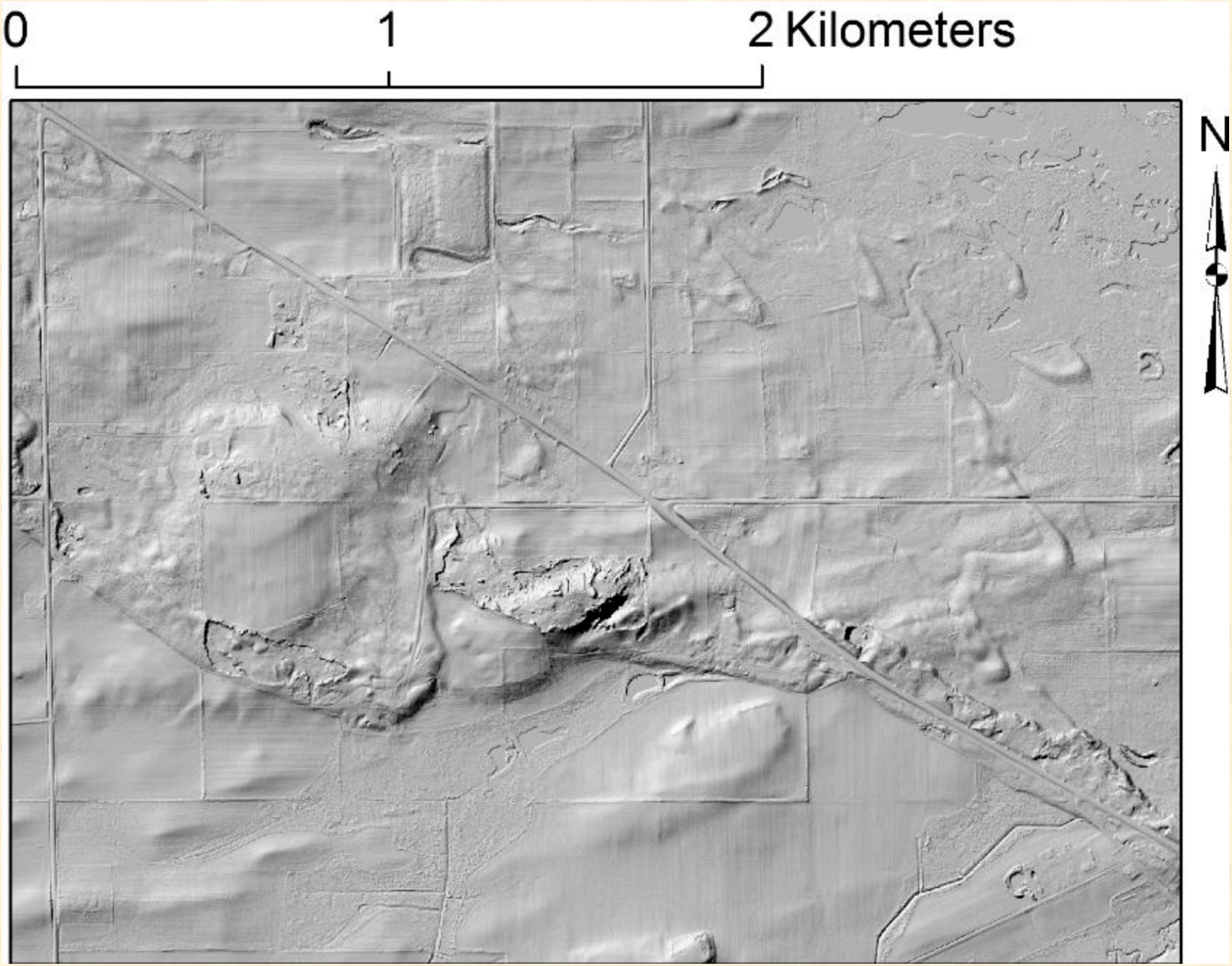
Central Juneau County



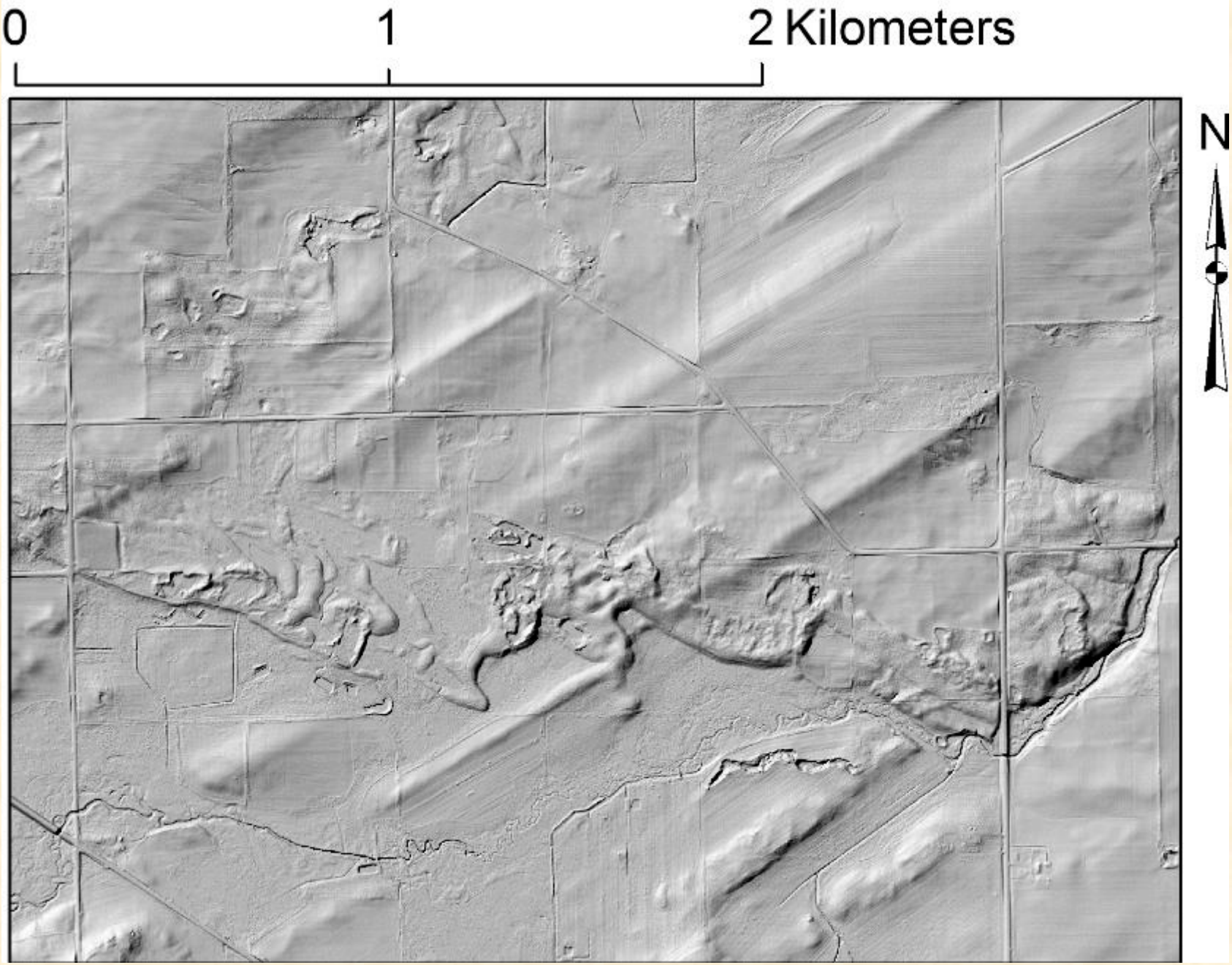
Southern Adams County at Johnstown Moraine



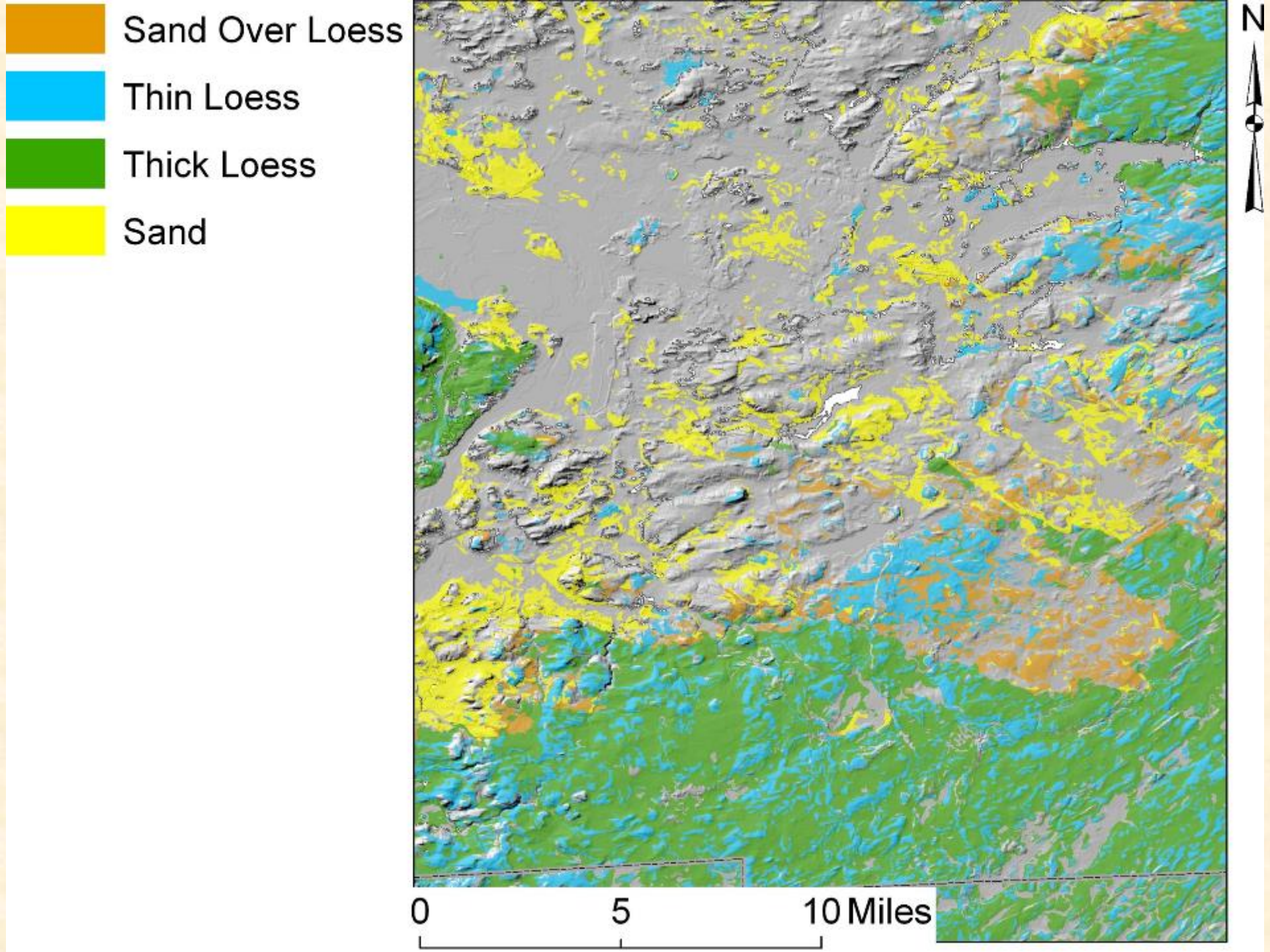
Poynette, Columbia County, at base of Oneota Escarpment.



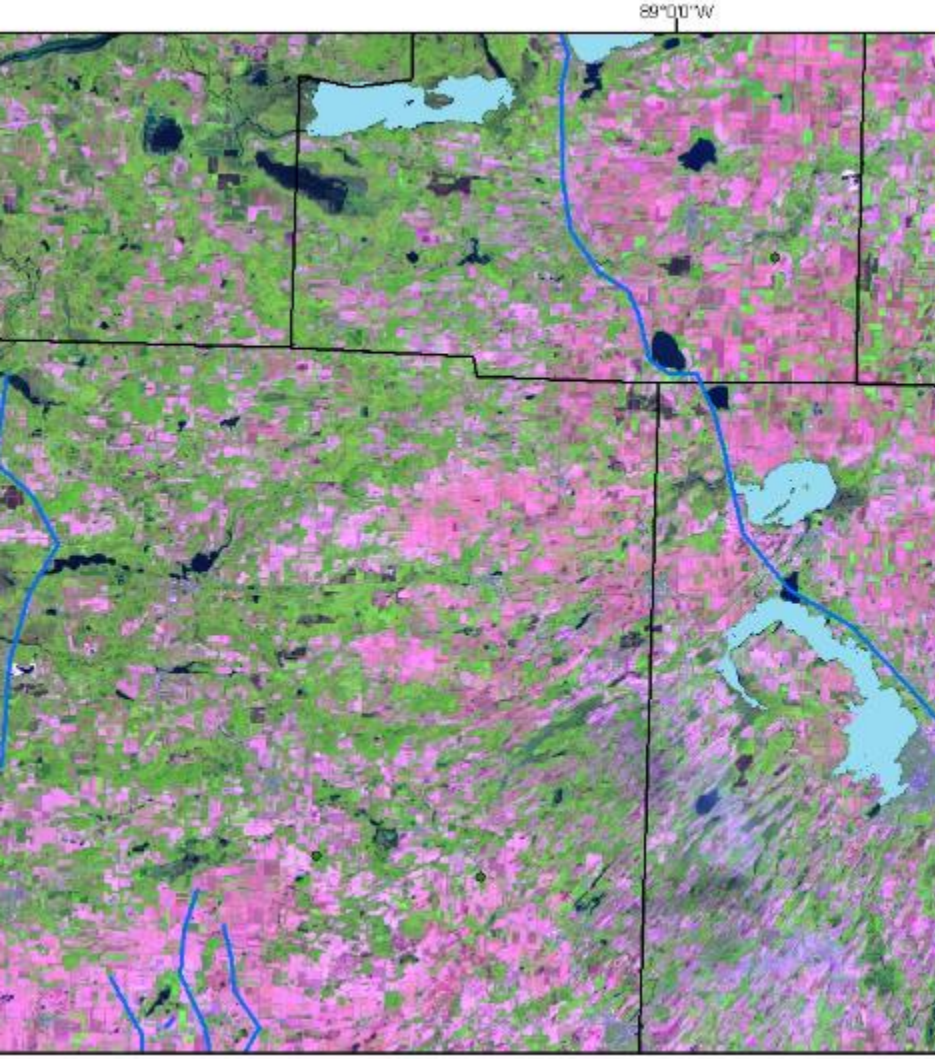
Central Columbia County, near Rio.

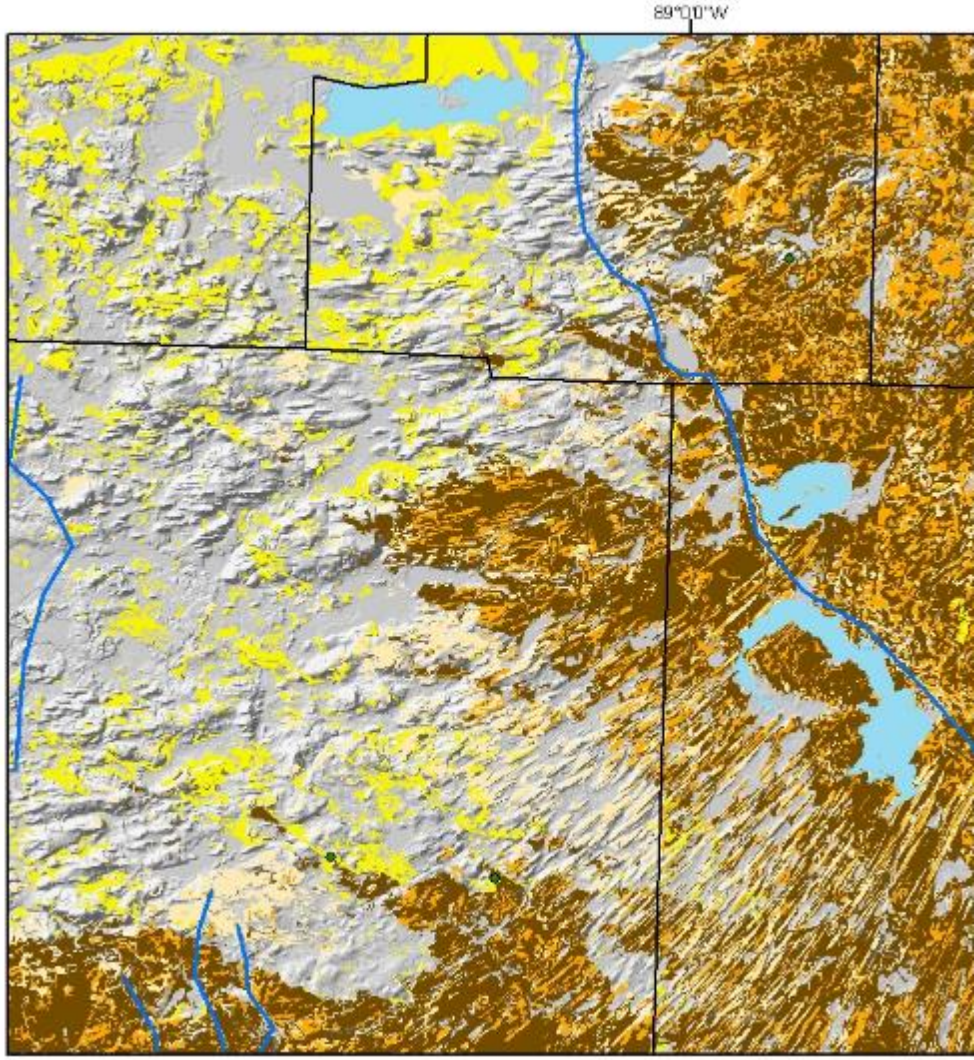


East-central Columbia County, near Fall River.


Sand Over Loess
Thin Loess
Thick Loess
Sand
N
0
5
10 Miles

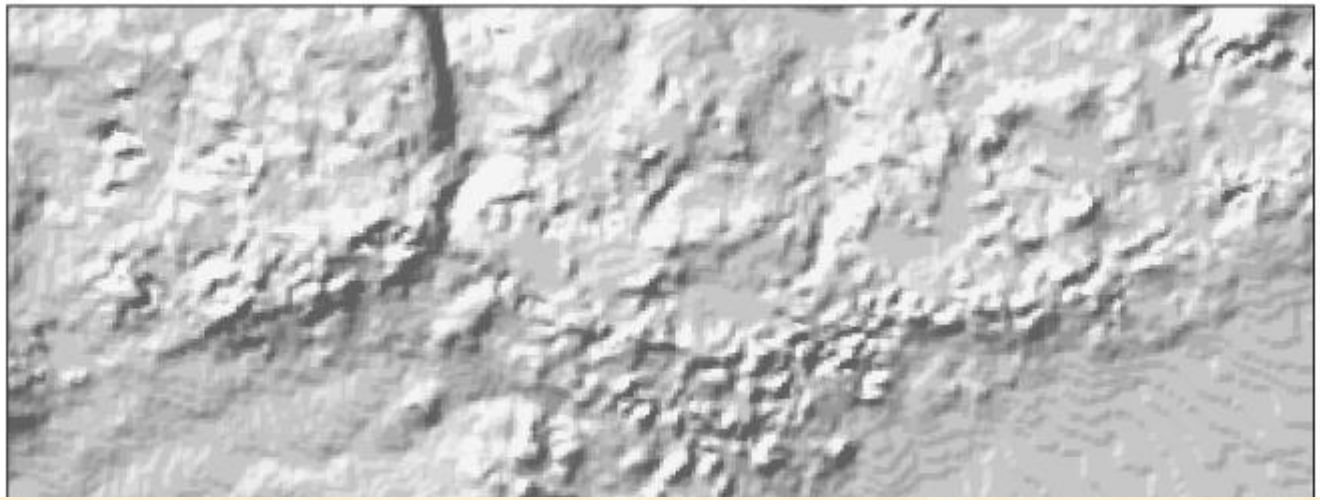
Land Use and Loess





Eolian Deposits of
the Green Bay Lobe

Outwash Plain

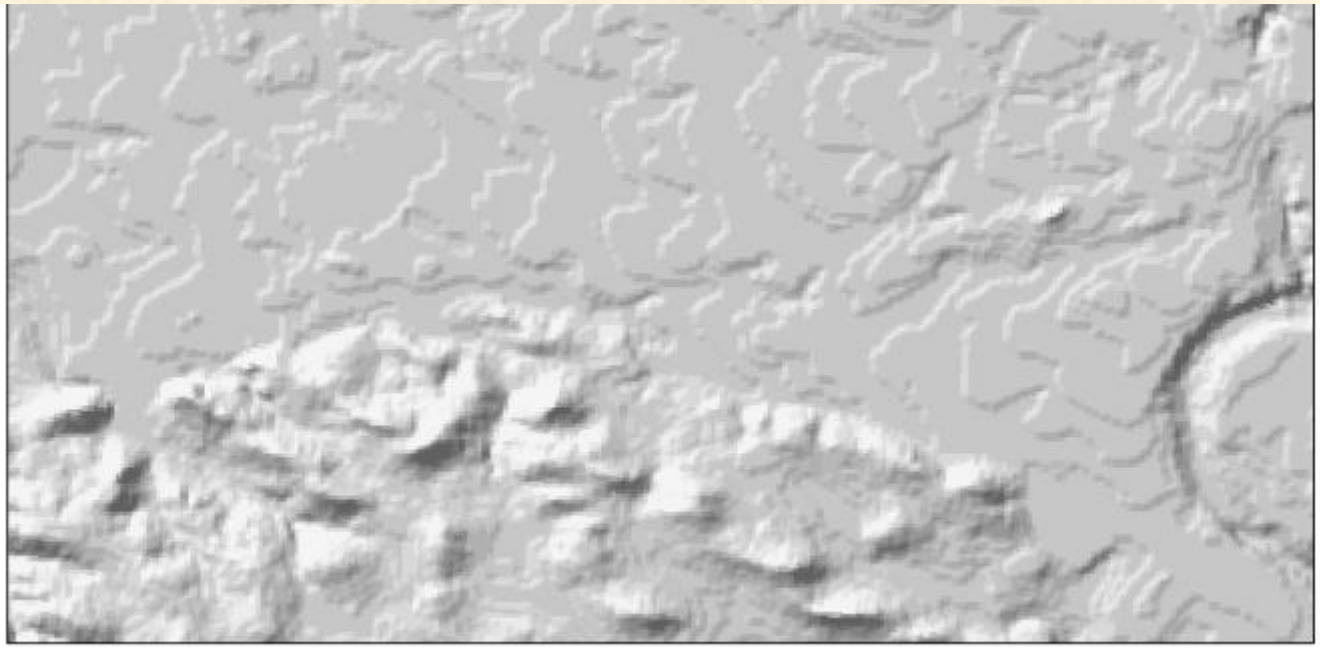


Topographic Effects on Loess Redistribution & Soil Cover Patterns

Quaternary

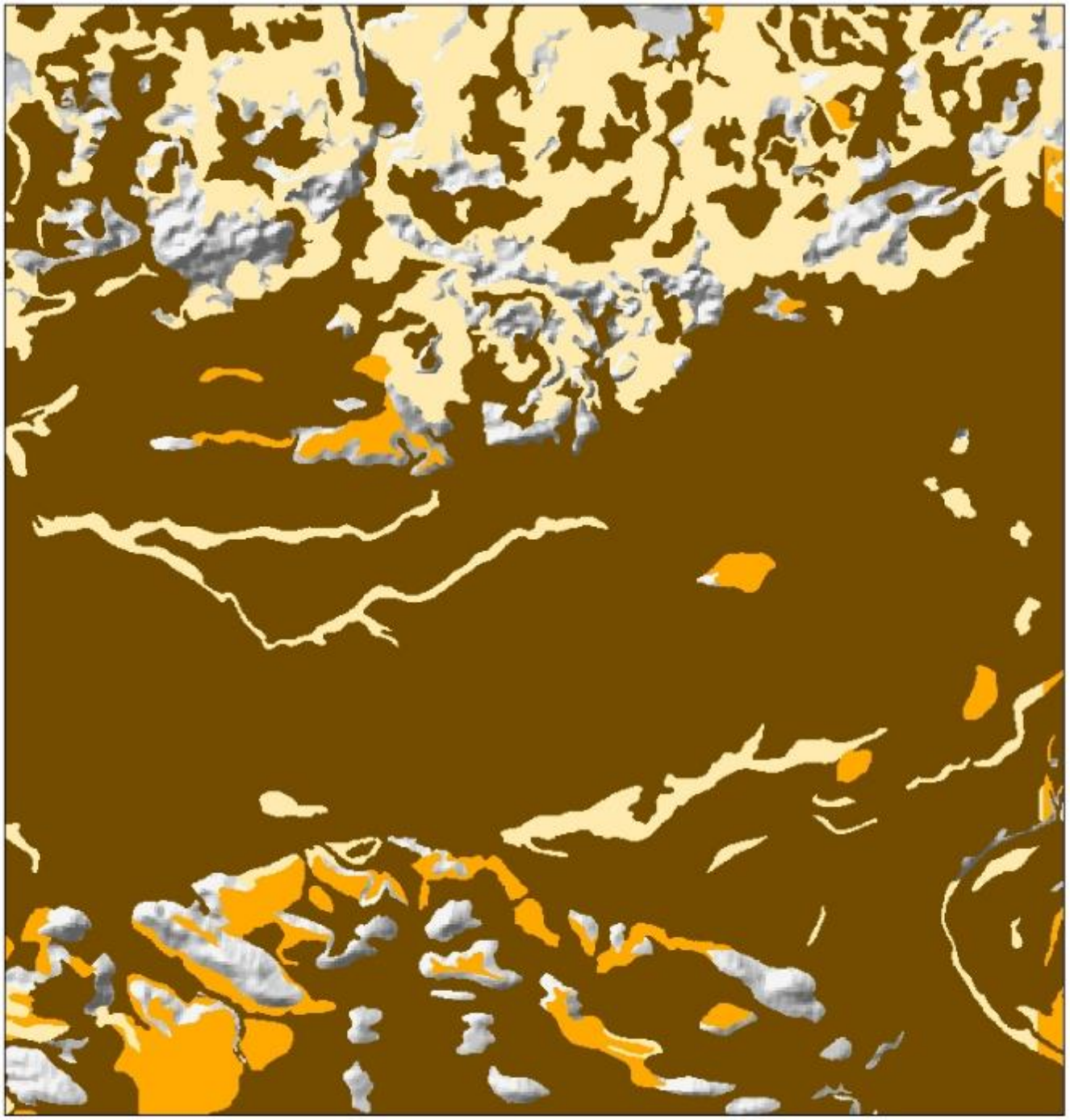
Kilometers
0 0.75 1.5

1:50,000



Eolian Deposits of
the Green Bay Lobe

Outwash Plain



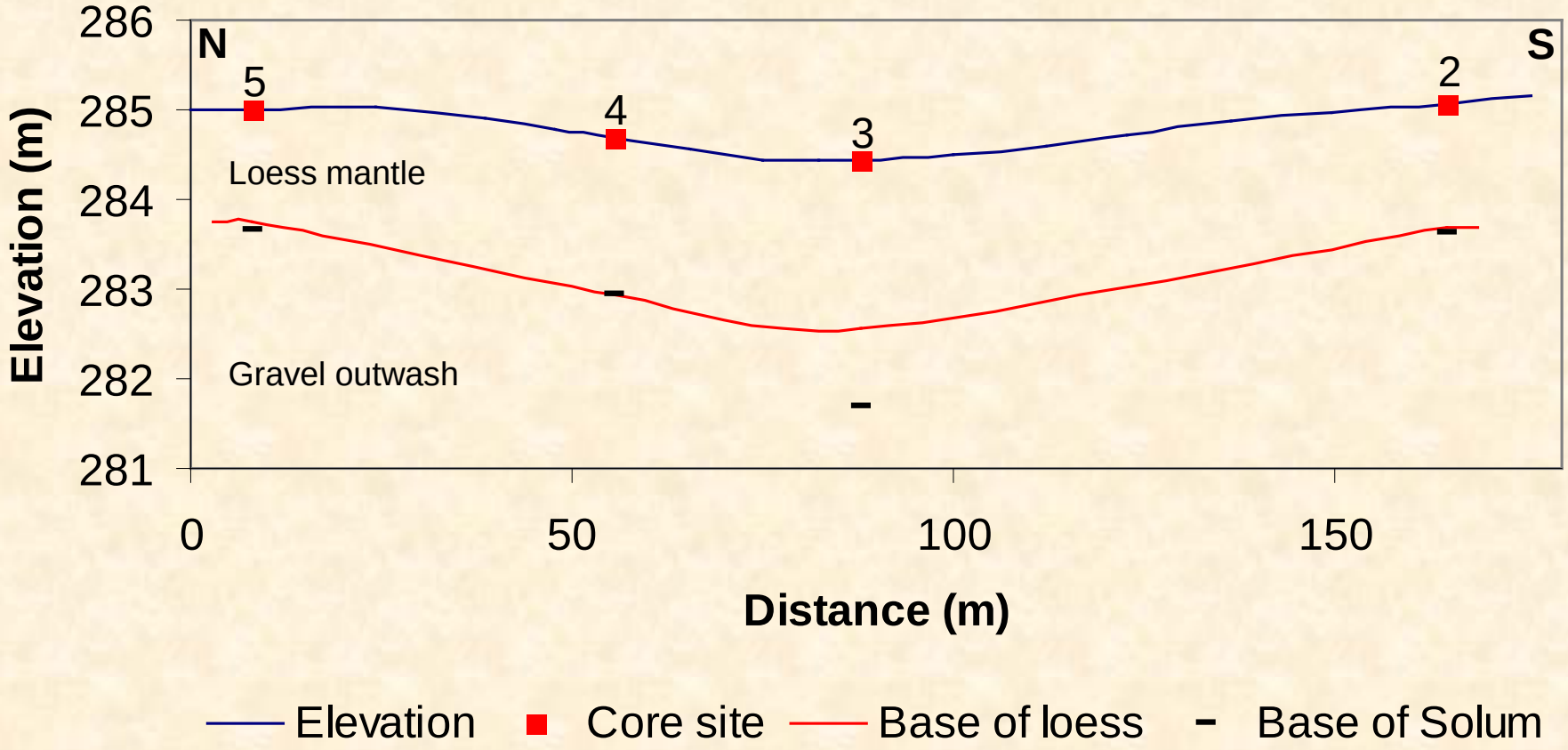
Quaternary

- Loess <50 cm
- Loess 50-100 cm
- Loess >100 cm

Kilometers
0 0.75 1.5

1:50,000

Weberpal Site



- Note uniform thickness of loess mantle – minimal reworking into braid channel.
- Solum mostly confined to loess mantle, except site with water run-on.

Eolian Deposits of
the Green Bay Lobe

Drumlinized Terrain

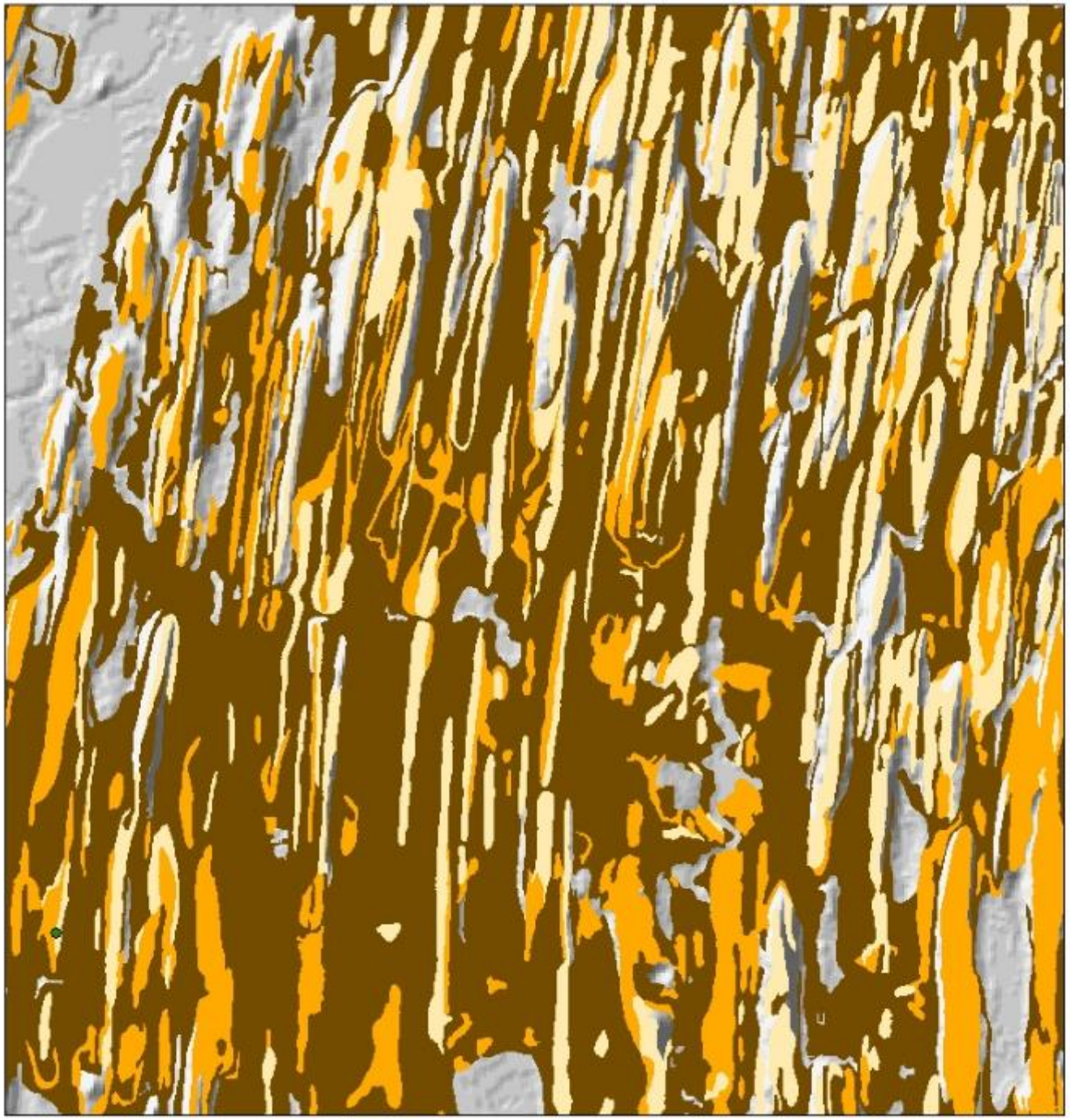
Quaternary

Kilometers
0 0.75 1.5

1:50,000

Eolian Deposits of
the Green Bay Lobe

Drumlinized Terrain

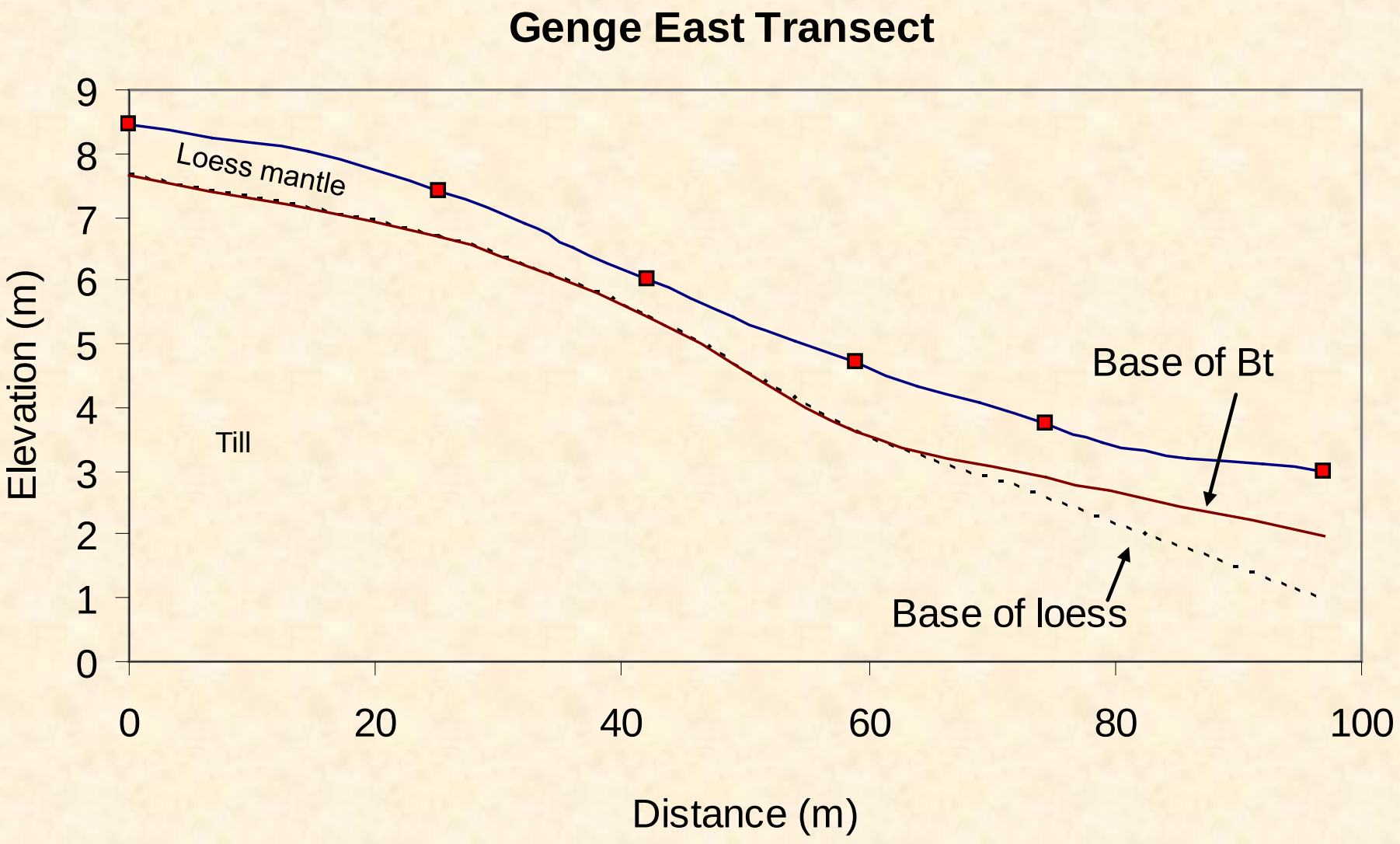


Quaternary

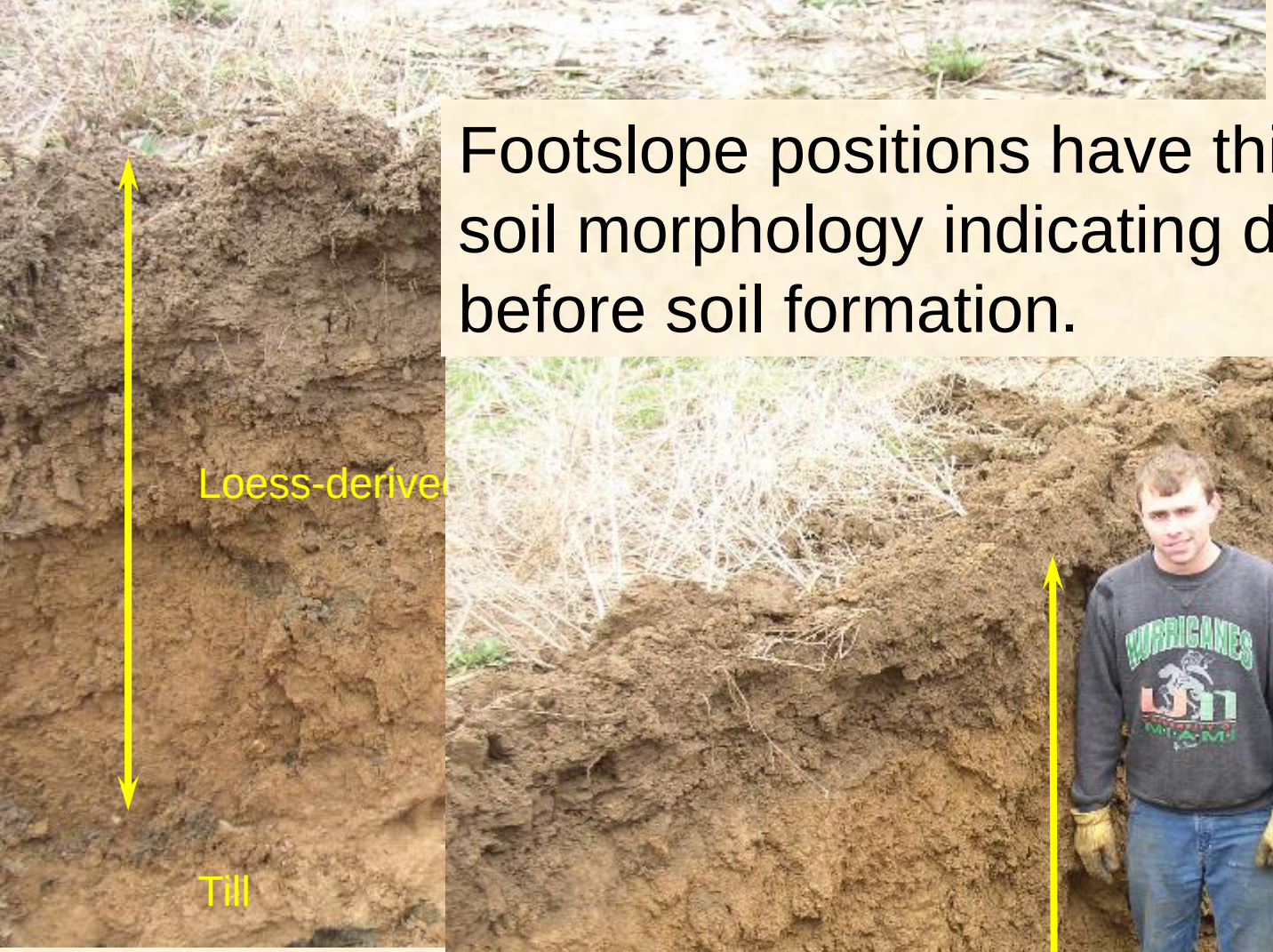
- Loess <50 cm
- Loess 50-100 cm
- Loess >100 cm

Kilometers
0 0.75 1.5

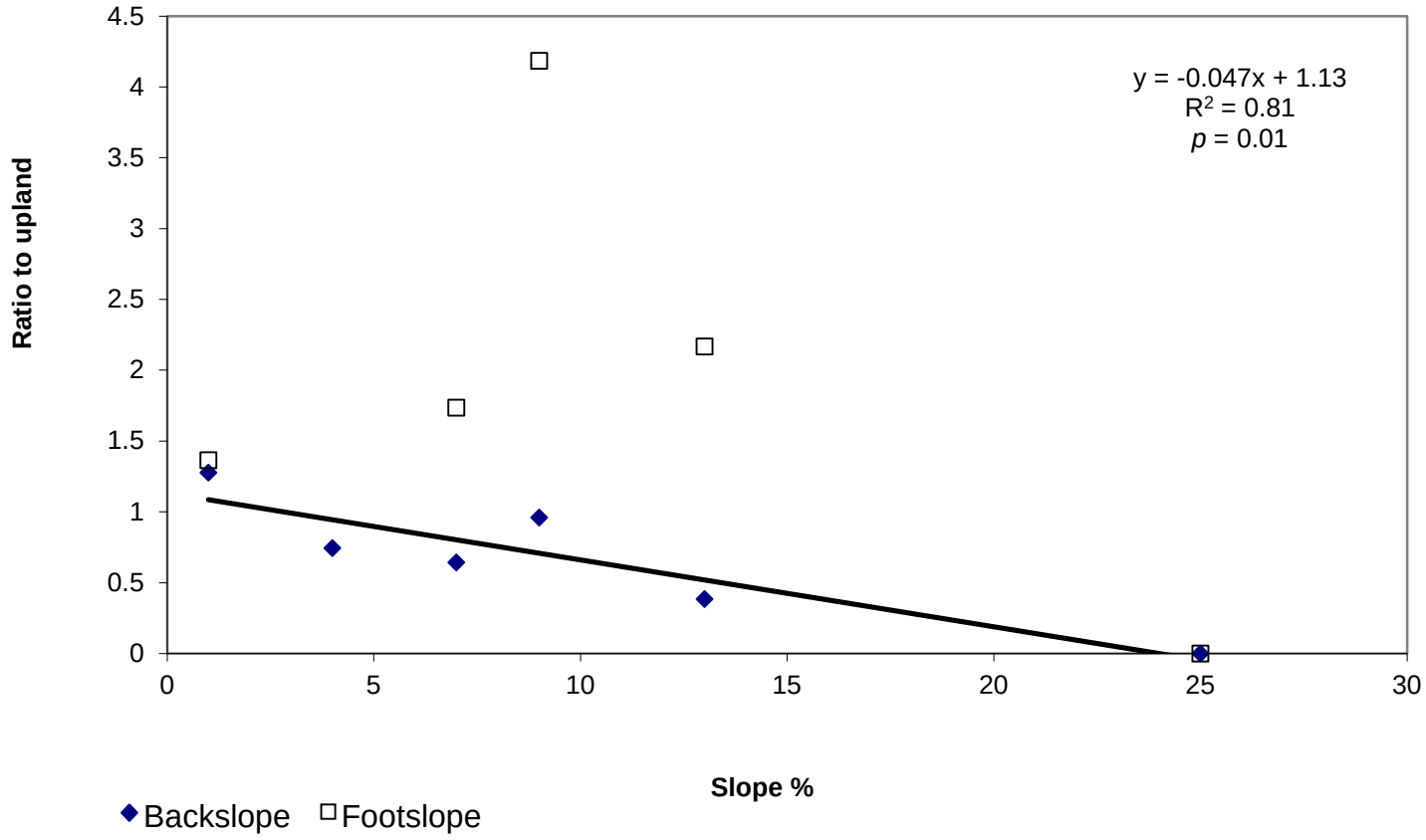
1:50,000


Genge East Transect
Elevation (m)
9
8
7
6
5
4
3
2
1
0
Loess mantle
Till
Base of Bt
Base of loess
0
20
40
60
80
100
Distance (m)

Footslope positions have thick loess and soil morphology indicating deposition before soil formation.



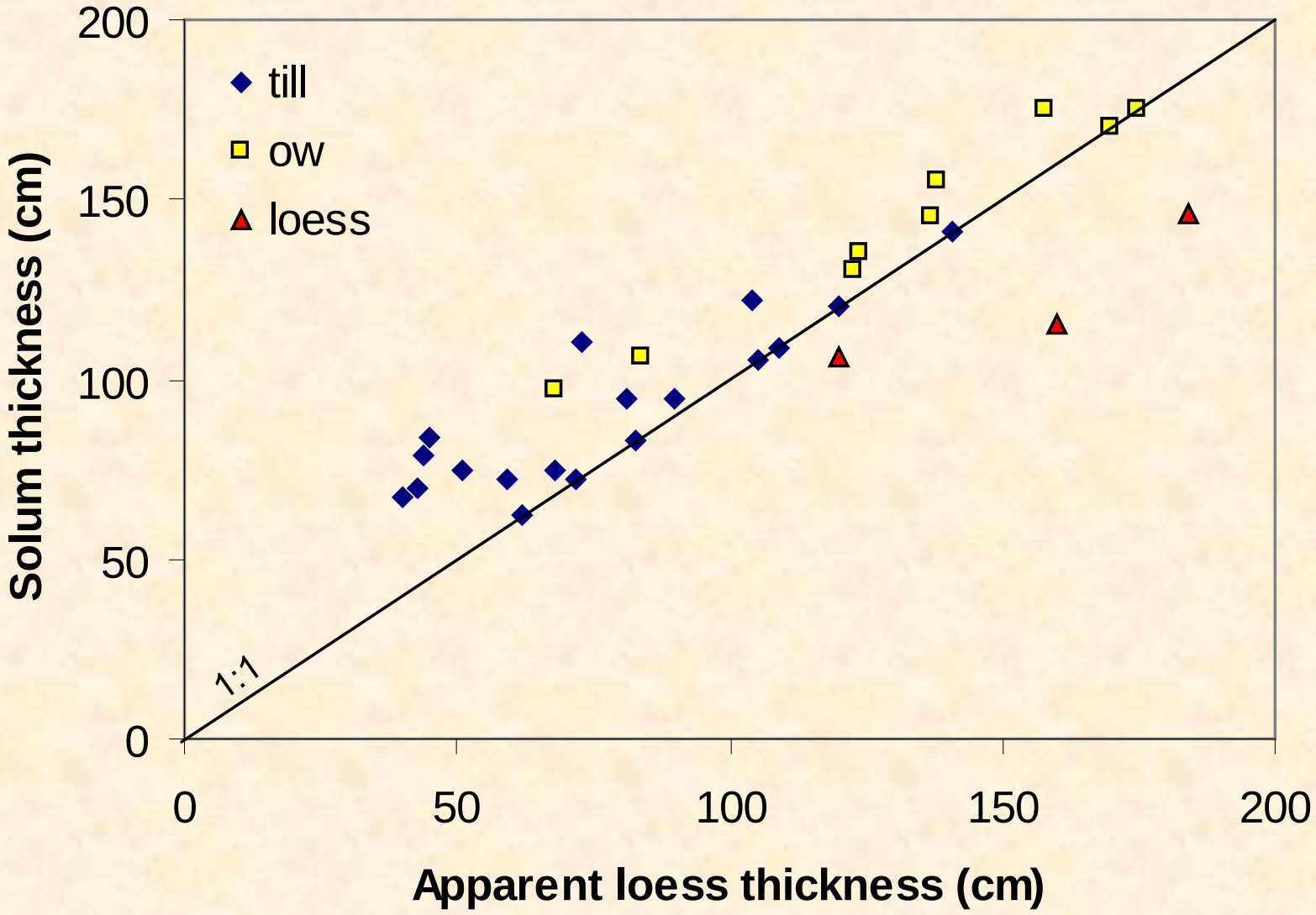
Summit posit

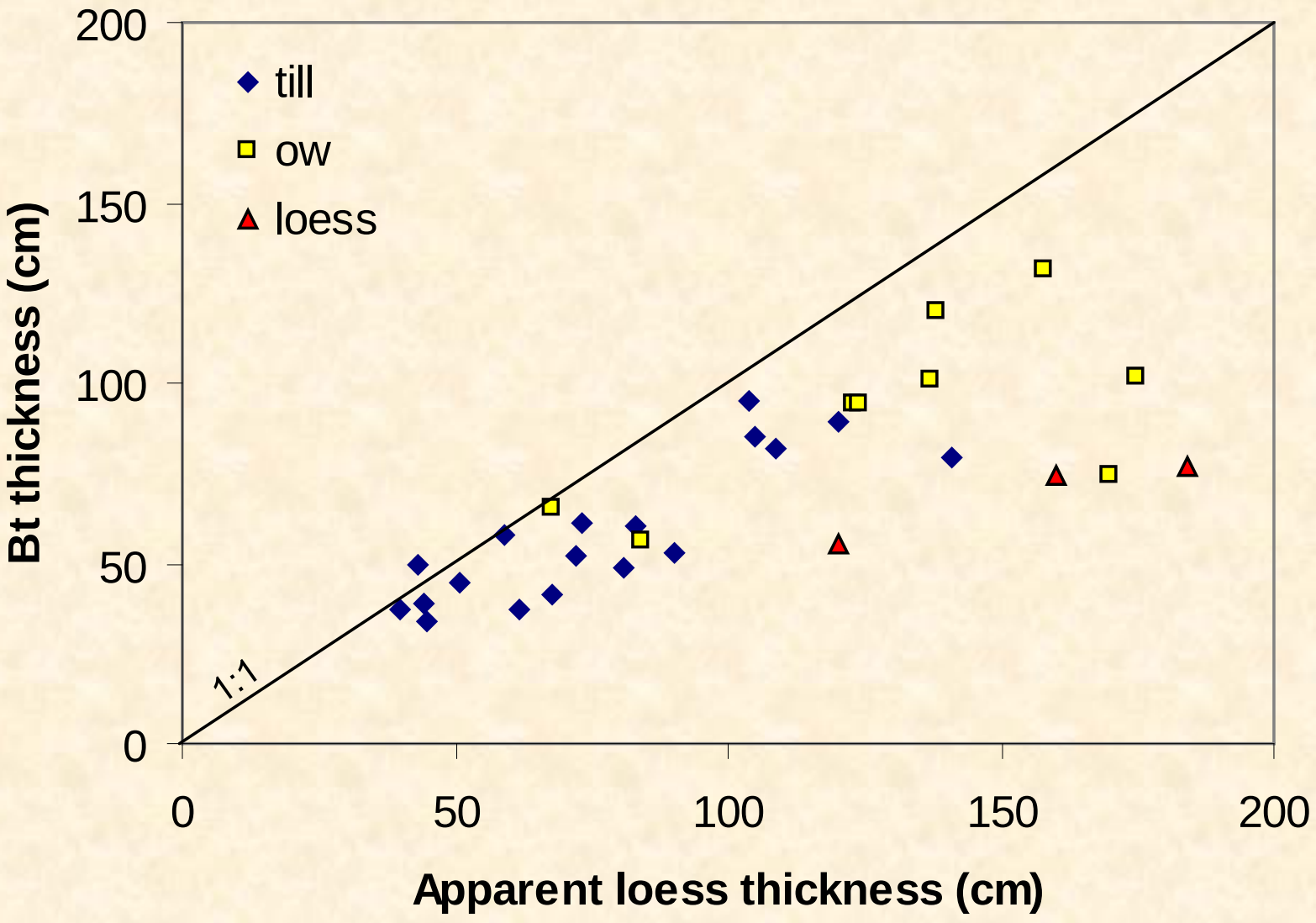


Loess redistribution is largely a function of slope. The ratio of loess thickness on backslope to upland varies systematically.

Loess Effects on Pedogenesis

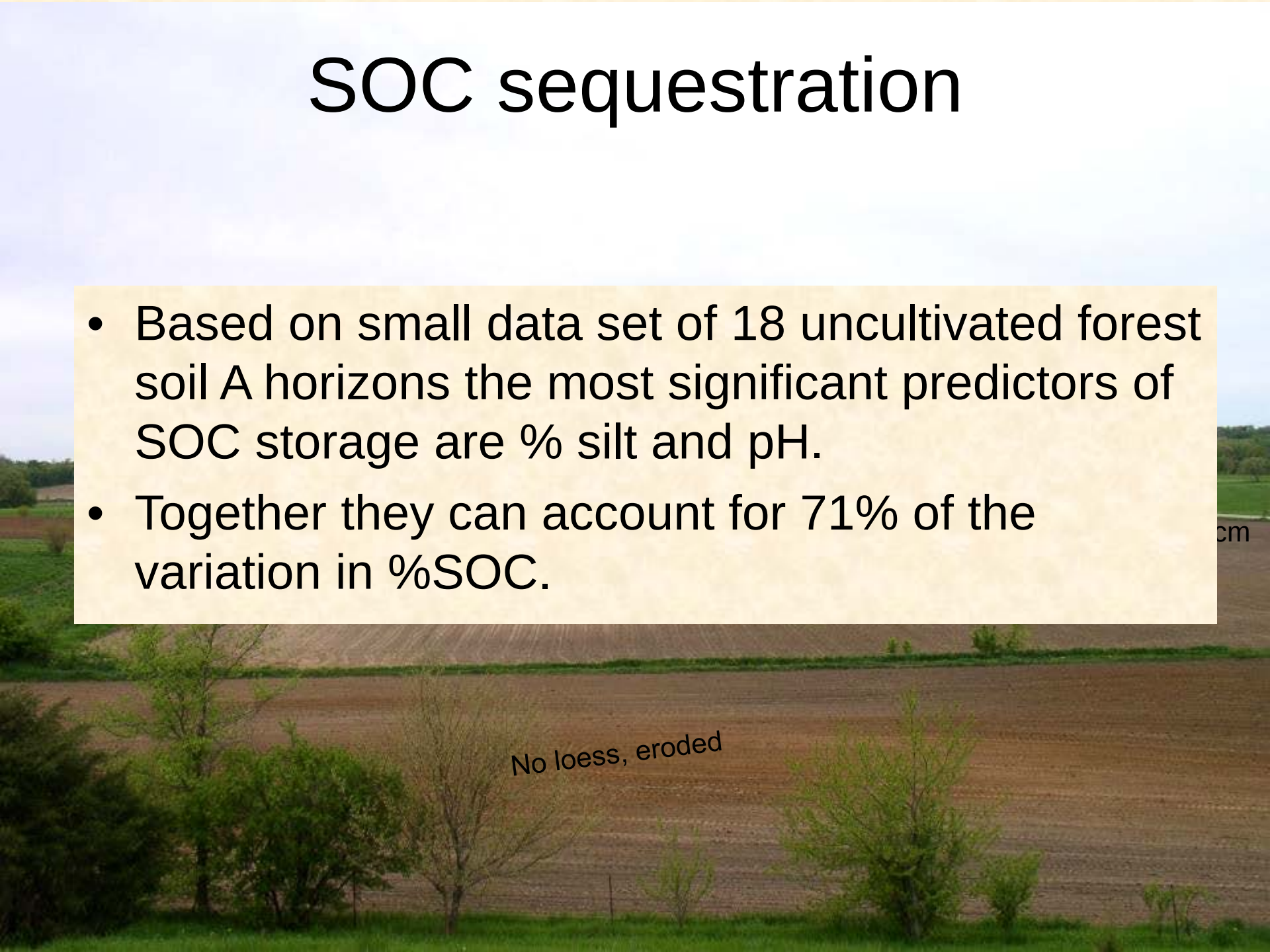
Property	Loess Soils	Till Soils
Particle size	Silt & clay rich	Sandy
Bulk density	Low	High
CEC	High	Lower
C storage	Higher	Lower
Water storage	High	Lower


200
150
100
50
0
0
50
100
150
200
till
ow
loess
1:1
Solum thickness (cm)
Apparent loess thickness (cm)

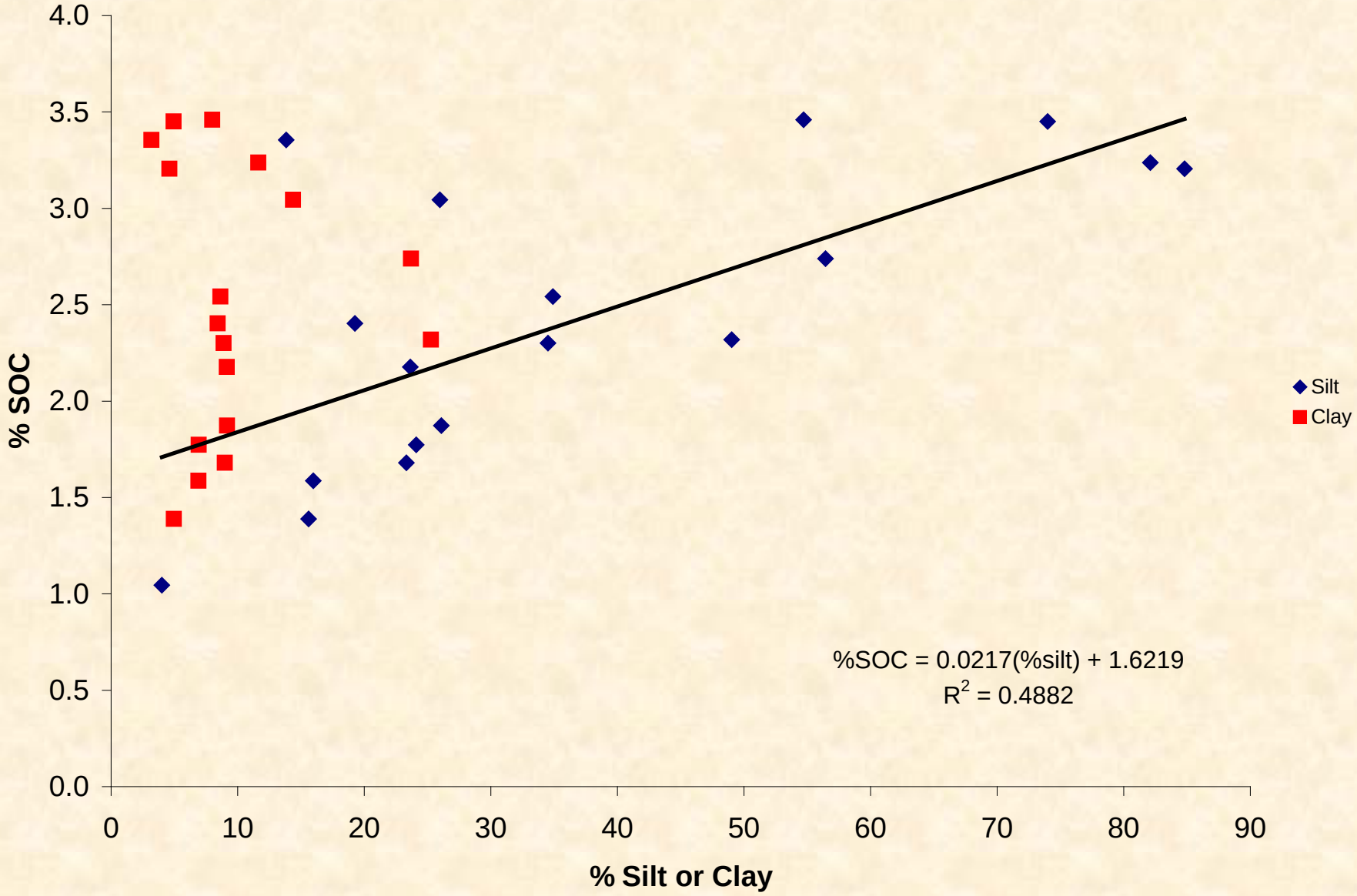

200
150
100
50
0
0
50
100
150
200
till
ow
loess
1:1
Bt thickness (cm)
Apparent loess thickness (cm)

SOC sequestration

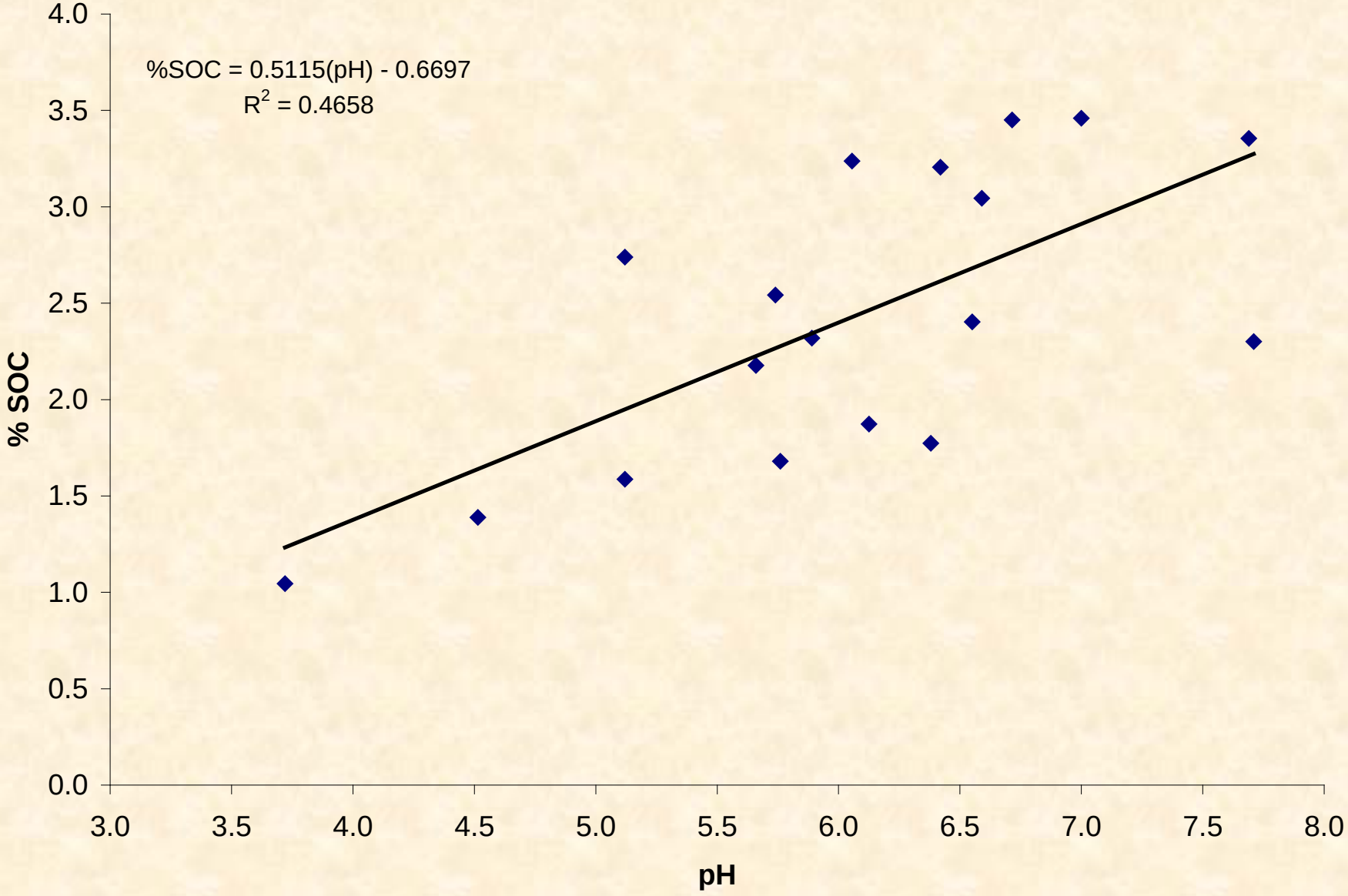
- Based on small data set of 18 uncultivated forest soil A horizons the most significant predictors of SOC storage are % silt and pH.
- Together they can account for 71% of the variation in %SOC.

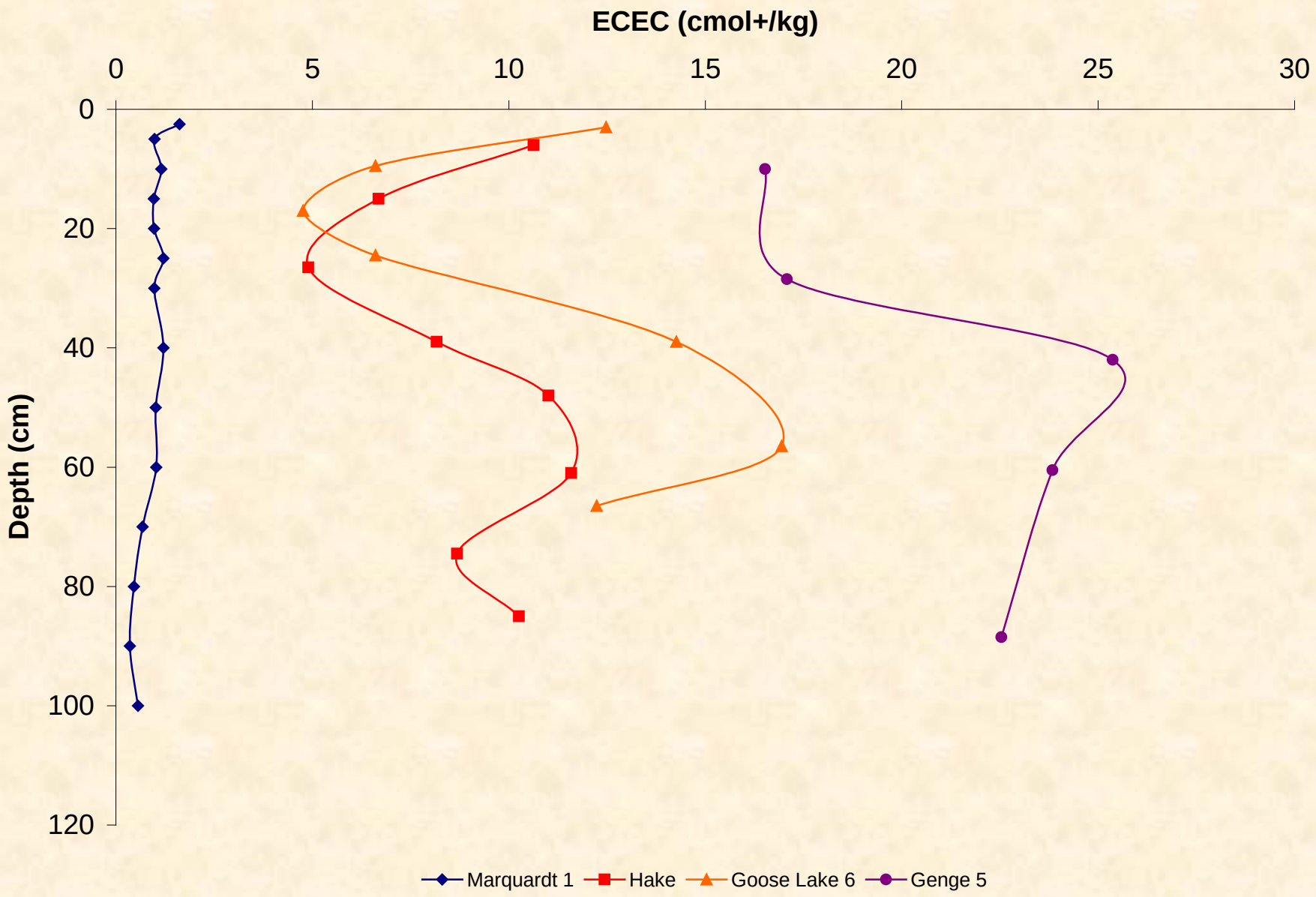


SOC sequestration



SOC sequestration

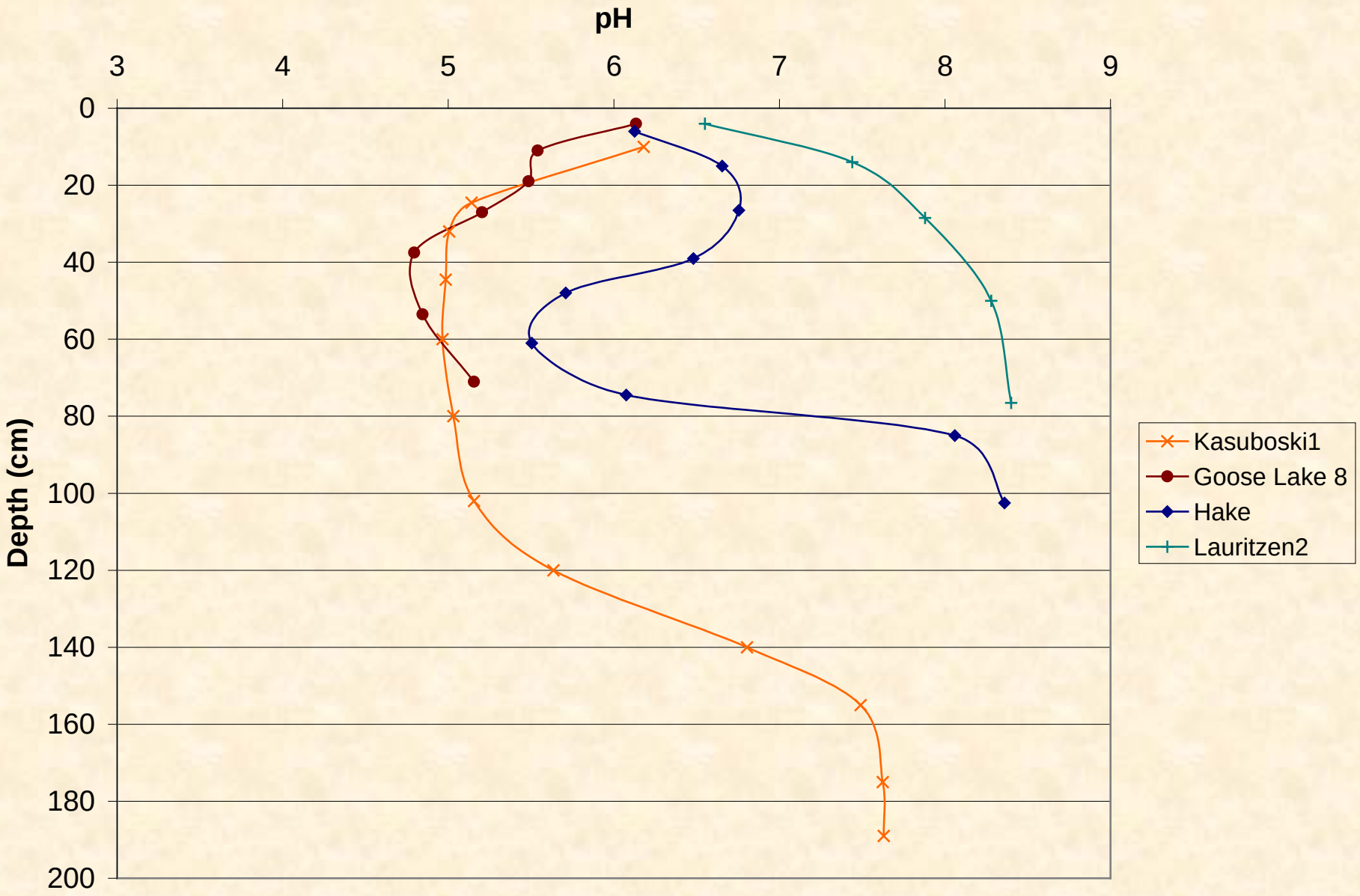




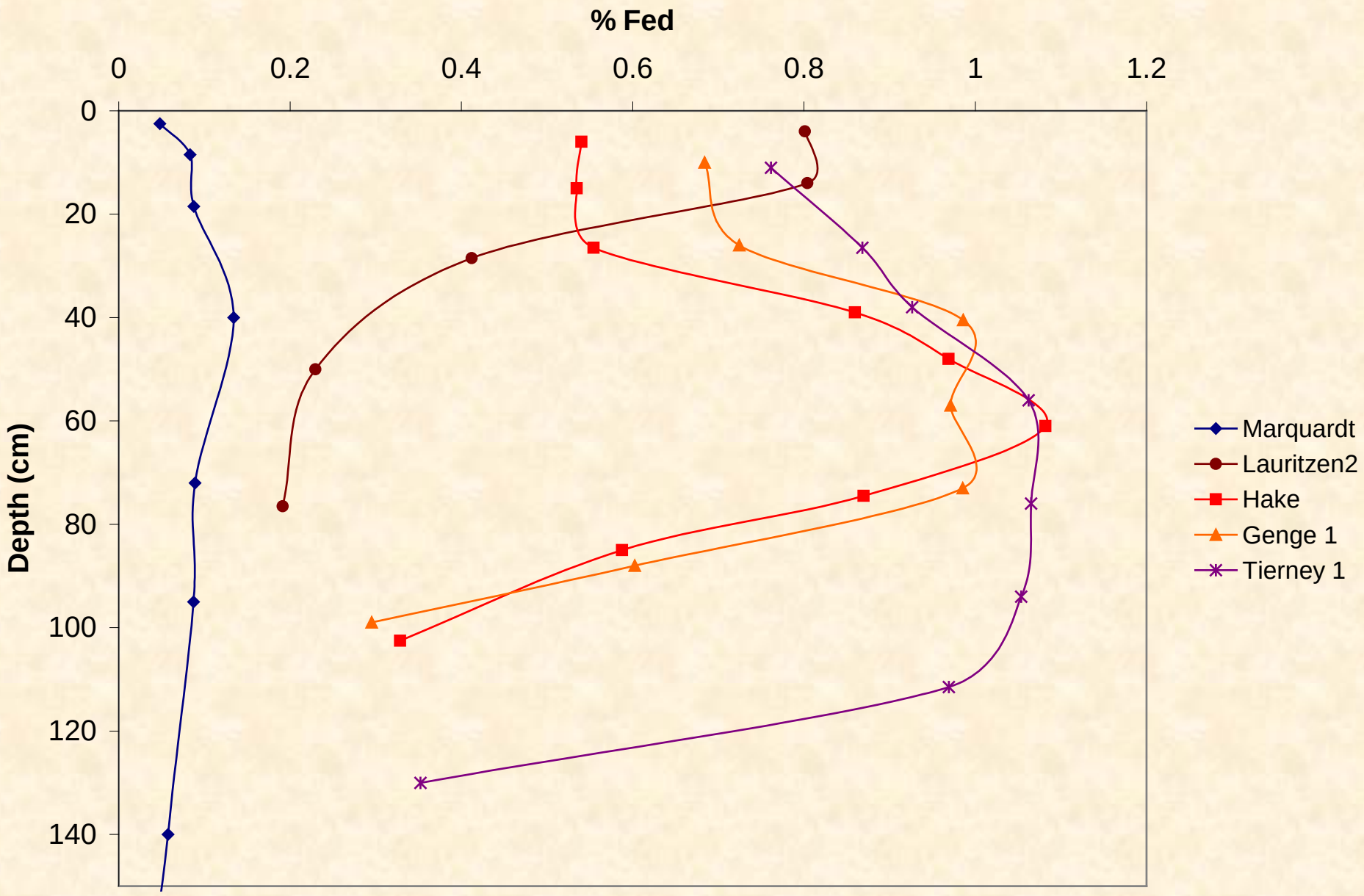
Increasing loess content & thickness increases reactivity (ECEC)

Mineral Weathering

- Carbonate dissolution primary wx process
  - High surface area and lower carbonate content has lead to leaching of loess
  - Loess is acidified throughout
- Clay min wx most pronounced
  - Illite to vermiculite
  - Formation of HIV/HIS
- Silt min wx minimal

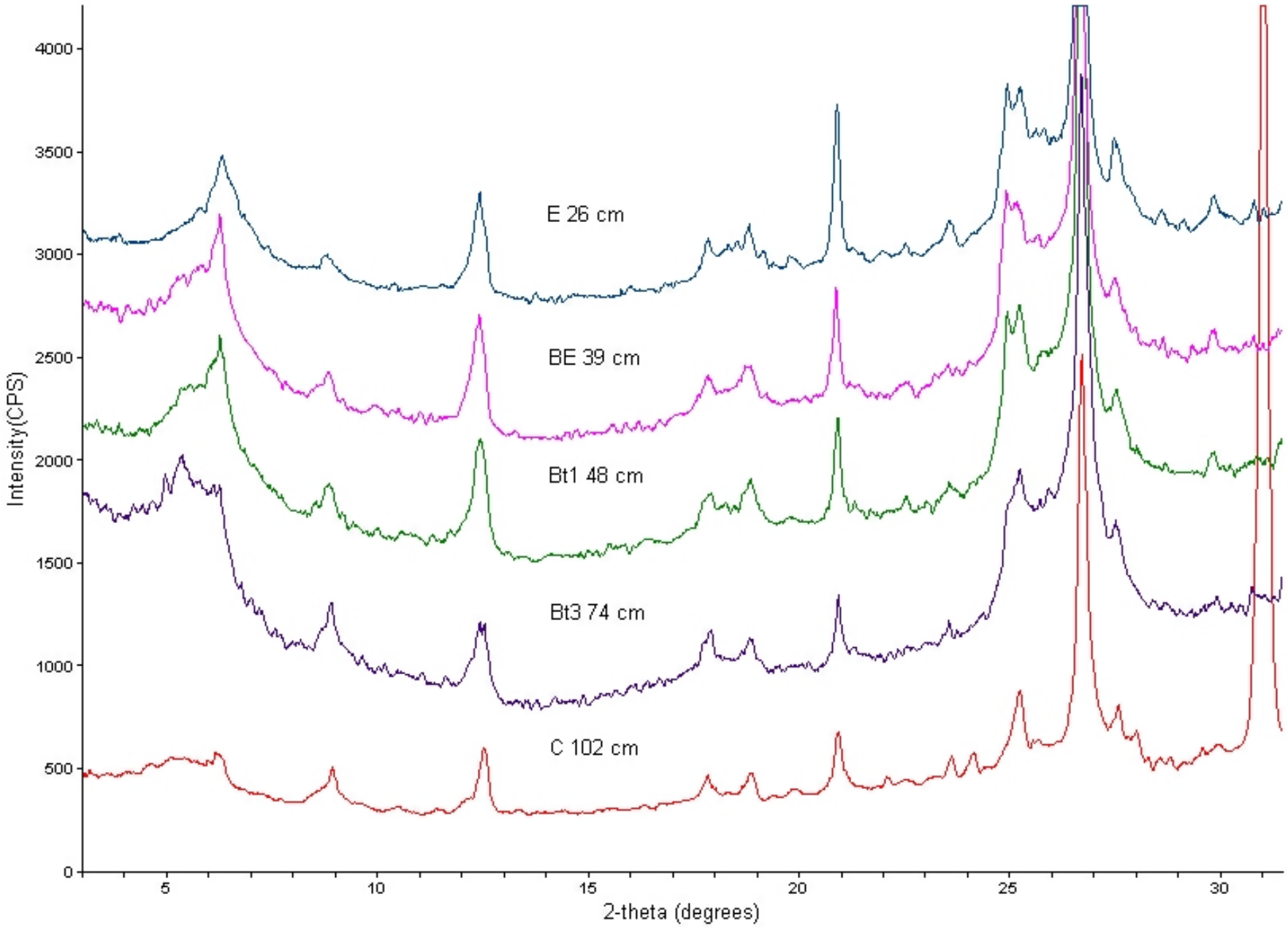


Depth of acidification increases with loess thickness.

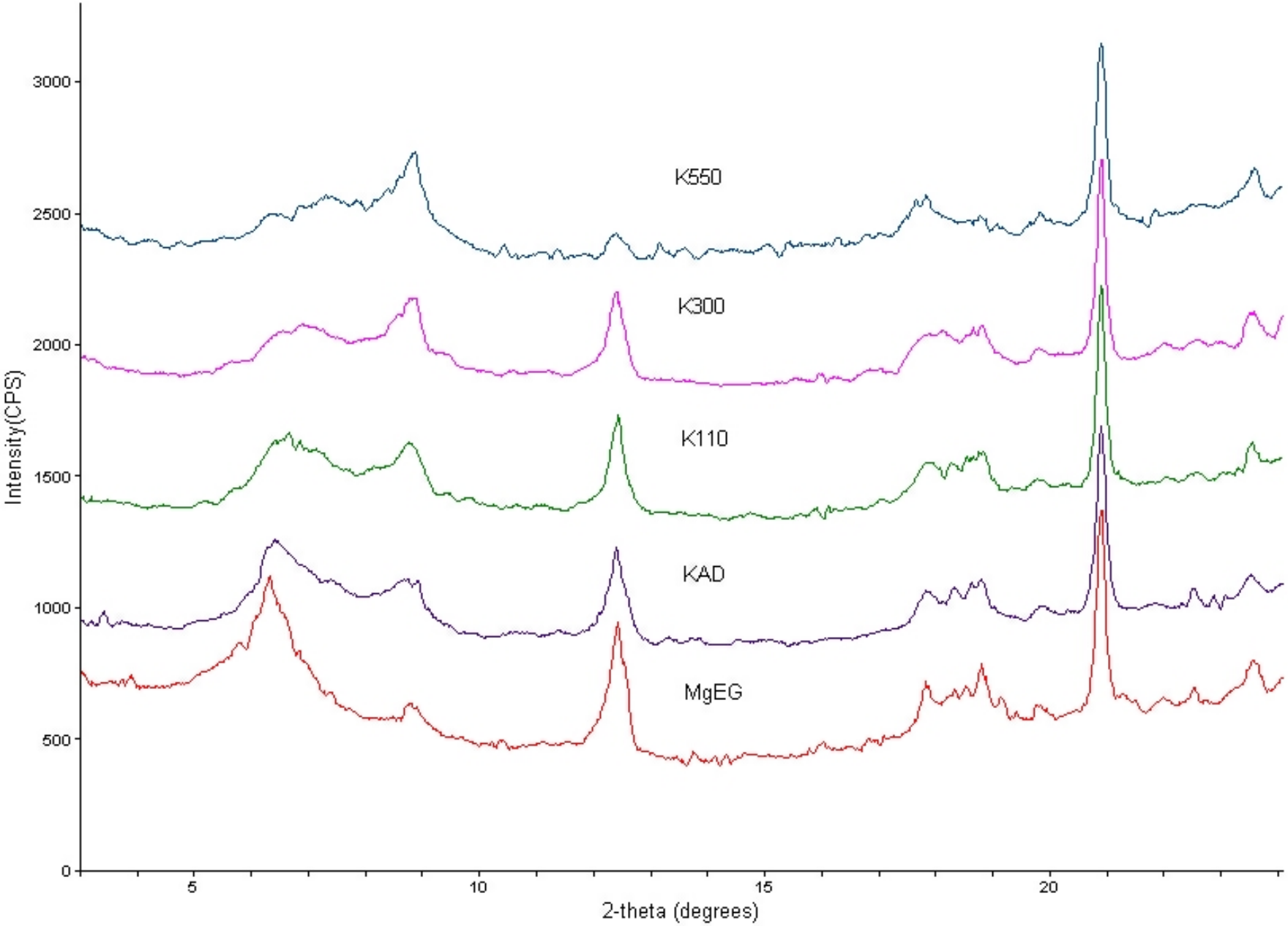


Depth distribution of Fe oxides increases with loess thickness.

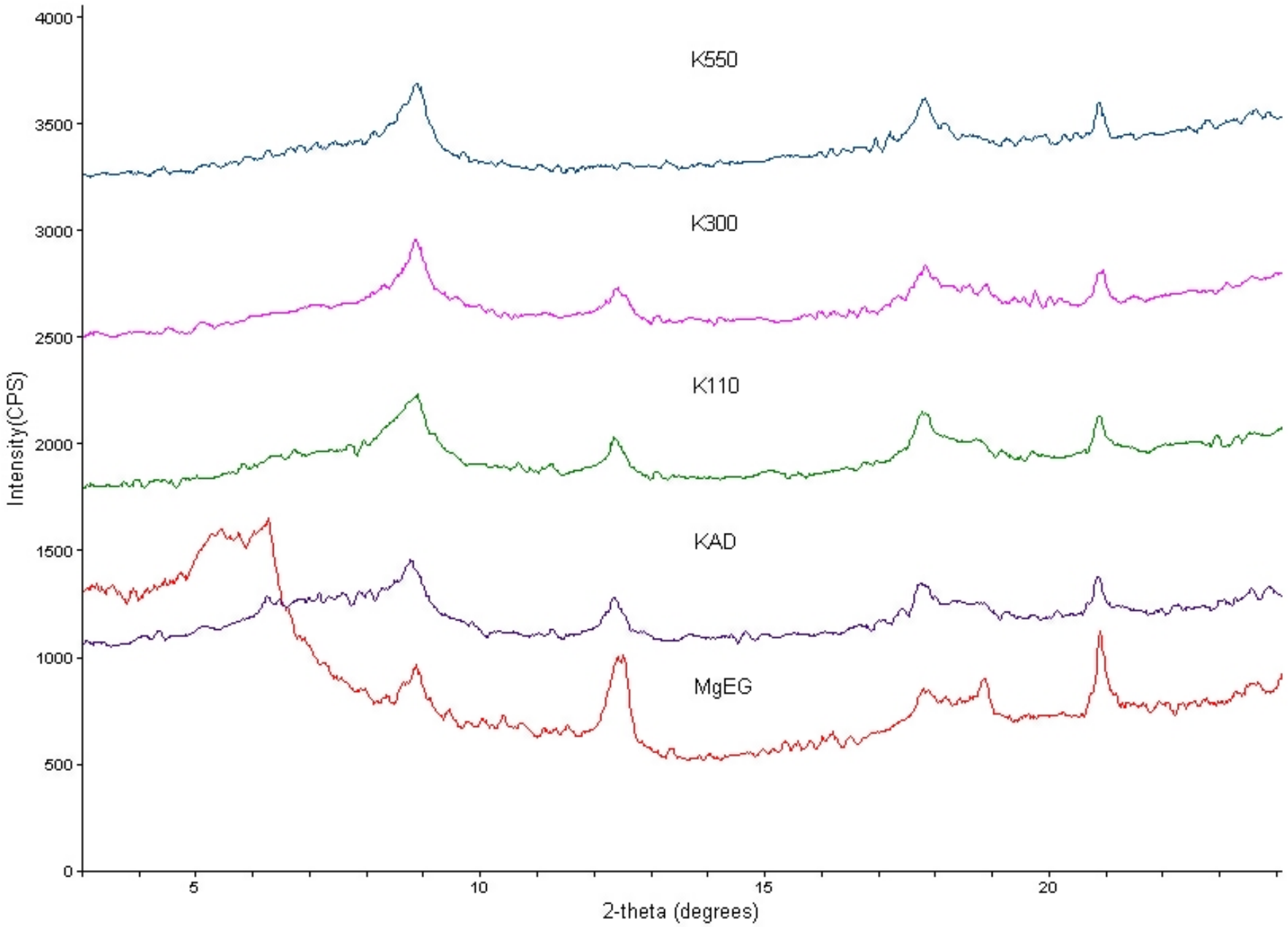
Hake Site – thin loess additions over till.

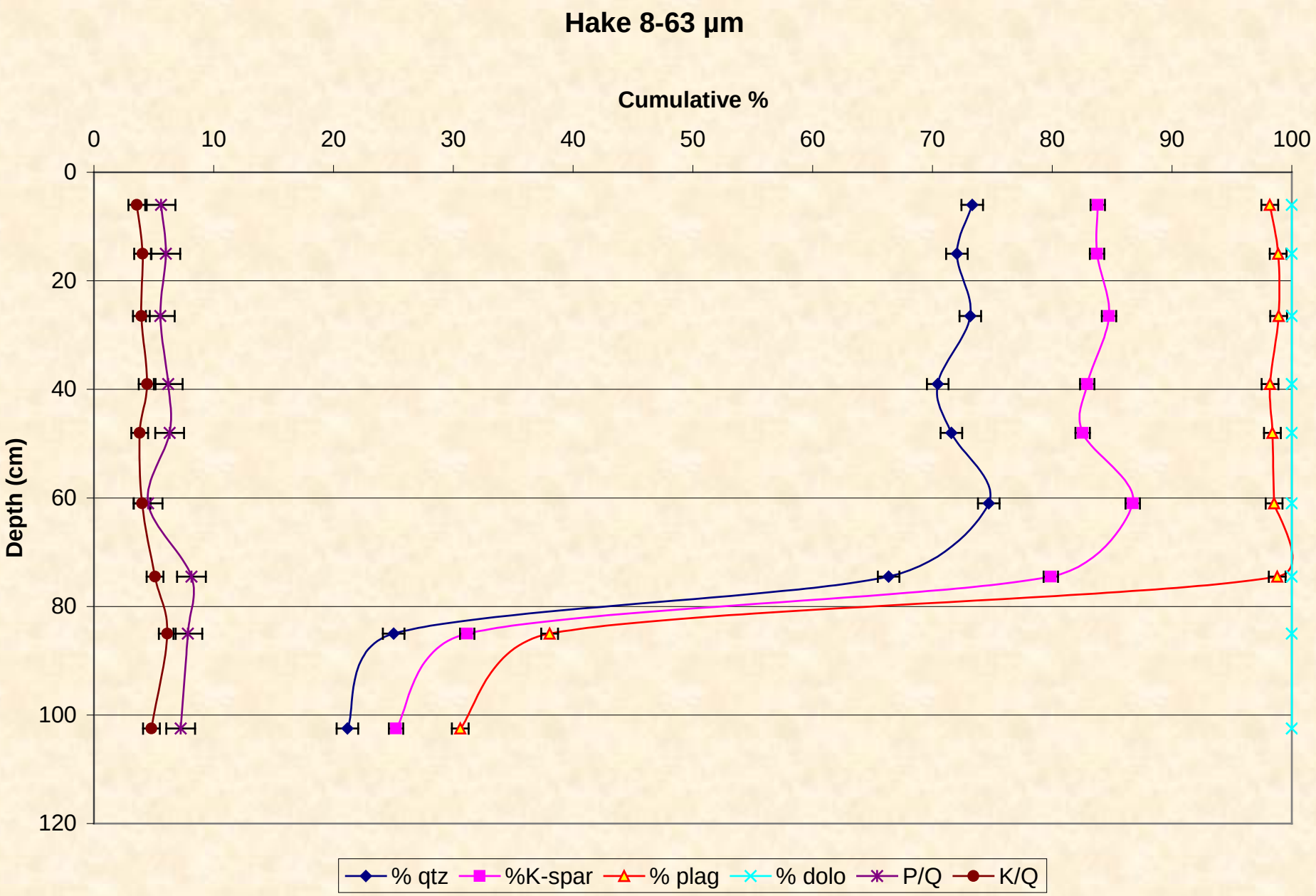


E horizon – note resistance of 1.4 nm peak to collapse with K sat. & heat.

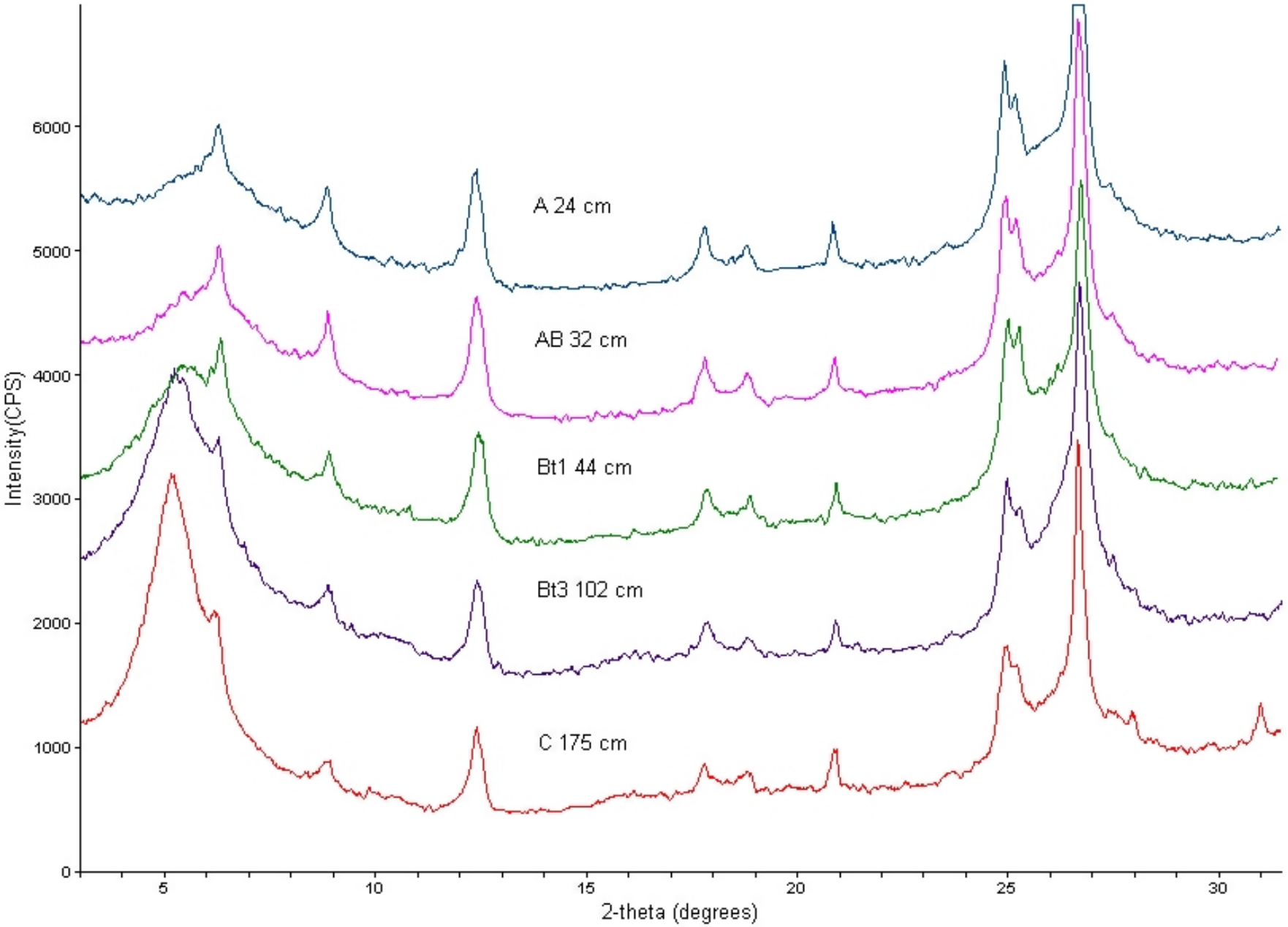


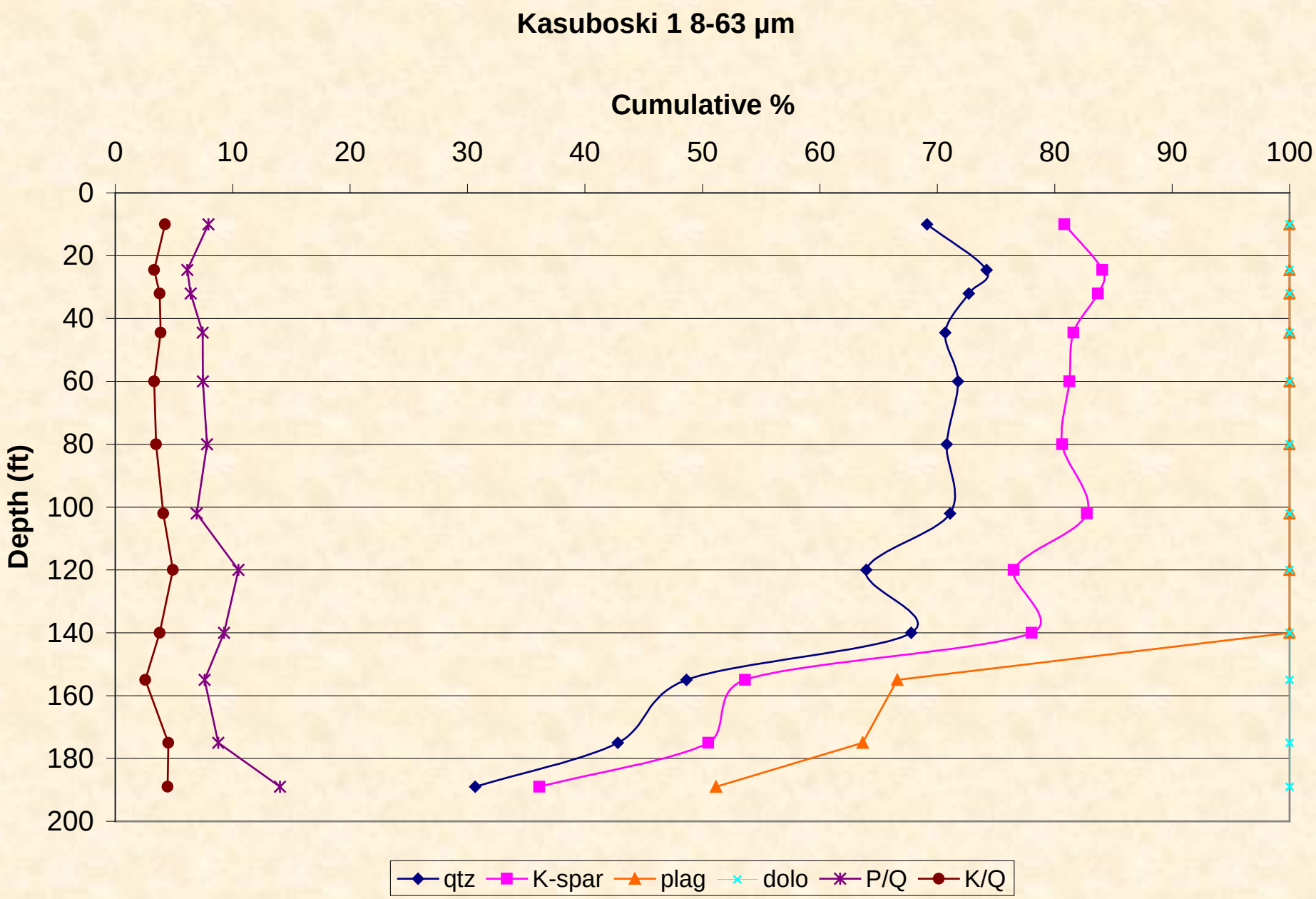
Bt2 horizon – note expansion of 1.7 nm & collapse of 1.4 nm peak




Hake 8-63 µm
Cumulative %
0
10
20
30
40
50
60
70
80
90
100
Depth (cm)
0
20
40
60
80
100
120
% qtz
%K-spar
% plag
% dolo
P/Q
K/Q

Kasuboski Site – thick loess profile.

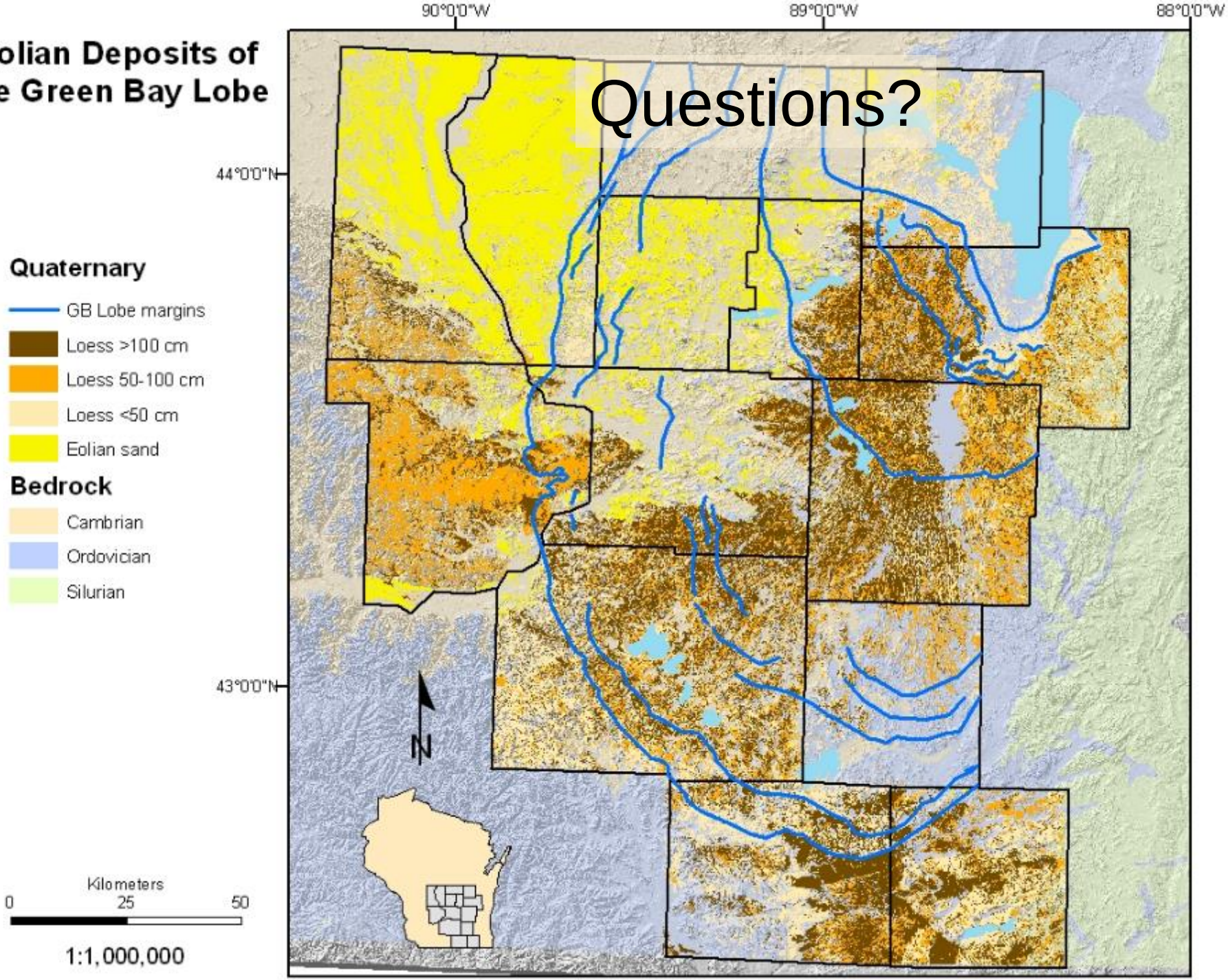



Kasuboski 1 8-63 µm
Cumulative %
0
10
20
30
40
50
60
70
80
90
100
Depth (ft)
0
20
40
60
80
100
120
140
160
180
200
qtz
K-spar
plag
dolo
P/Q
K/Q

Conclusions

- Loess on the GBL land surface is Mississippi Valley loess
  - Sandy landscapes of central lowlands acted as surface of transport
  - Loess accumulated above escarpments that prevented sand migration
- Loess redistributed downslope during deposition
  - probably under periglacial conditions
- Soil formation largely controlled by thickness of loess mantle – through surface area & soil moisture storage & flux
  - Loess affects acidification, ECEC, SOC storage

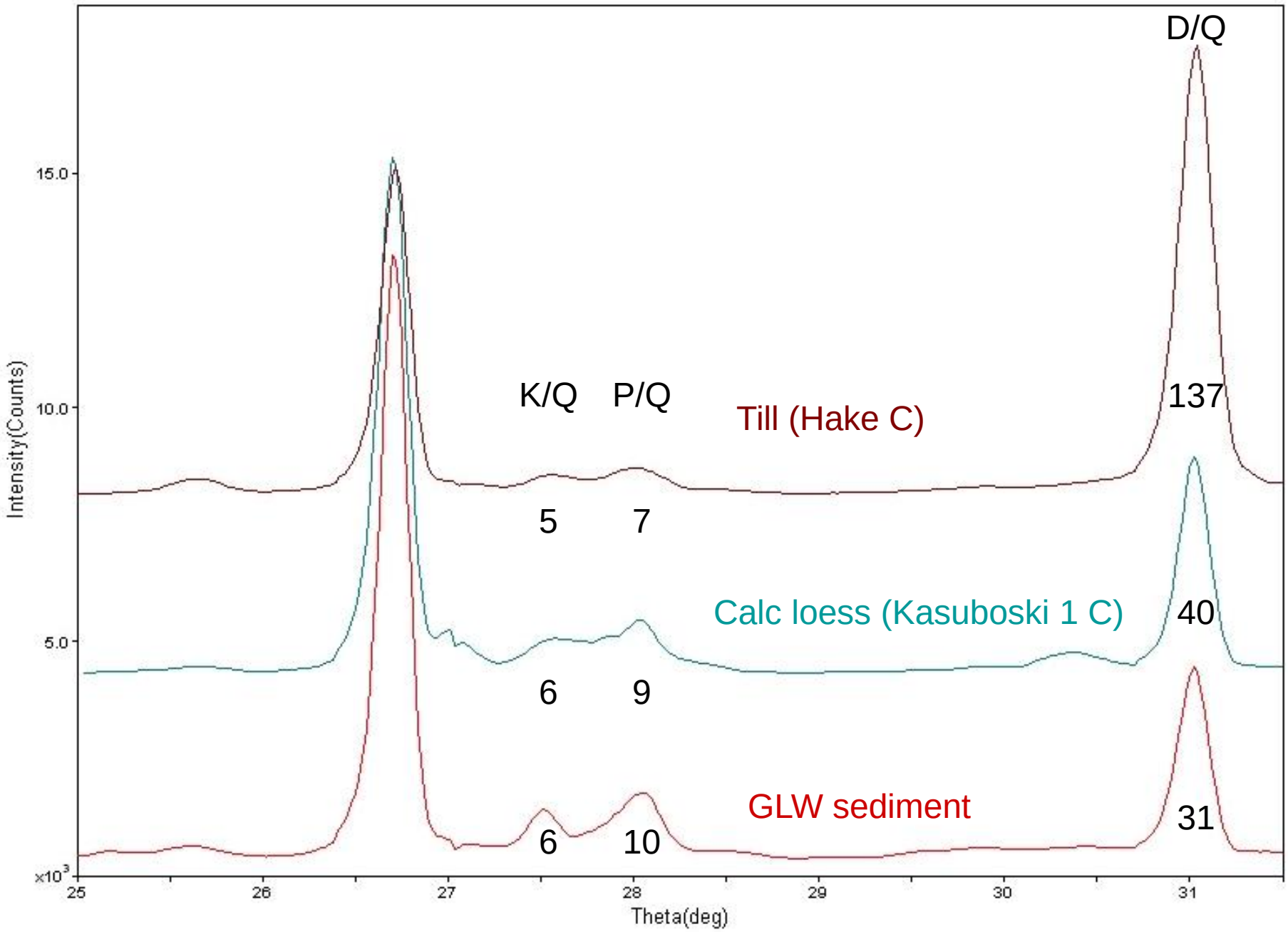
Eolian Deposits of the Green Bay Lobe



Gaumits 2

Kasuboski 1

Kasuboski 2


D/Q
K/Q
P/Q
Till (Hake C)
137
5
7
Calc loess (Kasuboski 1 C)
40
6
9
GLW sediment
31
6
10
15.0
10.0
5.0
x10^3
Intensity(Counts)
25
26
27
28
29
30
31
Theta(deg)