From Rocks to Streams:

The Geologic History of Southeastern Minnesota

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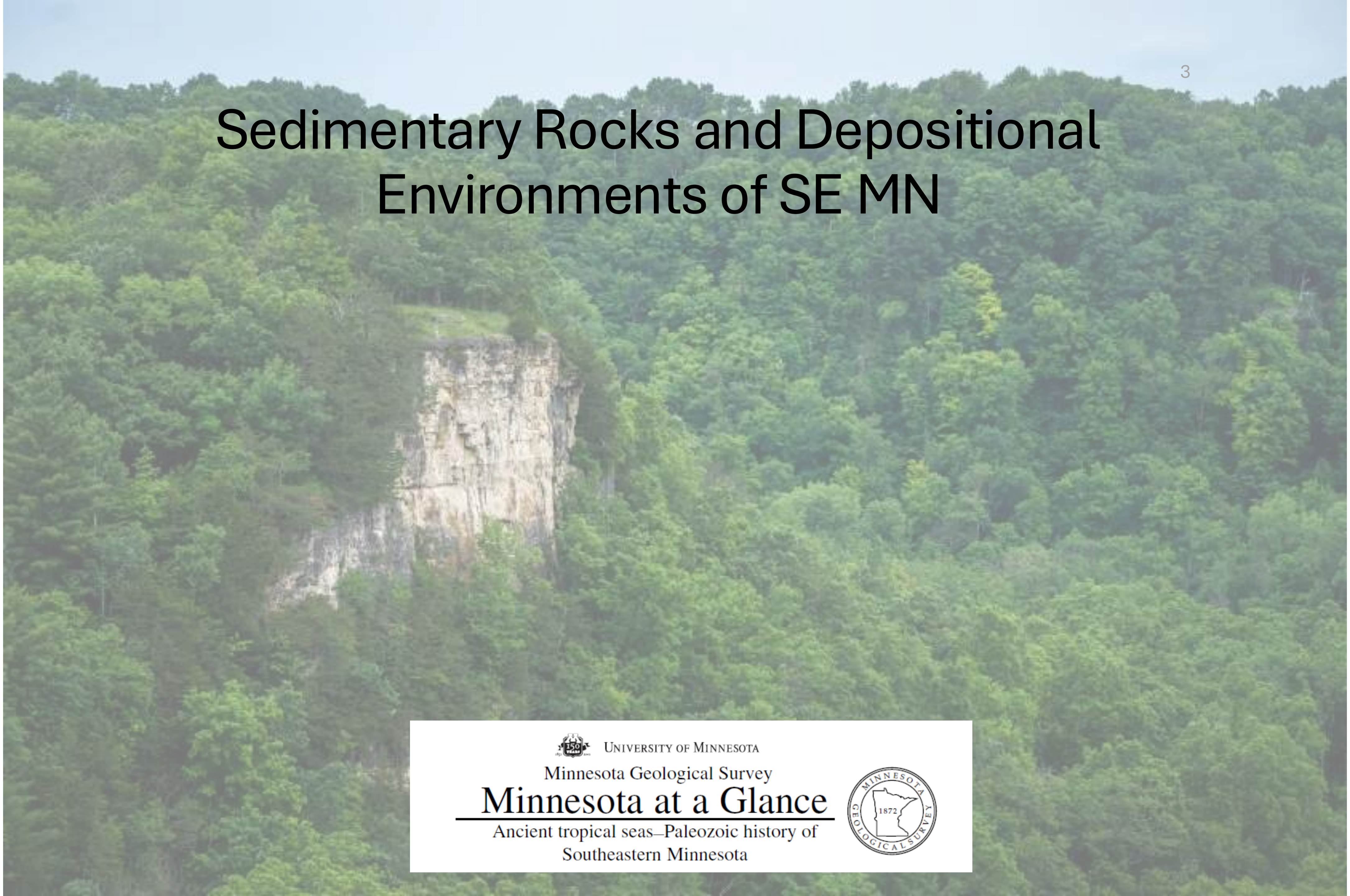
Lessard-Sams Outdoor Heritage Council Meeting
June 2026

Rocks

Karst

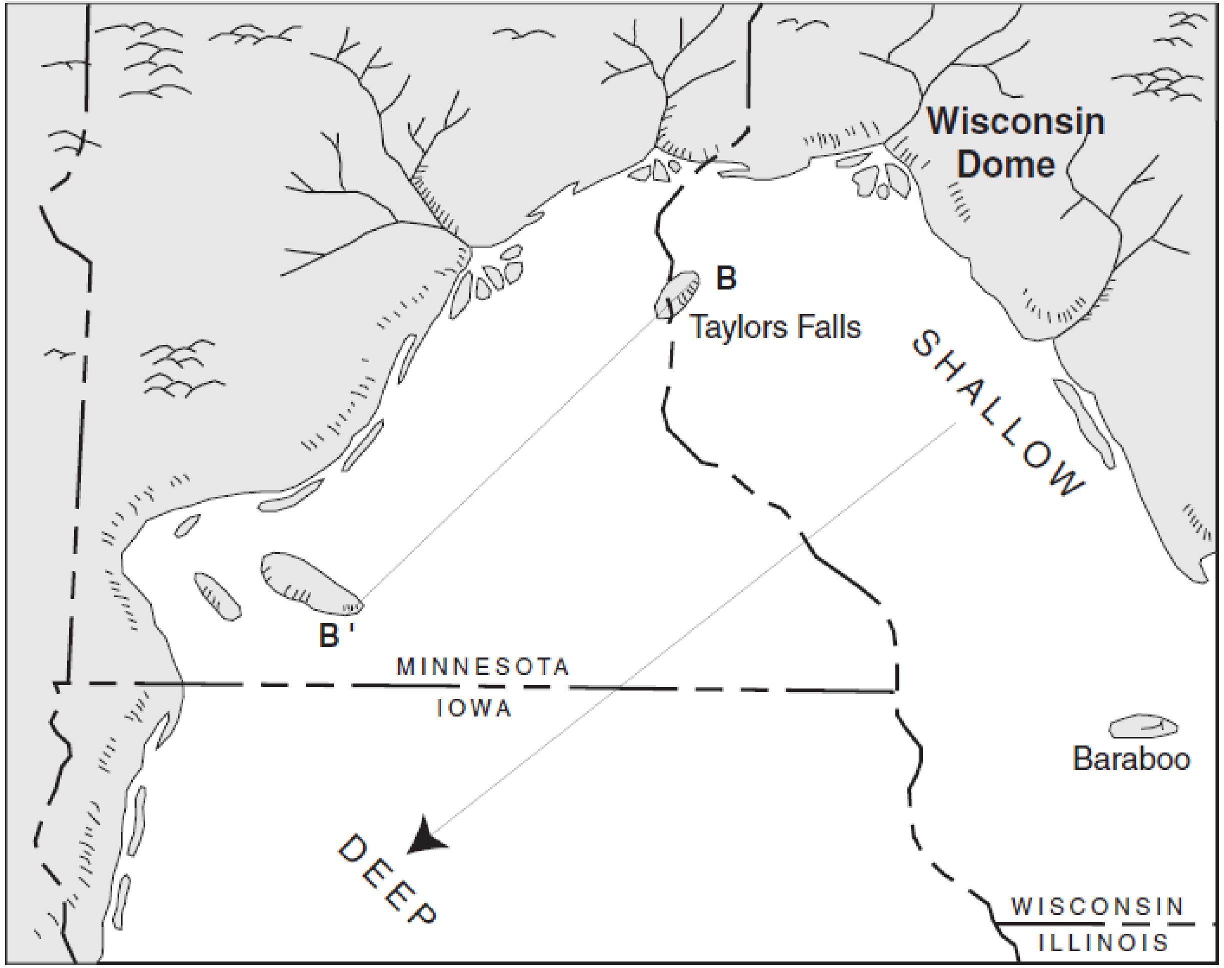
Glaciers

Sedimentary Rocks and Depositional Environments of SE MN



University of Minnesota
Minnesota Geological Survey
Minnesota at a Glance
Ancient tropical seas—Paleozoic history of Southeastern Minnesota

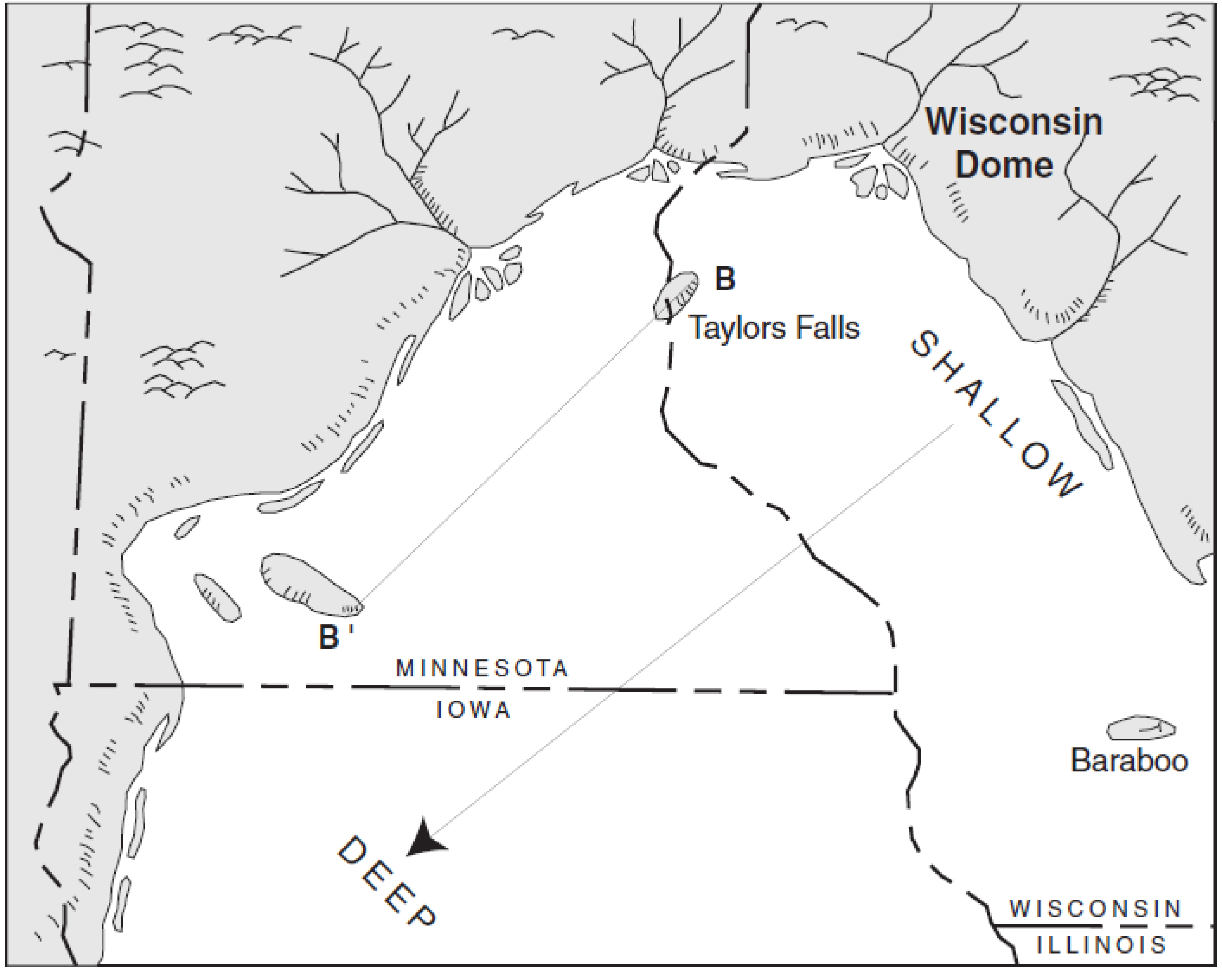
Cambrian and Ordovician periods:
MN, WI and IA were covered by a shallow tropical sea



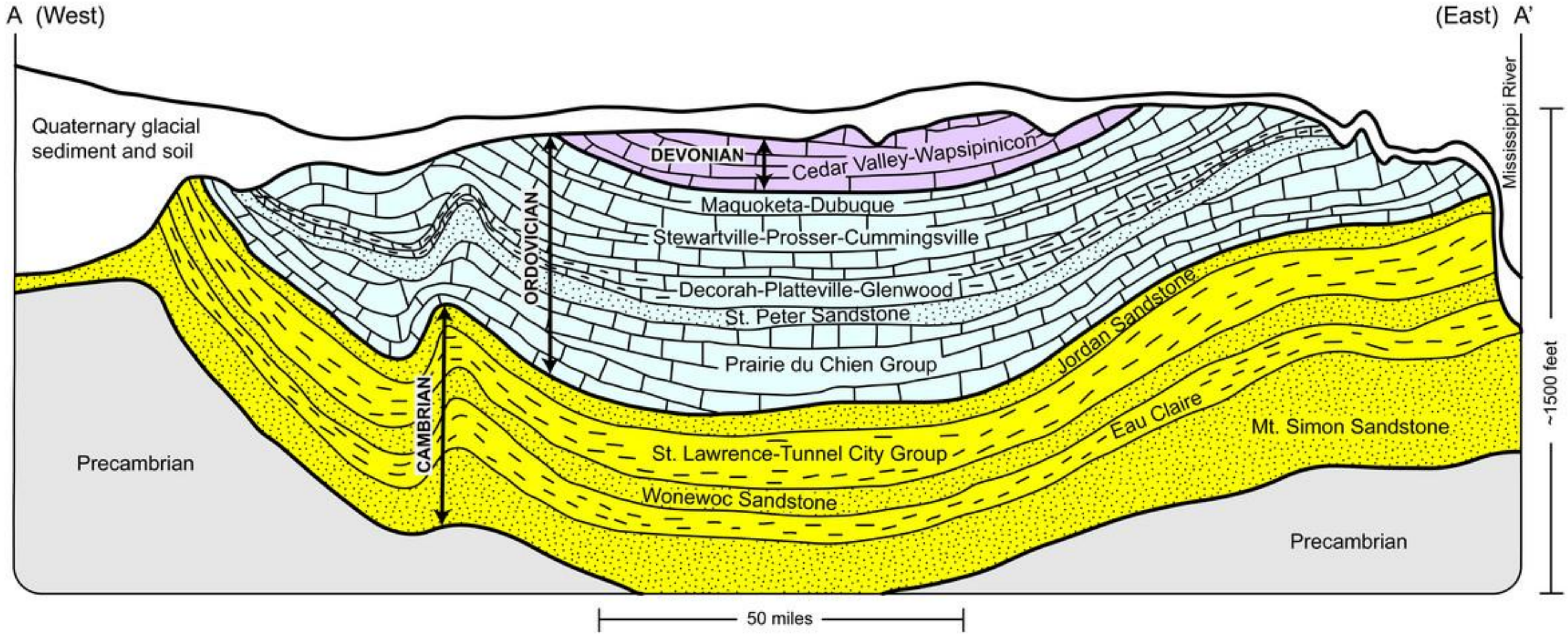
Images from Runkel, A.C., 1996, MGS Educational Series 9; Runkel and others, 1998, GSA Bulletin, v. 110 p. 188-210); Mossler, J.H., 2000, MGS Rept. of Inv. 50).

Sea level fluctuated significantly over 130 million years

Depositional environments changed…
…and so did the sedimentary rocks



Rocks of southern Minnesota were originally sediments deposited in this shallow sea

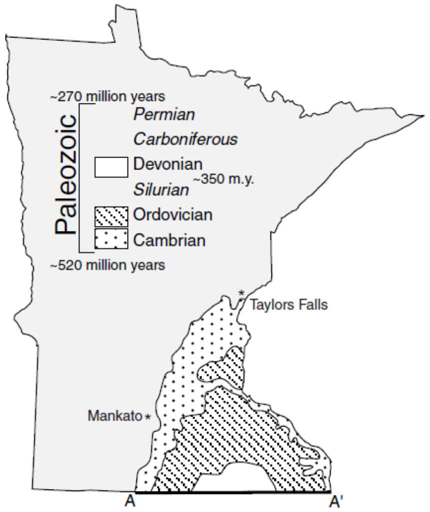


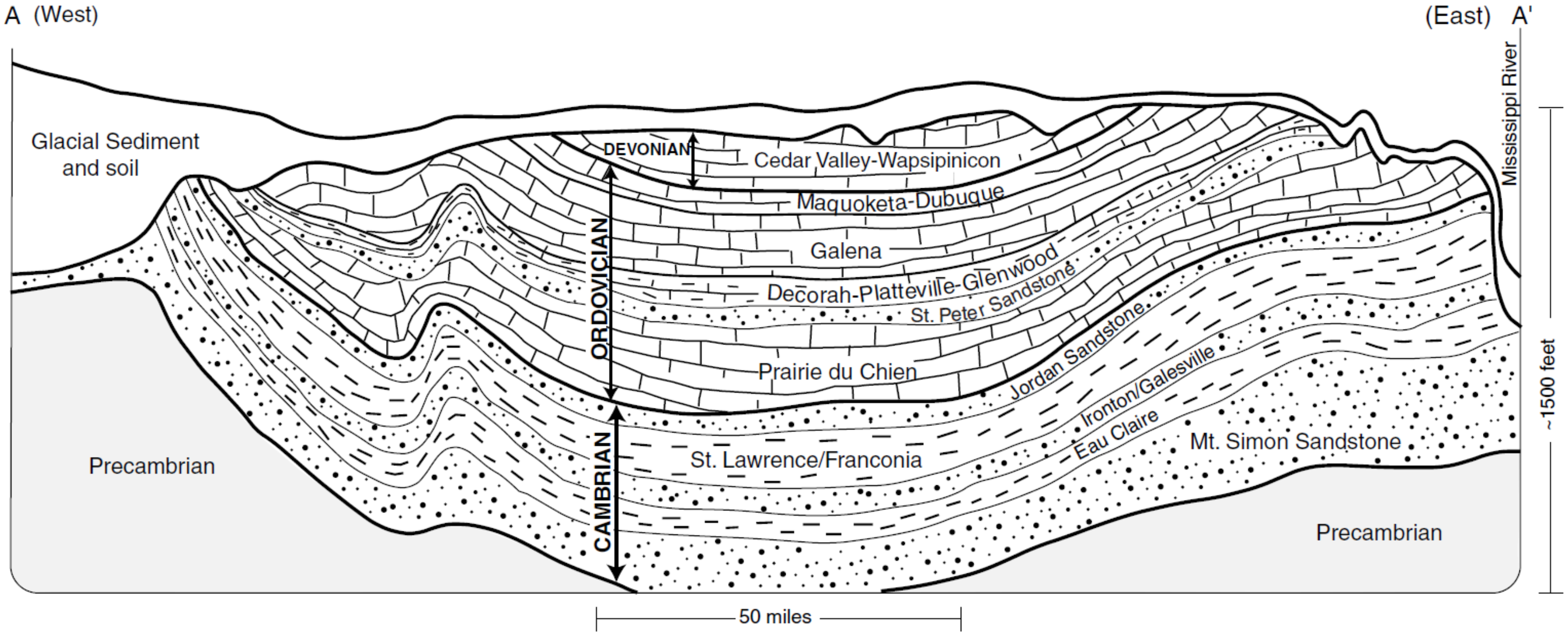
Schematic cross section of bedrock from west to east across southeastern Minnesota. The bedrock consists of sedimentary rock layers composed of sandstone, shale, and carbonate rocks such as limestone (modified from Runkel, 2020, fig. 2).

Up to 1500 feet thick (0.28 miles)

Deposited over 130 million years (starting ~500Ma)

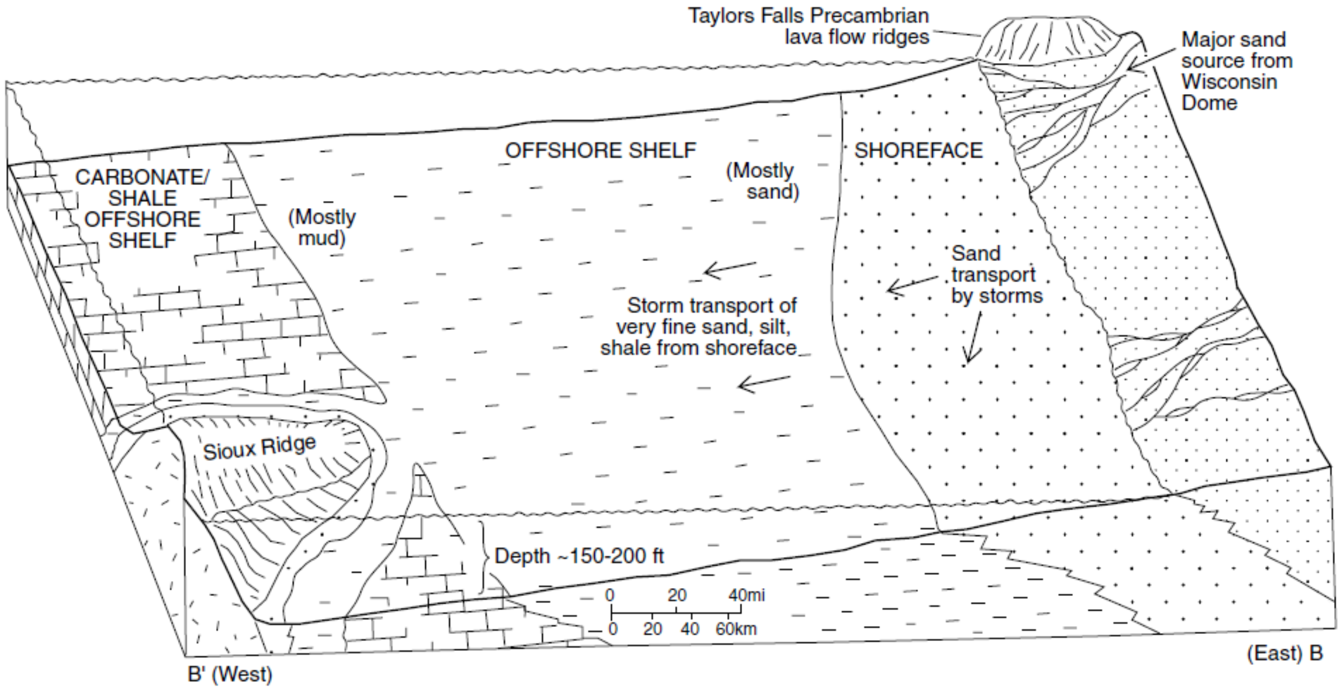
Periods: Cambrian – Ordovician - Devonian



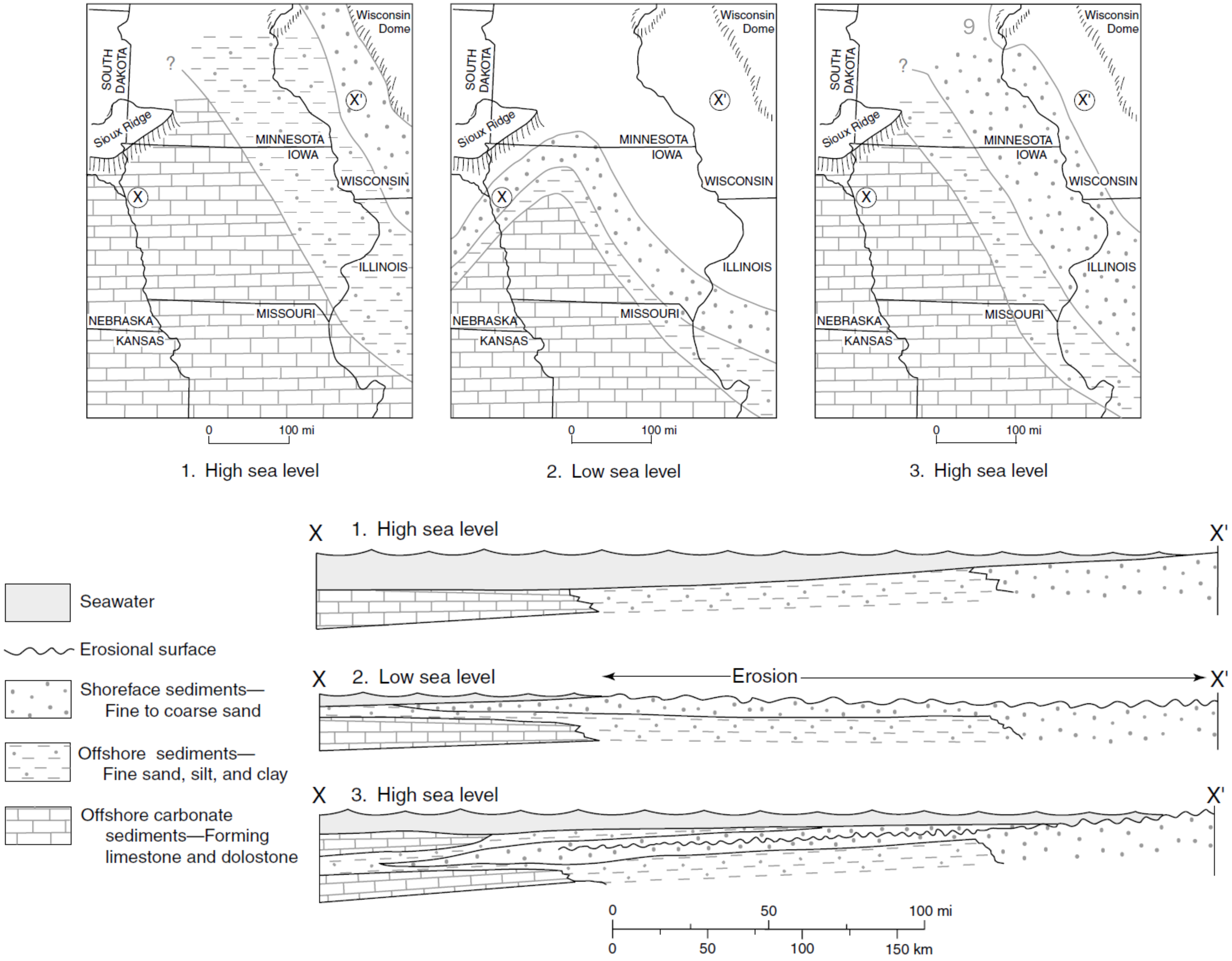


Cambrian - Ordovician

- Barren landscape
  - No plants to hold sediment in place on land
- Resulted in a texturally graded shelf
  - Sandy near beaches and graded to fine-grained deposits in deep water

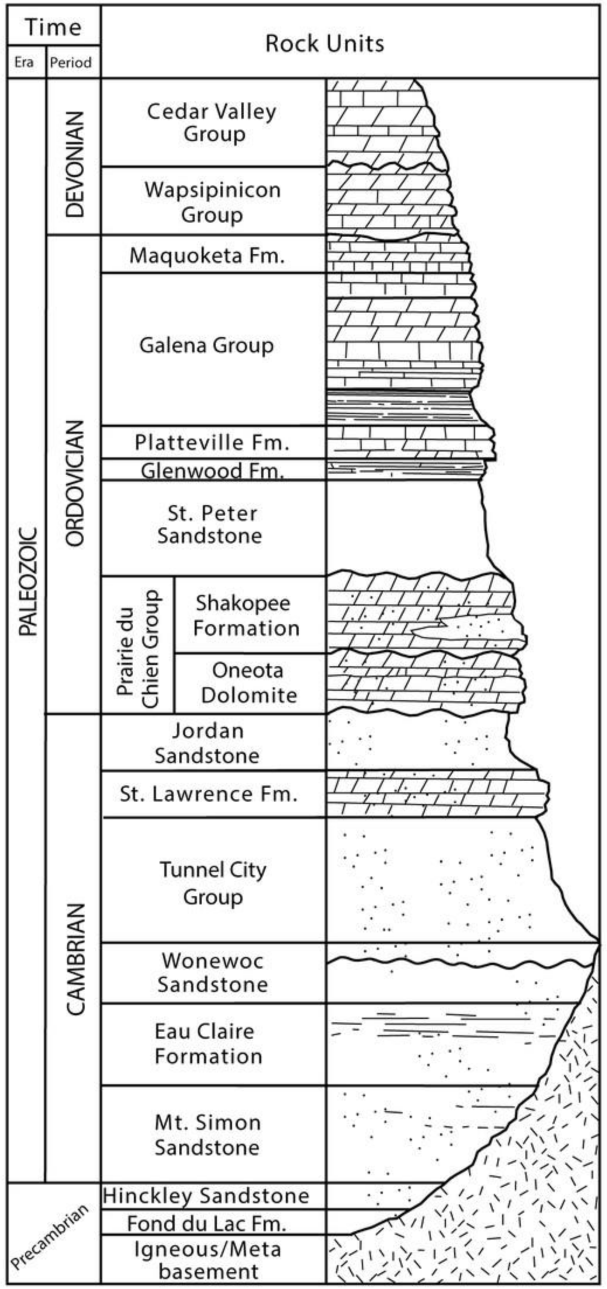


Changes in Sea Level moved the sandy shoreface back and forth



SE MN Paleozoic Rocks

- Transition between sandstone (shallow) and limestones (deep)
- Indicates changes in sea level through time

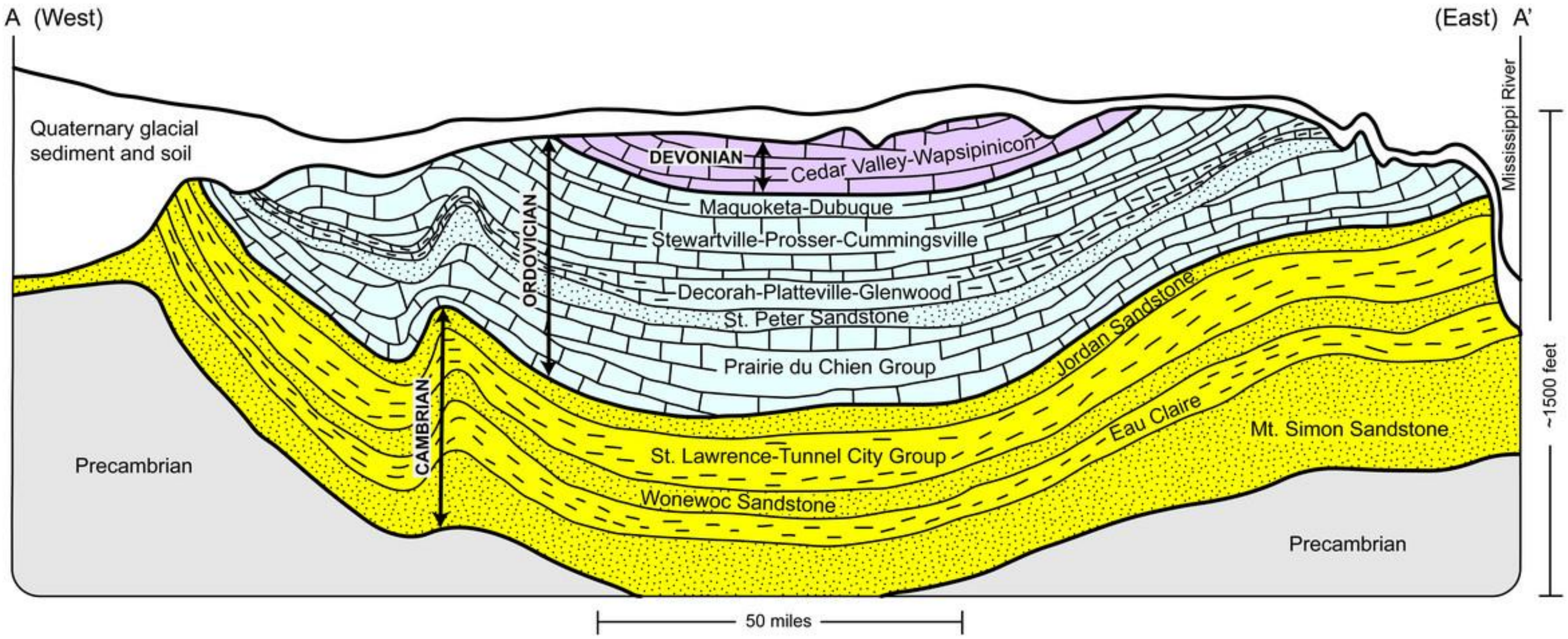


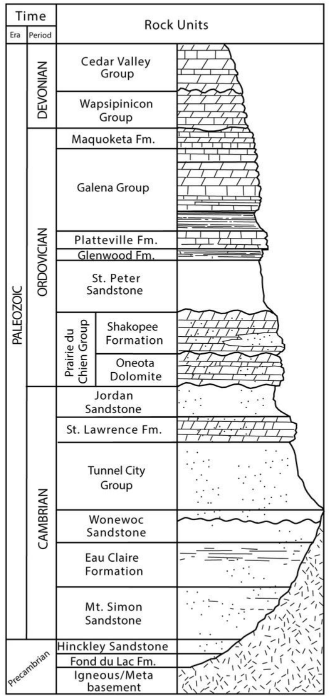
Great Ordovician Biodiversification Event

-Hundreds of new genera appeared

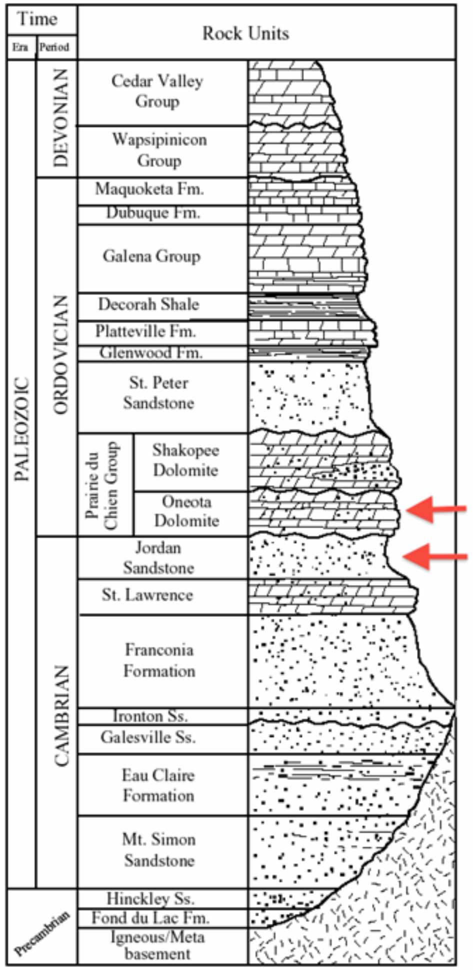
Late Ordovician - Devonian

- Plants evolve and thrive
  - Interior seaway is starved of sediment
- Resulted in calcareous sediment in basin
  - Capped graded sediments with thick sequence of limestones and dolostones





Limestone/Dolostone cap is what creates large bluff faces in SE MN

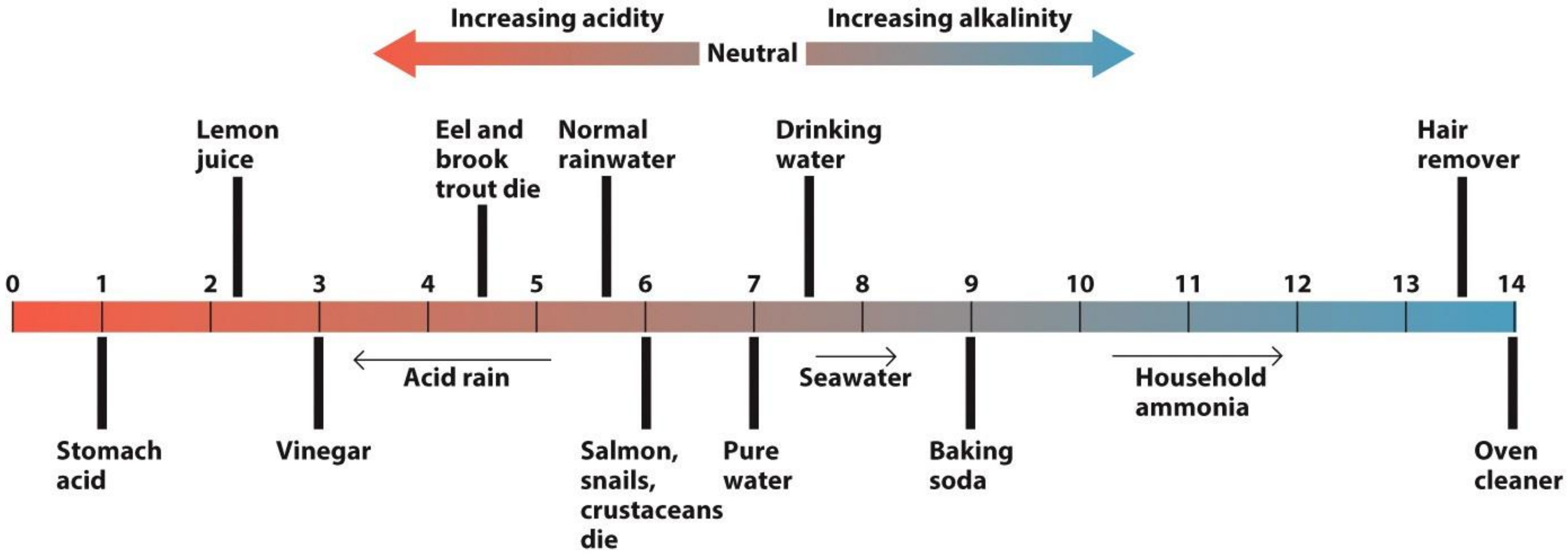


Karst Landscape

Škocjan Caves Park, Slovenia

Chemical Weathering

- exposure to acid and/or oxygen
  - rainwater is slightly acidic



Chemical Weathering

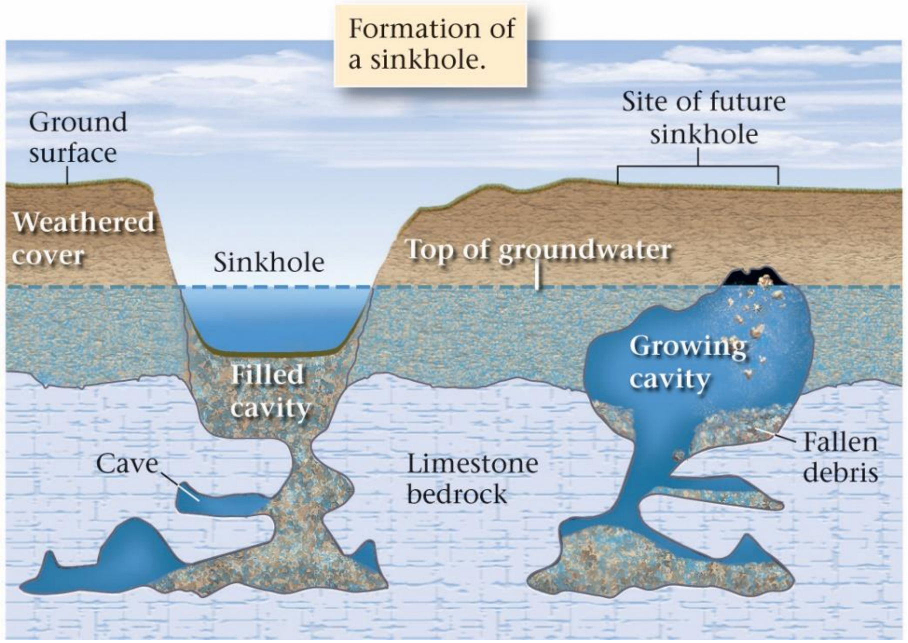
- Chemical weathering on granite (left) vs. limestone (right)
  - Limestone/marble is more soluble - more easily dissolved by acids
  - Granite is less soluble - resistant to chemical weathering

Caves & Karst

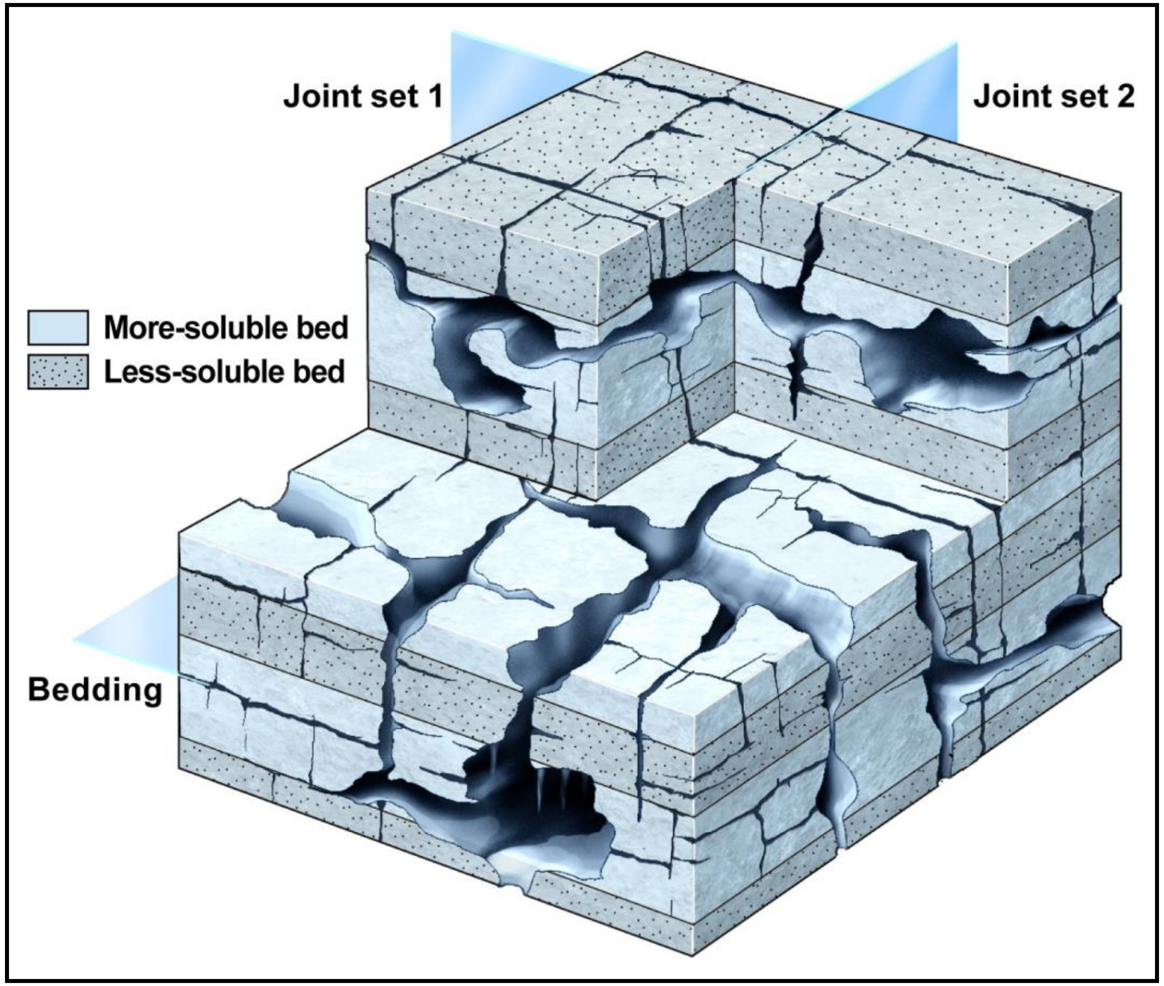
- Caves form when groundwater (GW) dissolves rock
  - usually Limestone
- GW is weakly acidic
  - CO_2 in air and soils reacts with water to form carbonic acid.

$$H_2O + CO_2 \rightarrow H_2CO_3$$

  - Carbonic acid interacts with limestone to dissolve the rock.

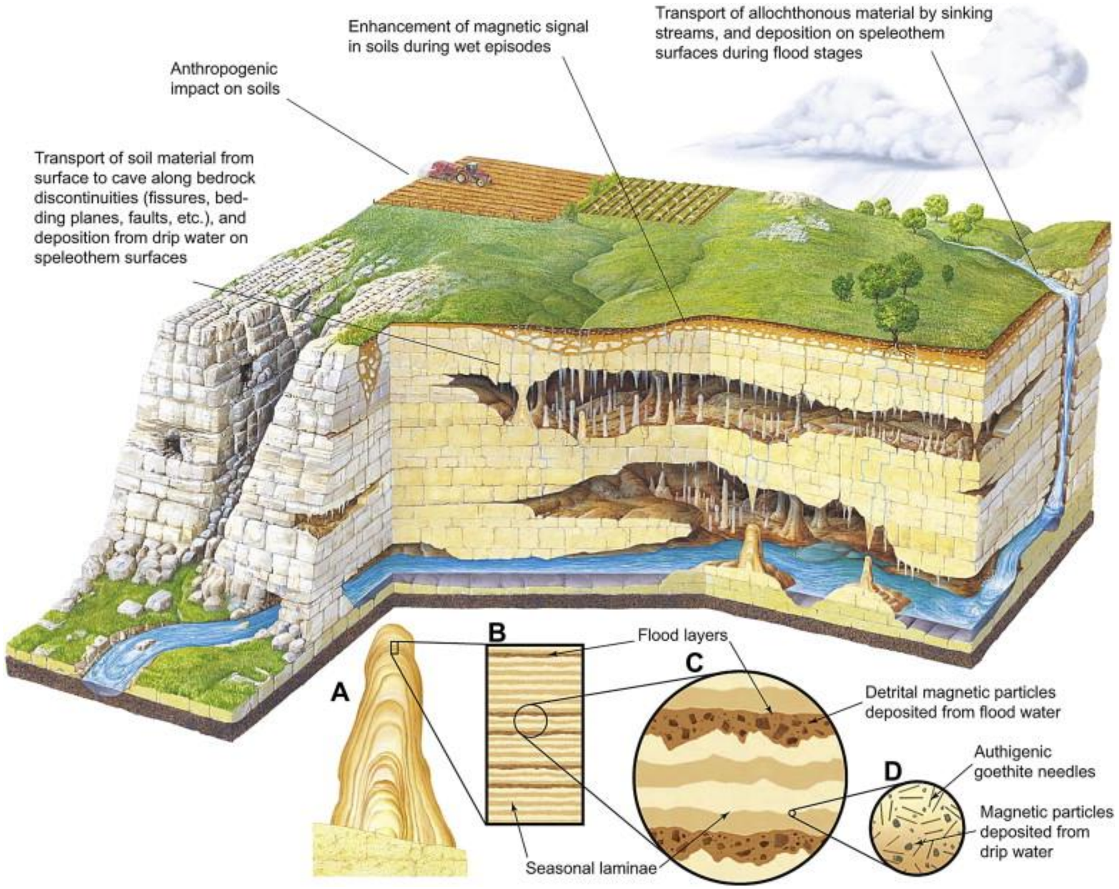


- Cave networks develop. Need to have:
  - Limestone bedrock
  - Abundant freshwater
- Caves grow as cracks are enhanced by dissolution
  - Changes in rock layers and characteristics influence dissolution.



Formation of karst landscapes

- Limestone dissolution creates unique karst landscapes.
- Karst landforms are evidence of dissolution:
  - Disappearing streams
  - Natural bridges
  - Caves
  - Speleothems
  - Sinkholes
  - Springs
- Karst creates irregular terrain



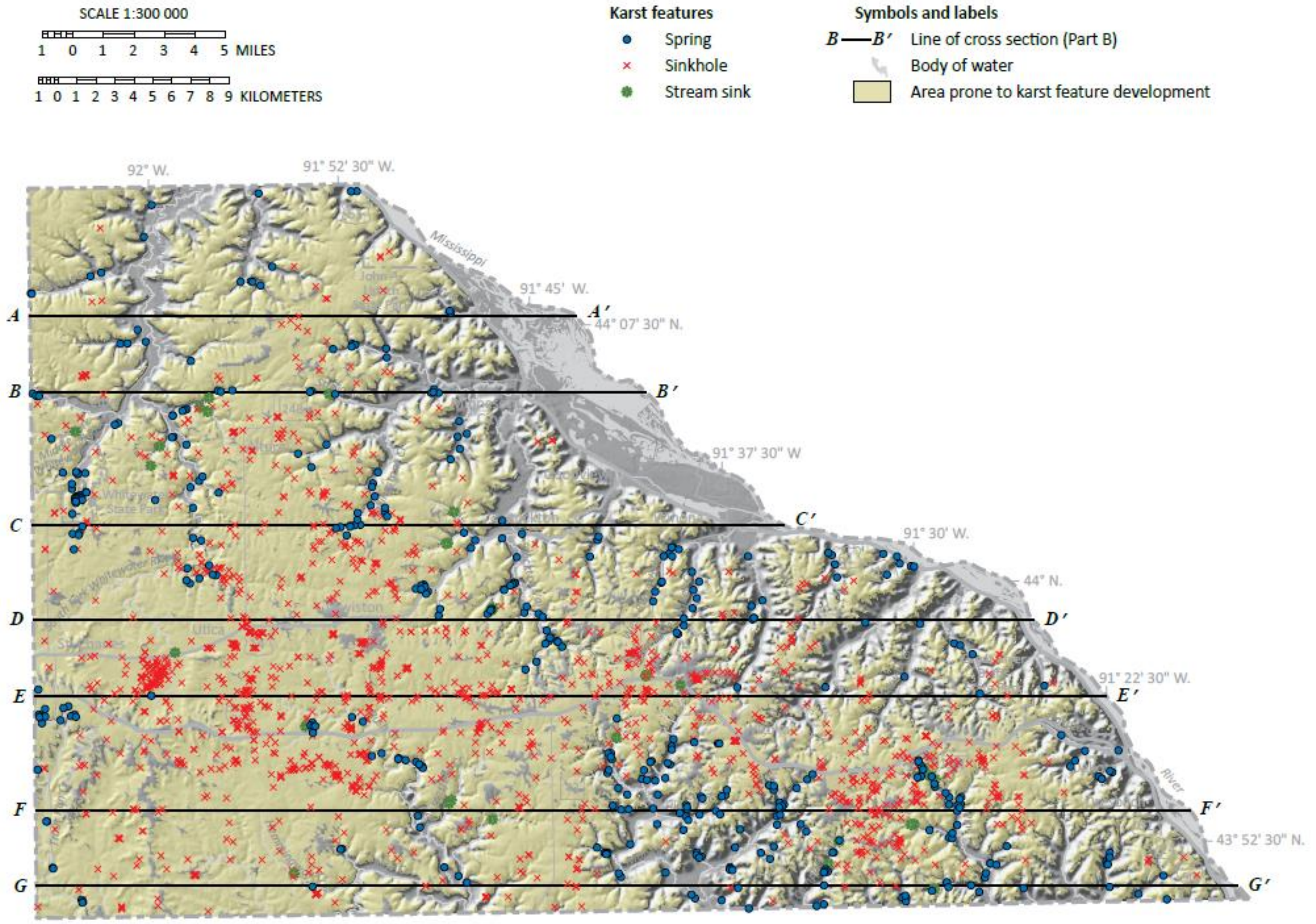
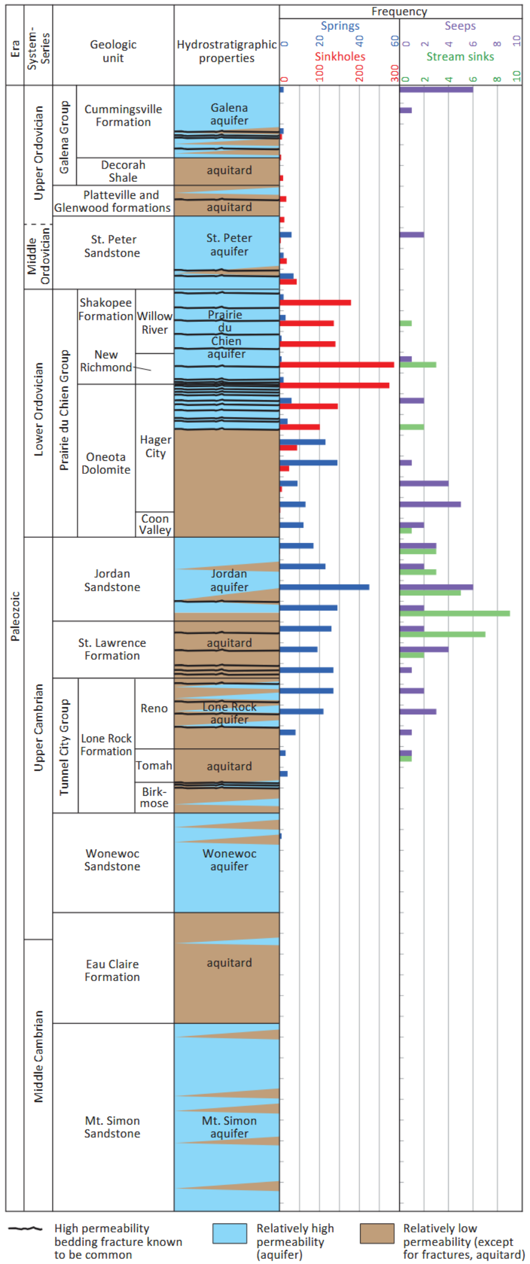
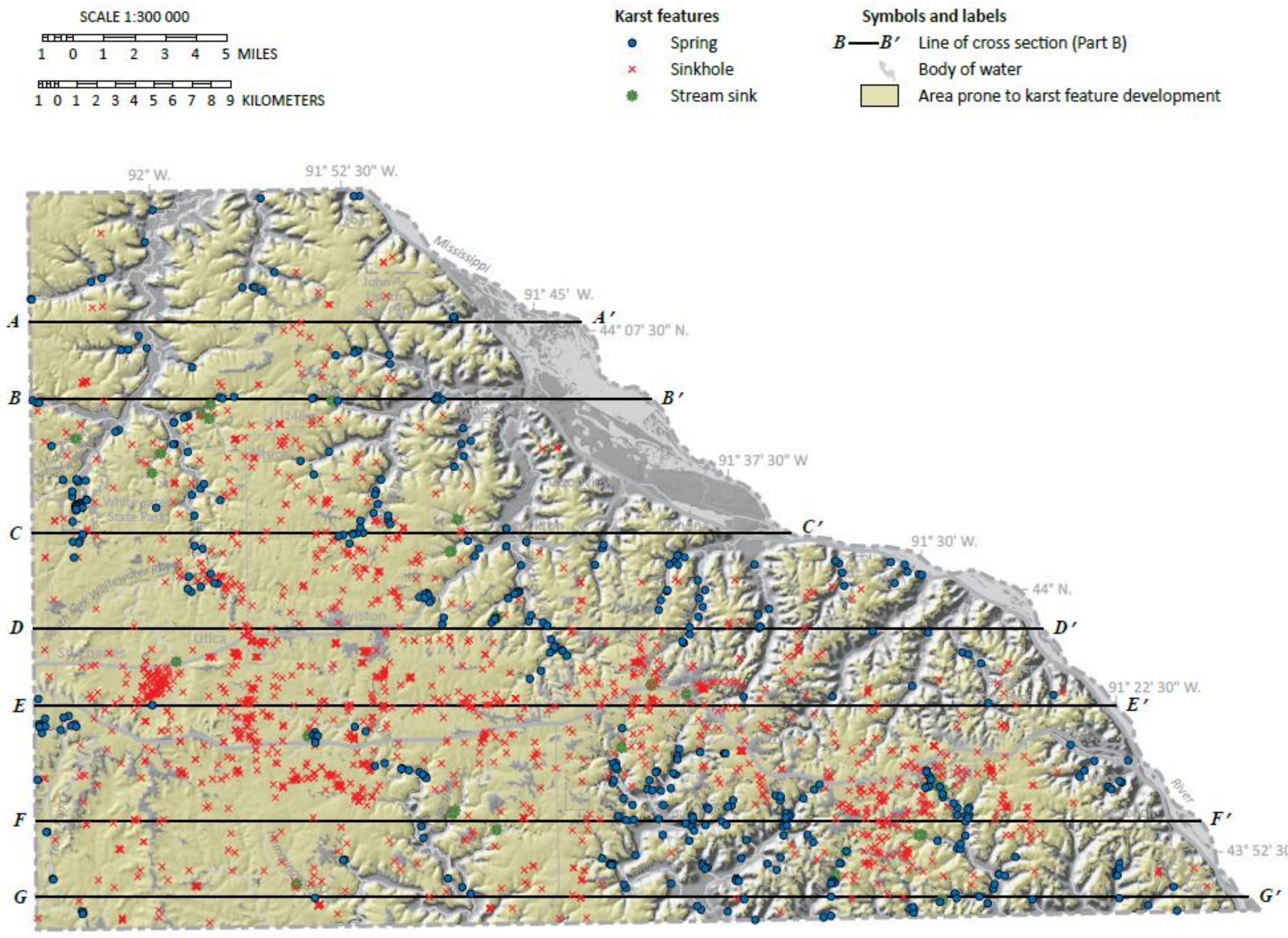


Figure 4. Area prone to karst feature development and distribution of karst features

The area prone to karst feature development is shown draped on a hillshade model of county landform. The area delineated as karst prone was created by identifying regions underlain by carbonate bedrock with less than 50 feet of sediment as described in DNR, 2016b. The majority of the county that is prone to karst feature development occurs in upland areas. Sinkholes primarily occur on the plateaus; springs and stream sinks occur within valleys. Sinkholes and stream sink locations are from the *Karst Feature Inventory Points* (University of Minnesota, 2020). Spring locations are from the *Minnesota Spring Inventory* (DNR, 2020b).





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Report: Groundwater Atlas of Winona County, Minnesota, County Atlas Series C-34, Part B (John Barry, 2021)

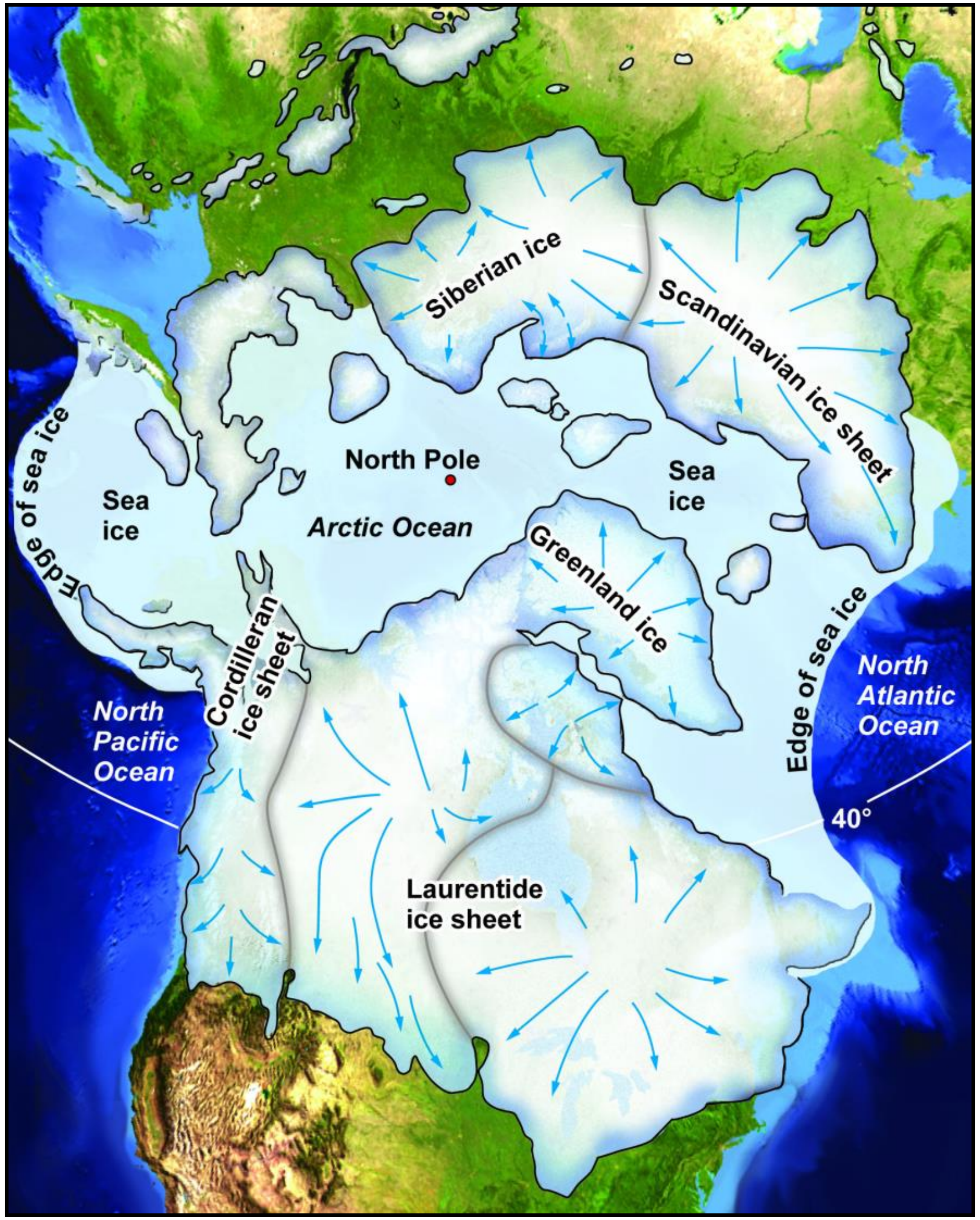
Forestville/Mystery Cave State Park
Preston, MN

Niagara Cave
Harmony, MN

Minnesota Glaciation

Glaciers and Ice Ages

- Glaciers
  - Thick masses of ice
    - Last all year long
    - Flow via gravity
  - Glacial coverage of Earth
    - Present: ~10%
    - During ice ages: ~30%



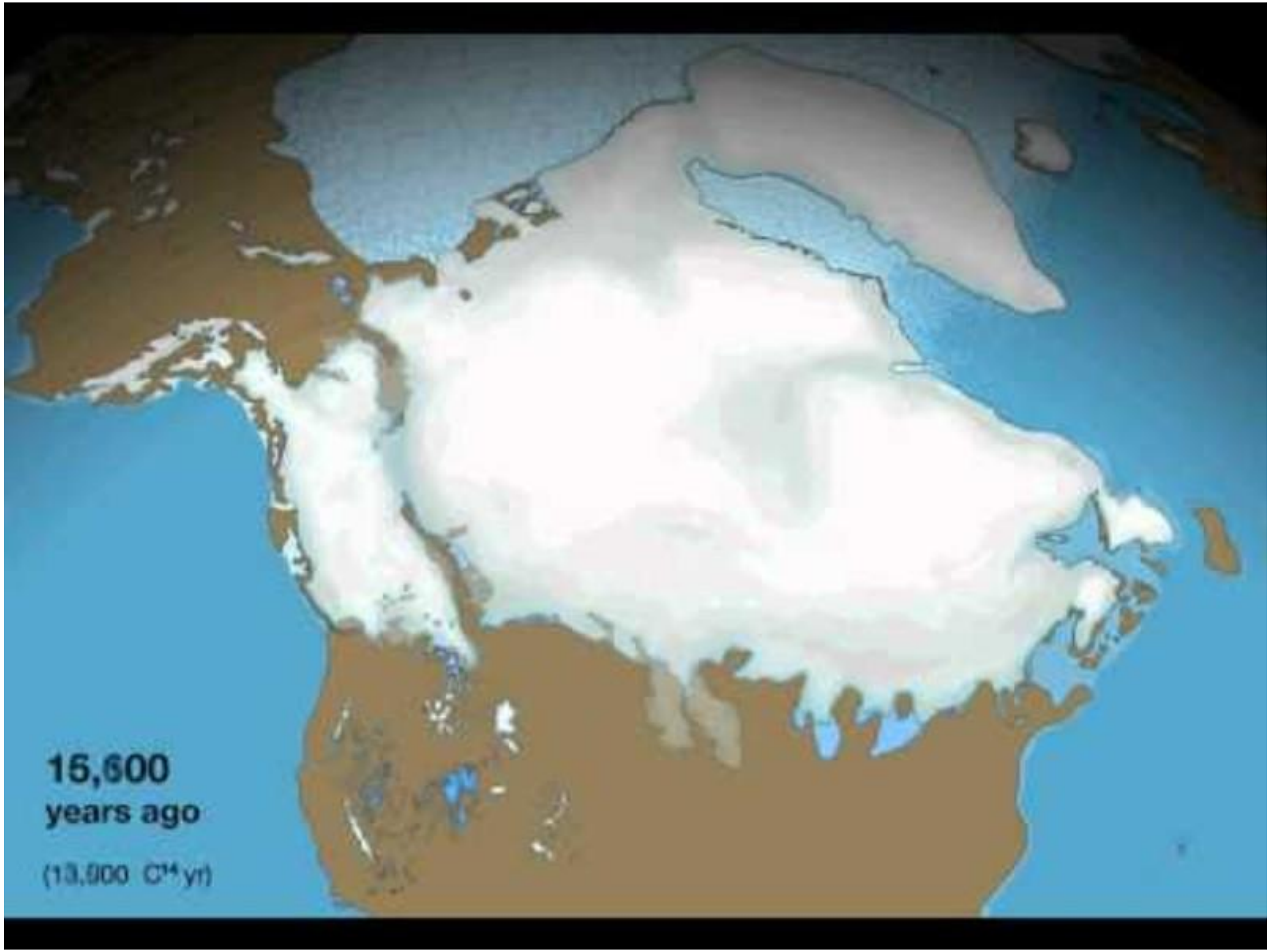
Glaciers and Ice Ages

- Most recent ice age ended ~11 ka
- Ice sheets were thousands of feet thick

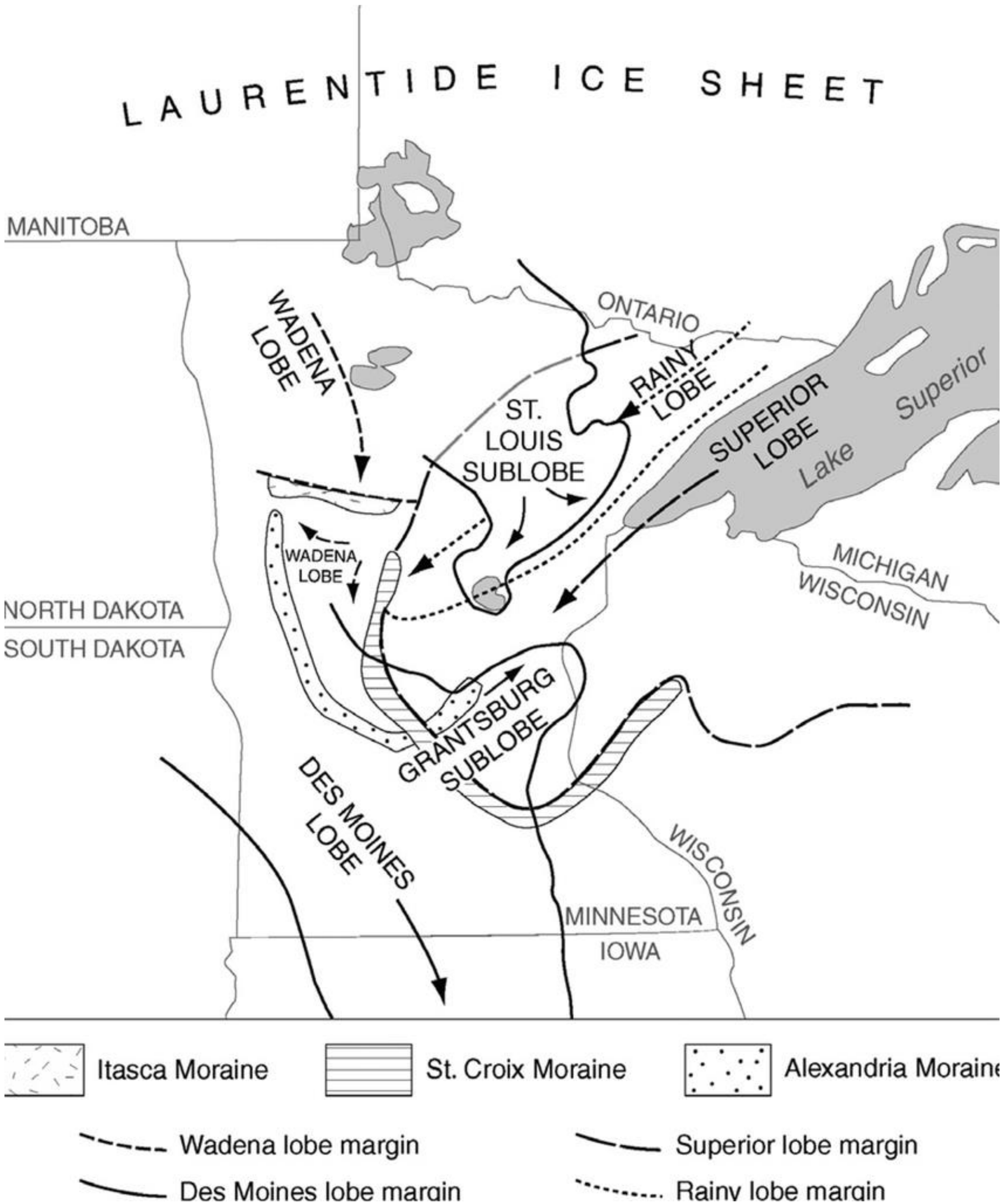
Maximum extent of Laurentide ice sheet: 14,000 Years Ago

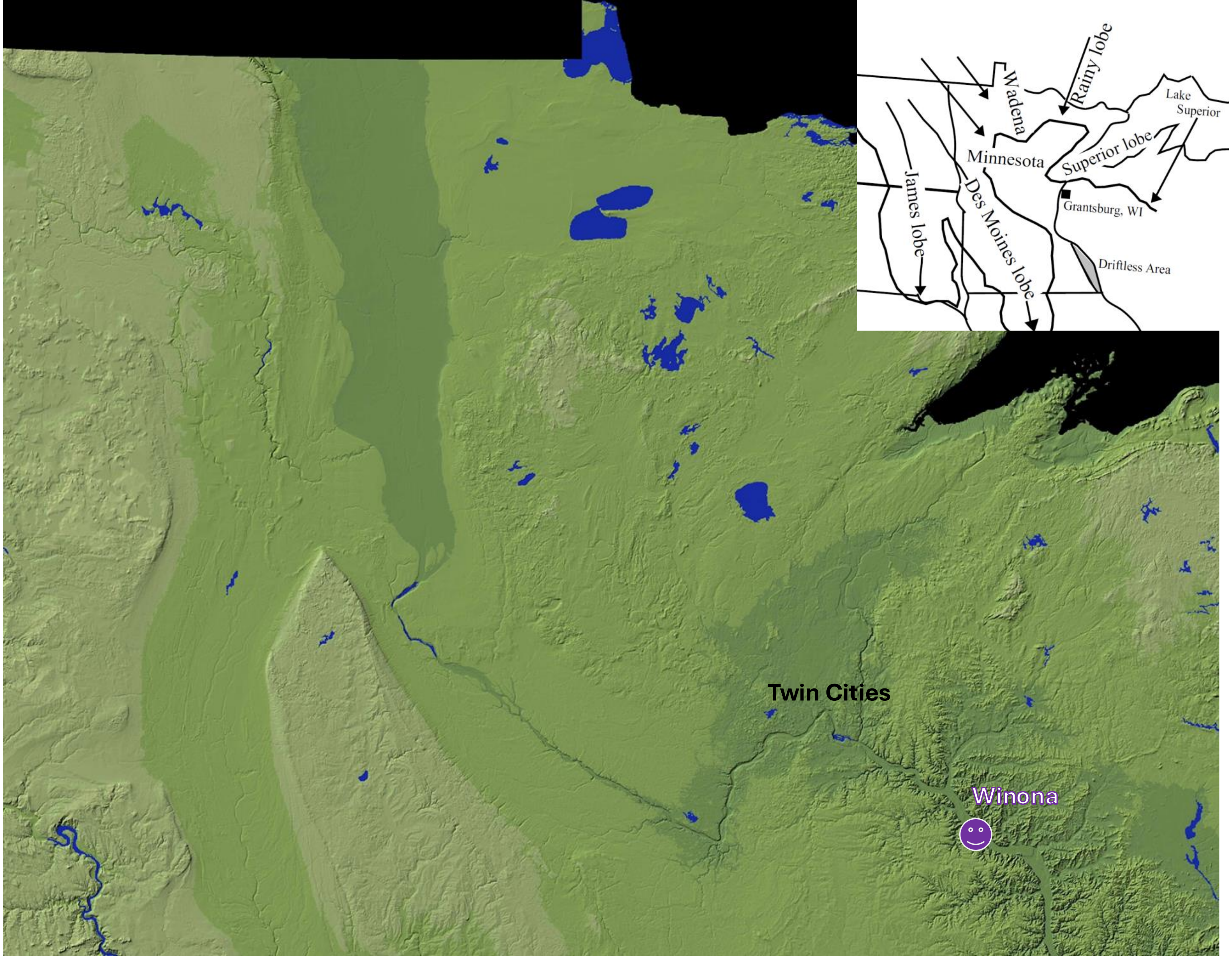
Ice Thickness Estimates:

- Average= 1-2 miles
- Maximum = ~2.5 miles (Hudson Bay)
- In Minnesota = 1-2 miles


15,600
years ago
(13,900 C14 yr)

Multiple advancing lobes over thousands of years




Wadena
Rainy lobe
Lake Superior
Minnesota
Superior lobe
James lobe
Des Moines lobe
Grantsburg, WI
Driftless Area
Twin Cities
Winona

- **Glacial outwash**: sediment transported by meltwater
  - Muds are removed
  - Dominated by sand and gravel

Glacial outwash

- Filled Mississippi River Valley (and tributaries)
- ~85 feet higher than today

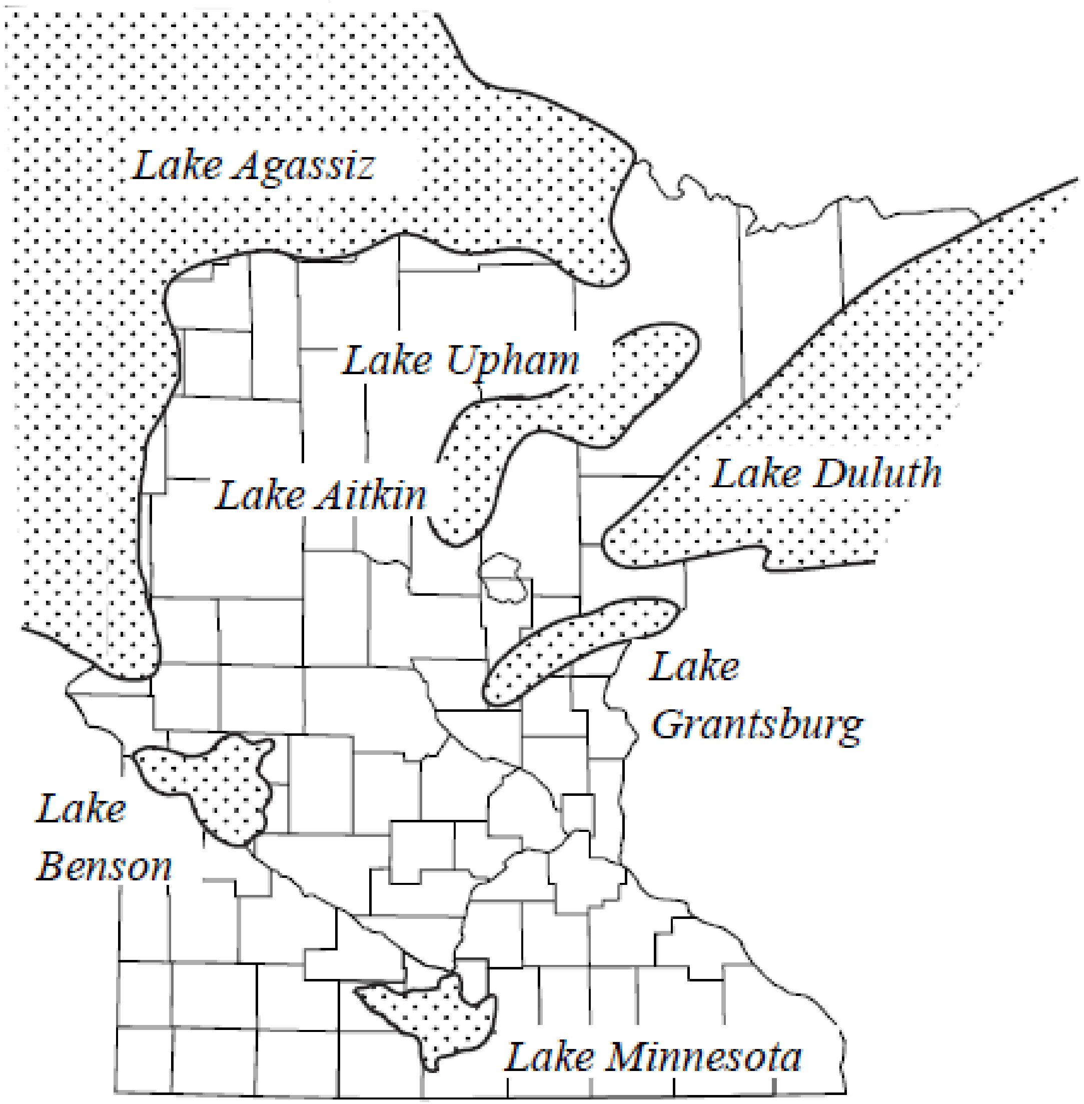
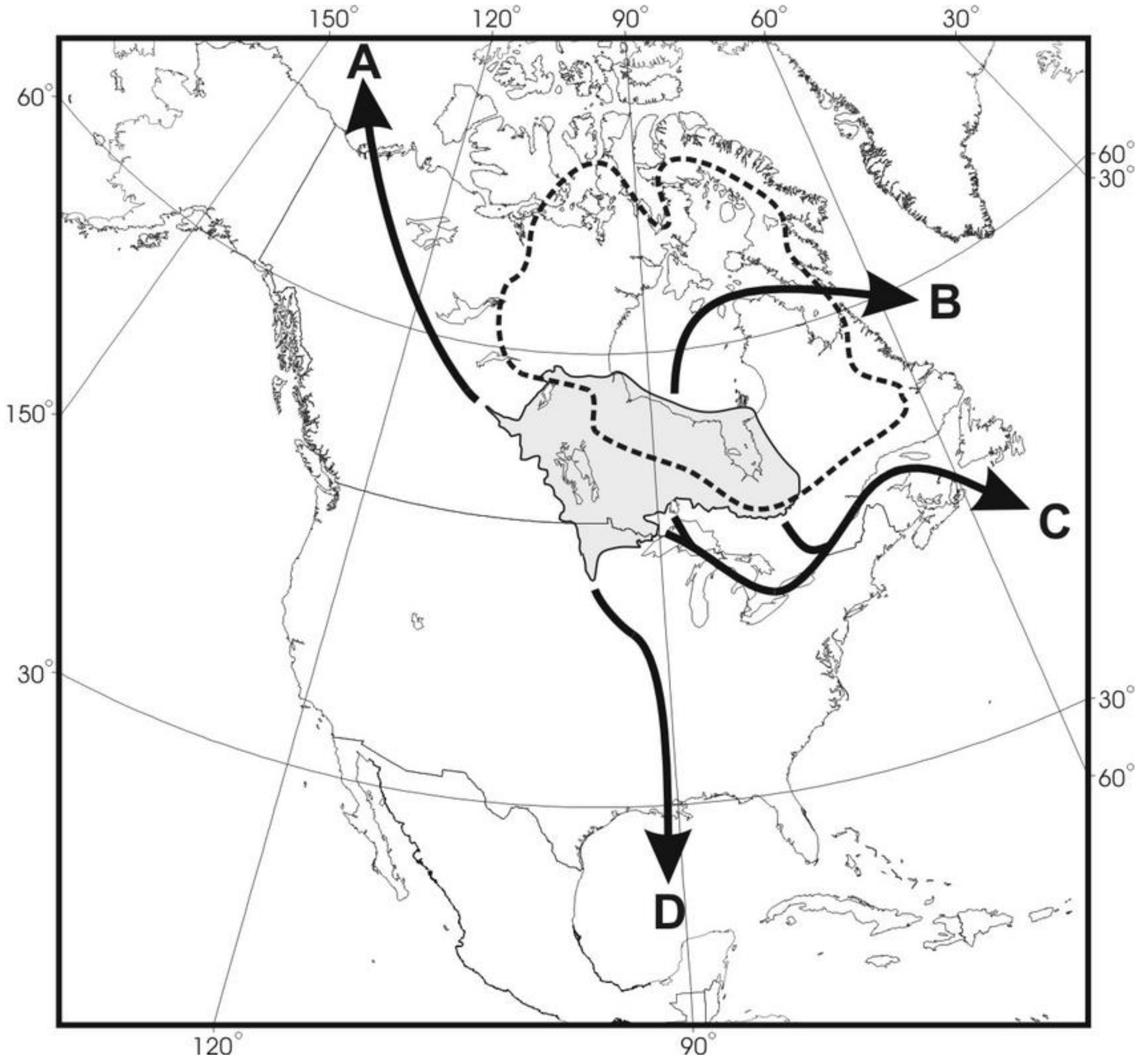
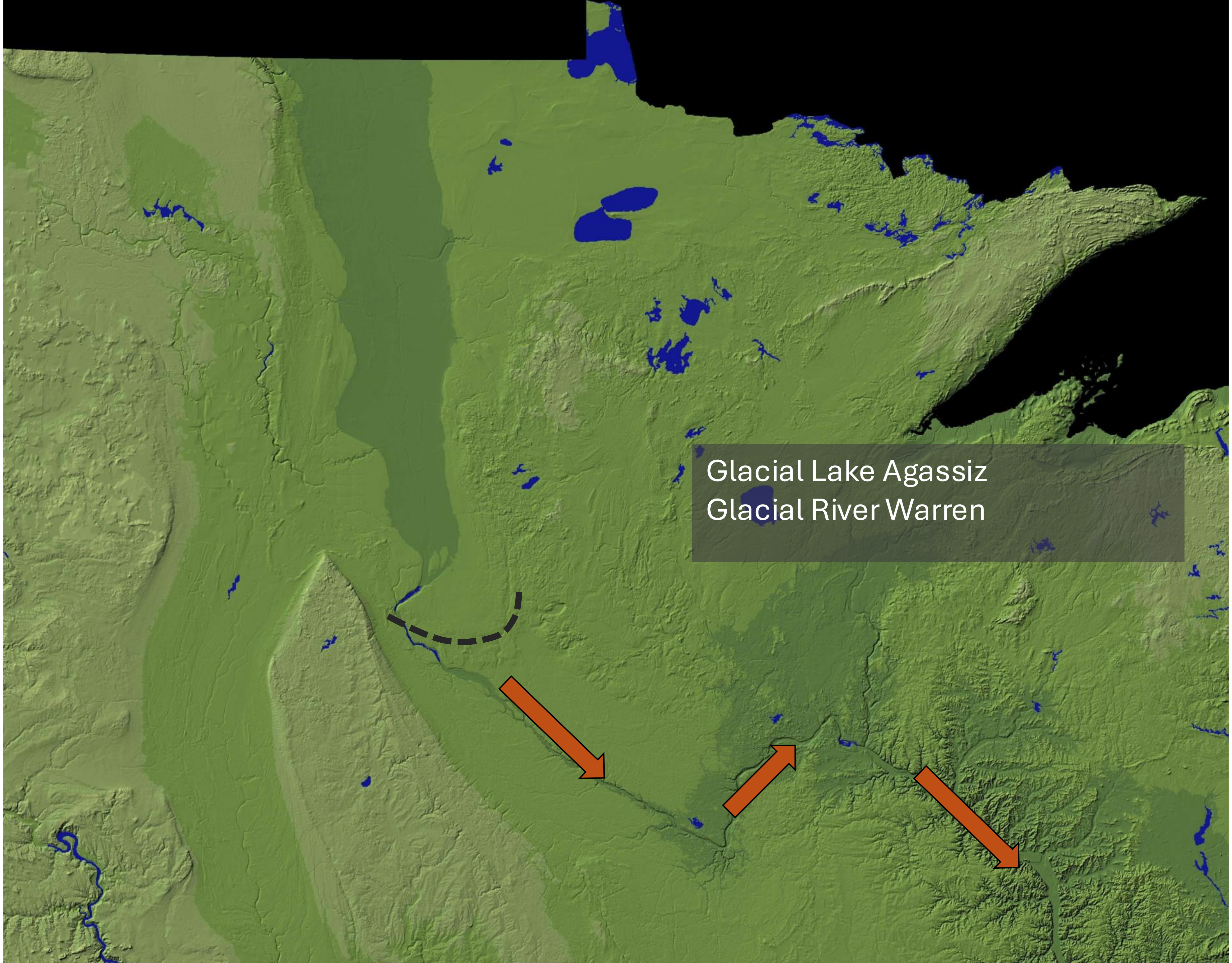


Figure 4. Major glacial lakes during Wisconsin Age (not necessarily contemporaneous).

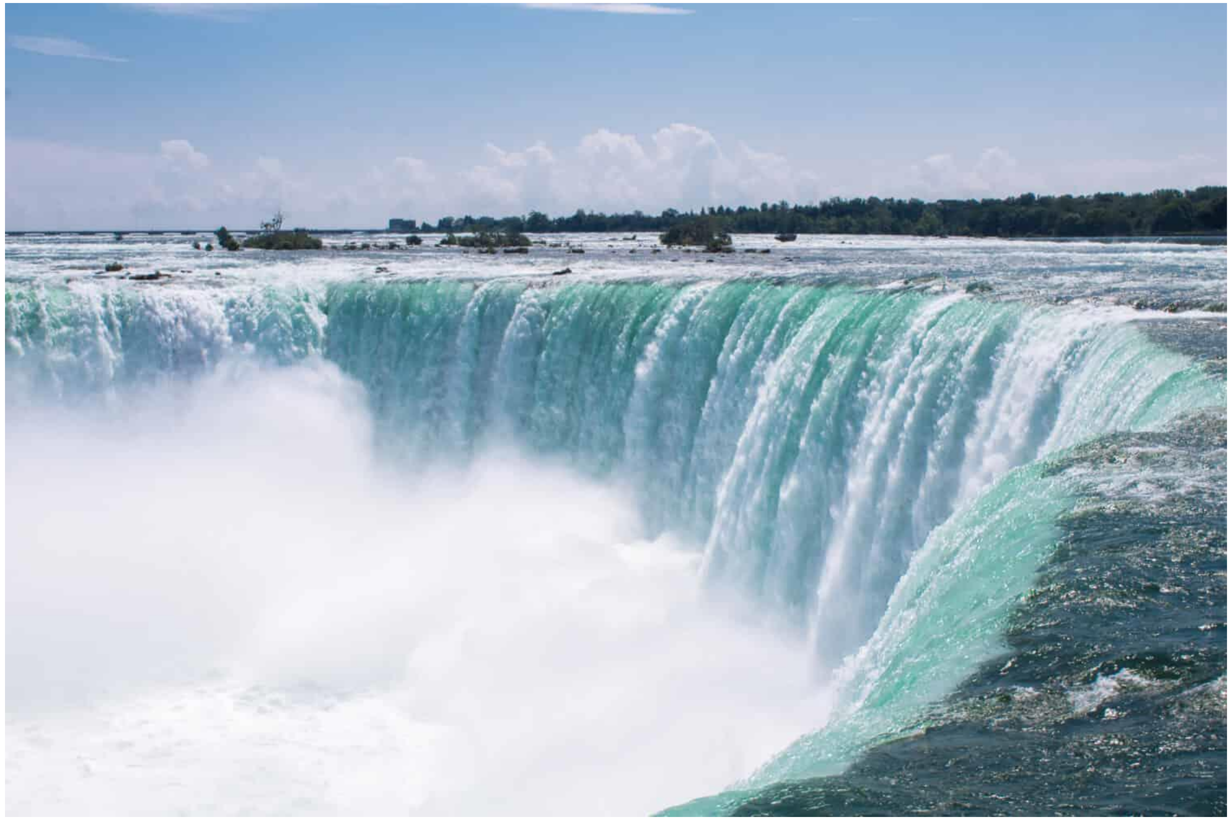

Lake Hudson/
Hudson Bay
Lake
Agassiz
Lake
Superior


150°
120°
90°
60°
30°
A
B
C
D


Glacial Lake Agassiz
Glacial River Warren

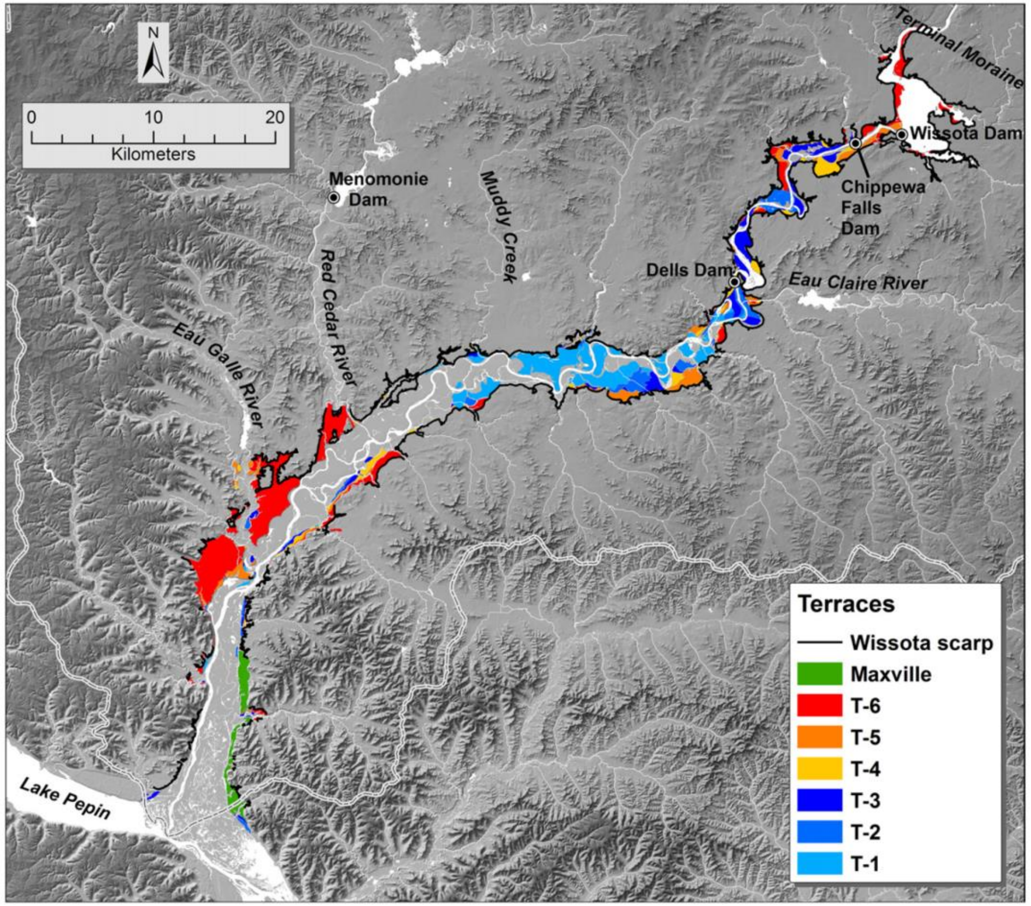
River Warren

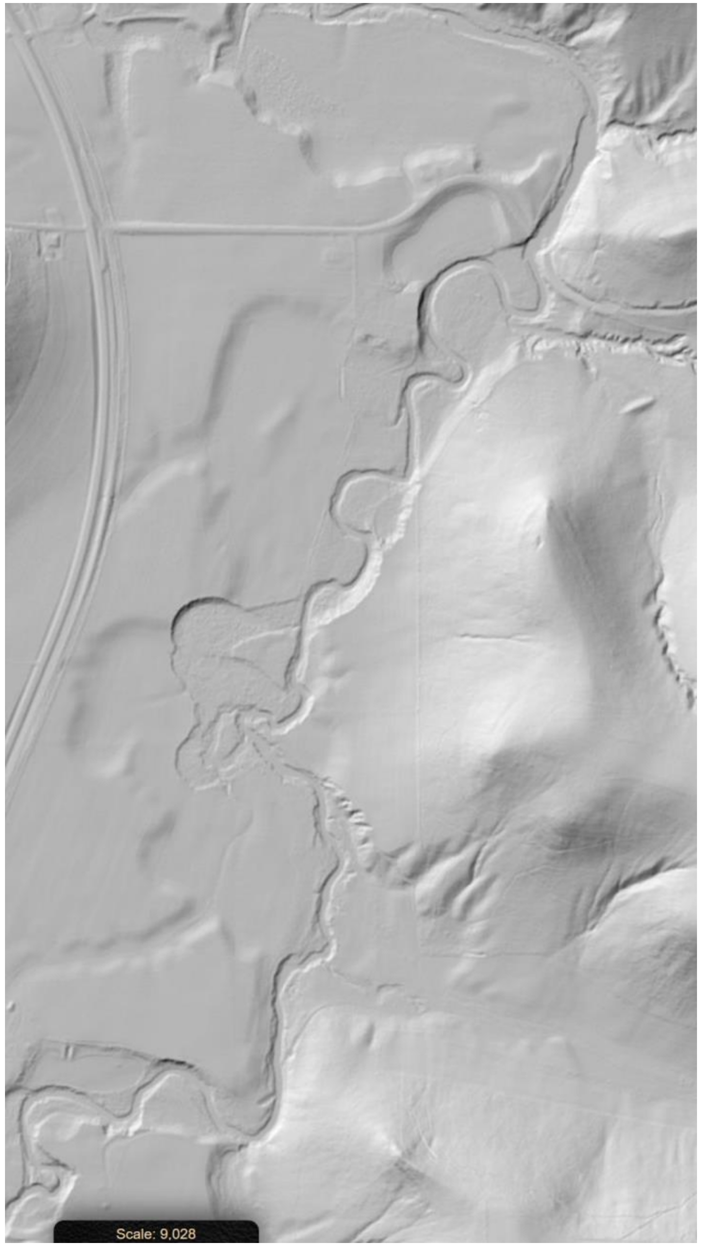
- 100-200 times more water than today
- Very erosive flows
- Incised valley deeper than current level



- Tributaries are still incising today
    - Response to lowering base level

D.J. Faulkner et al. / Geomorphology 266 (2016) 75–95





What is the "Driftless" Area?

- **Glacial Drift** = Sediments deposited by glaciers
- **Driftless** = No glacial sediments

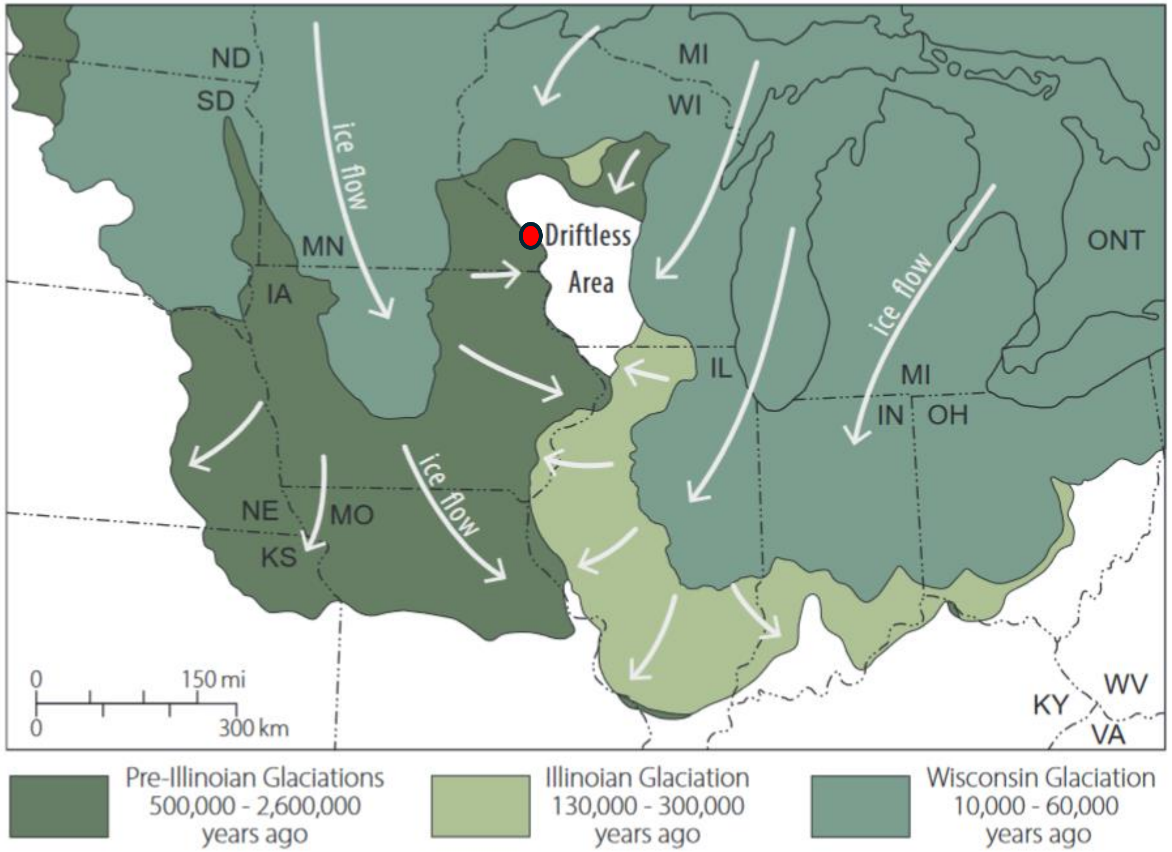
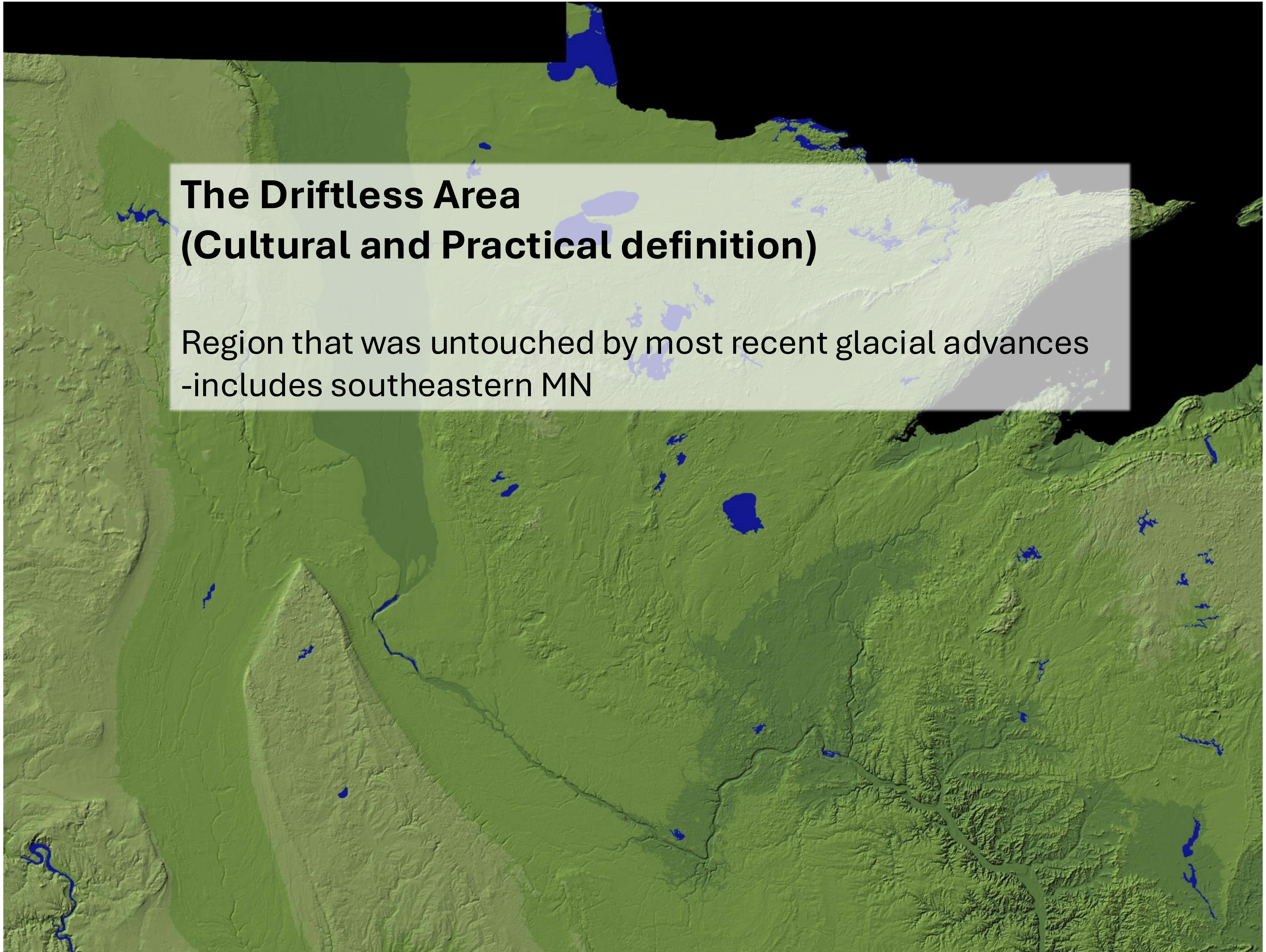


Figure 1. Age and distribution of glacial deposits surrounding the Driftless Area, showing general direction of ice flow for glaciers that bounded the Driftless Area.



The Driftless Area
(Cultural and Practical definition)

Region that was untouched by most recent glacial advances
-includes southeastern MN

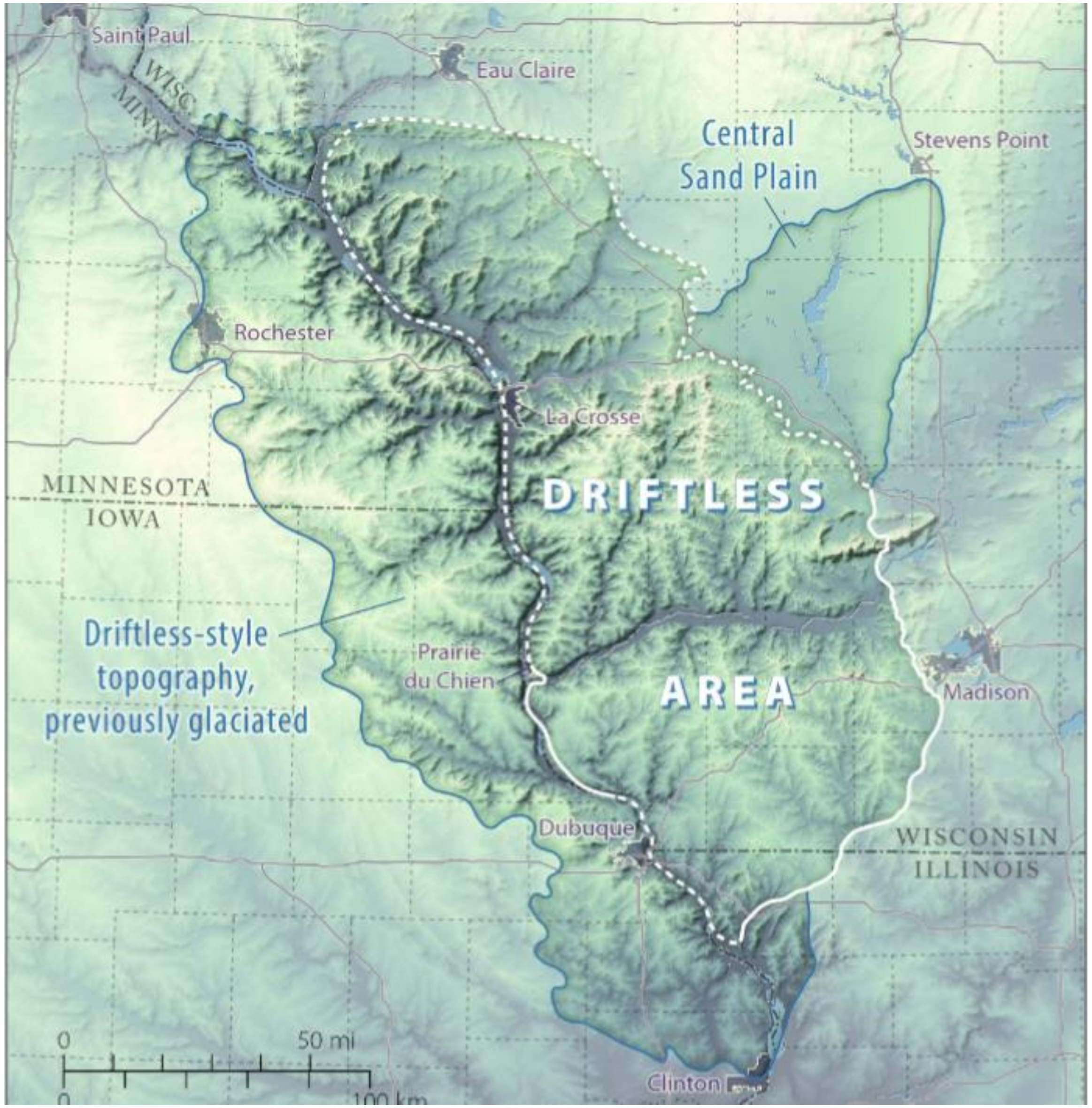
Driftless Area

- Defined by:
  - Deep valleys
  - Steep bluffs
  - Lack of lakes
  - Many streams/rivers

Driftless Area

True Driftless Area lies almost entirely in WI

Surrounding areas have same landscape

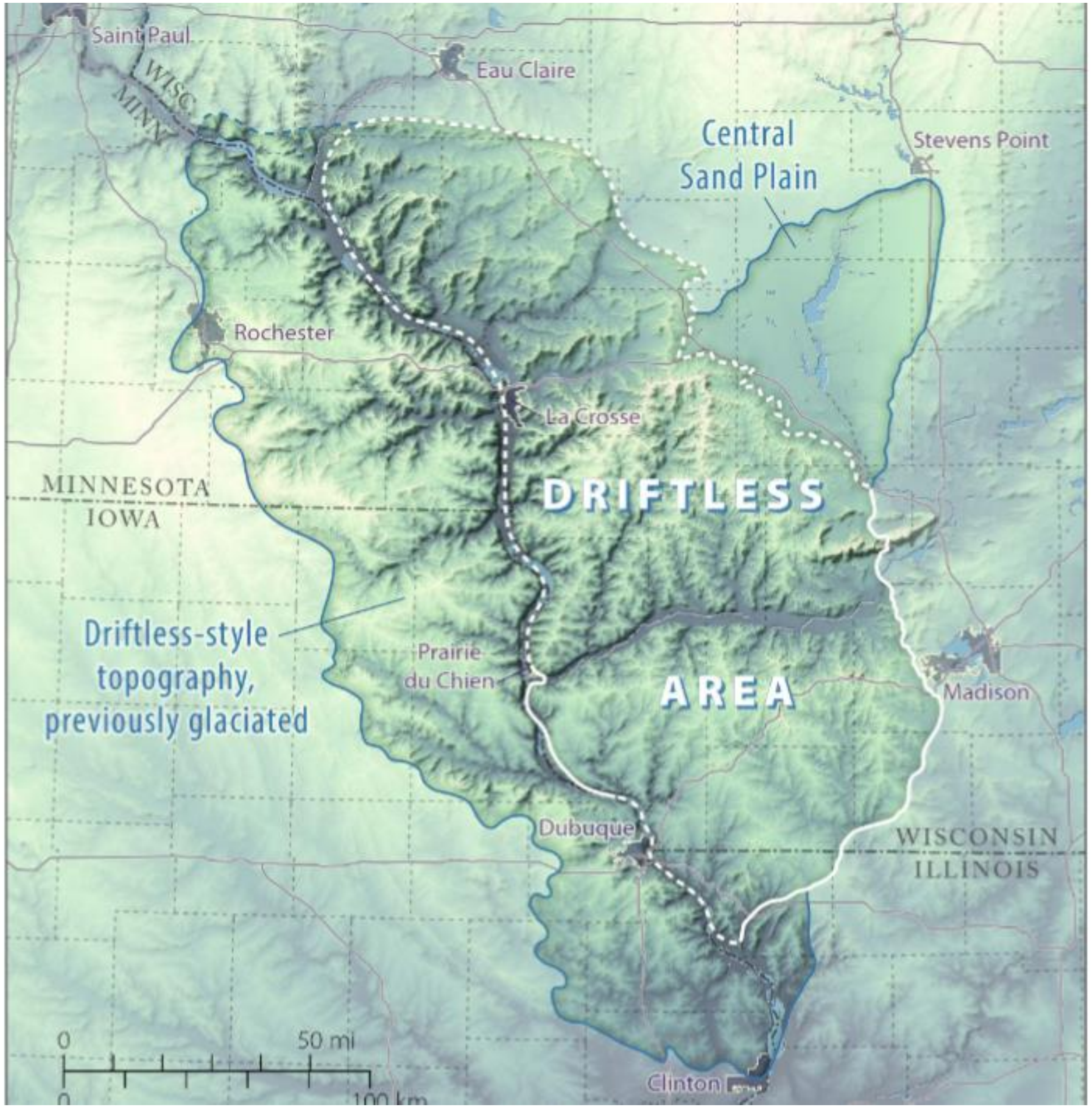


Driftless Area

Thick Ice sheets surrounded the Driftless Area

Still Impacted the Driftless Area

- Glacial Outwash
- Colder Climate
- Crustal Flexure



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