Iowa's Environmental Resources

Applied Geochemistry

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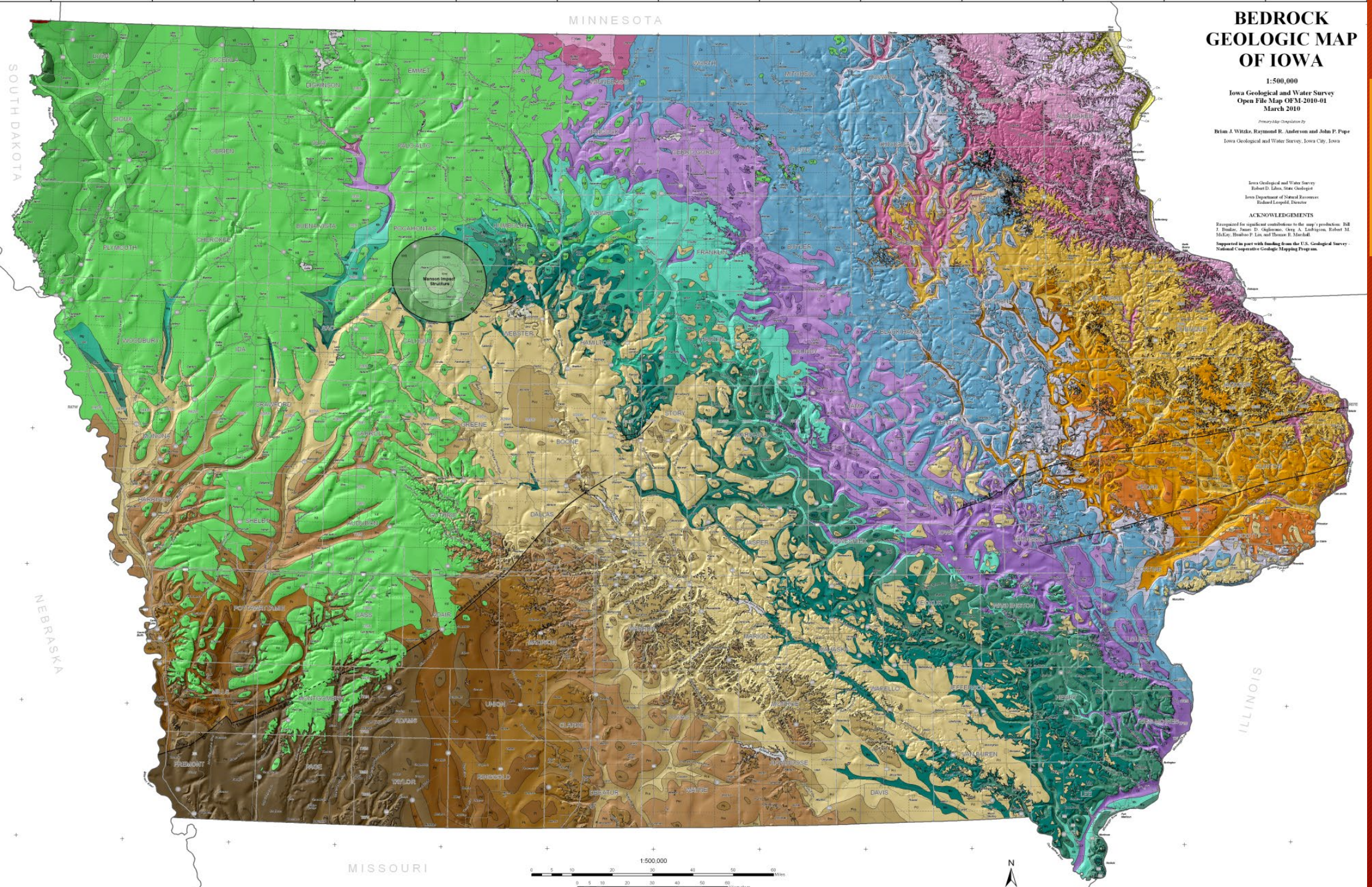
Course objectives

- Investigate the upper Midwest's environmental resources: Rock, Sediments, Water and their subsequent products
- Identify their historical context and future developments
- Apply geochemistry to understand the resource's potential benefits and hazards (*economics to health*)
- Develop materials that may help students learn about our environmental resources and their importance.



BEDROCK GEOLOGIC MAP OF IOWA

1:500,000

Iowa Geological and Water Survey
Open File Map OFM-2010-01
March 2010

Primary Map Compilation by

Brian J. Witzke, Raymond R. Anderson and John P. Pope

Iowa Geological and Water Survey, Iowa City, Iowa

Iowa Geological and Water Survey
Robert D. Libra, State Geologist

Iowa Department of Natural Resources
Richard Leopold, Director

ACKNOWLEDGEMENTS

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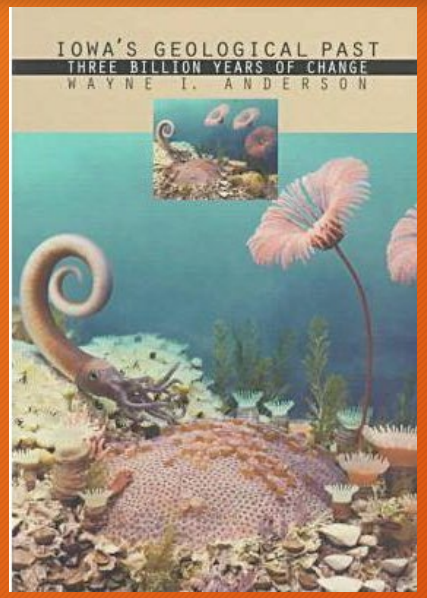
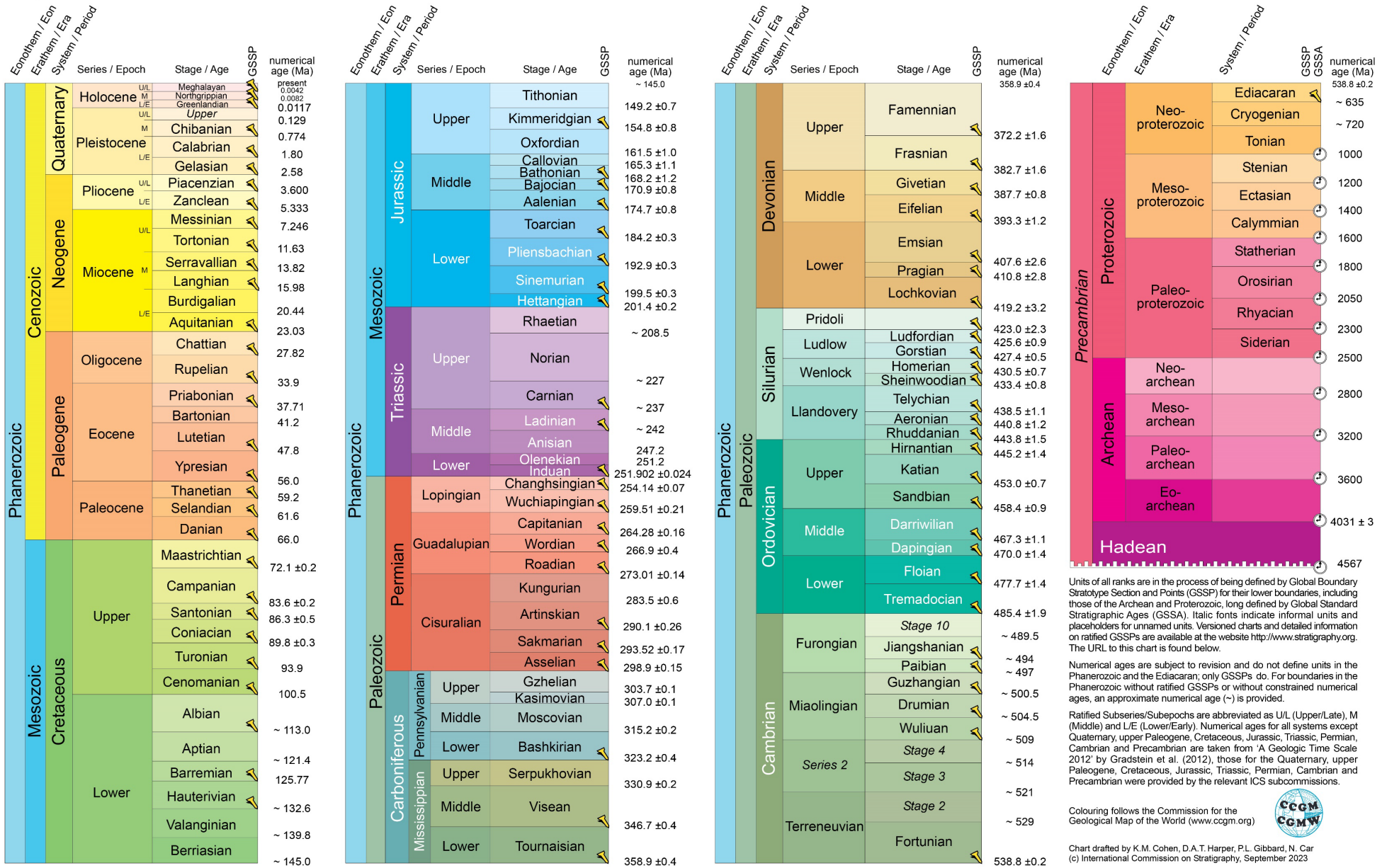
Geologic Time



Wayne Anderson
Brian Glenister
Jim Walters
Ray Anderson

INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

IUGS www.stratigraphy.org International Commission on Stratigraphy v 2023/09



Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Italic fonts indicate informal units and placeholders for unnamed units. Versioned charts and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is found below.

Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

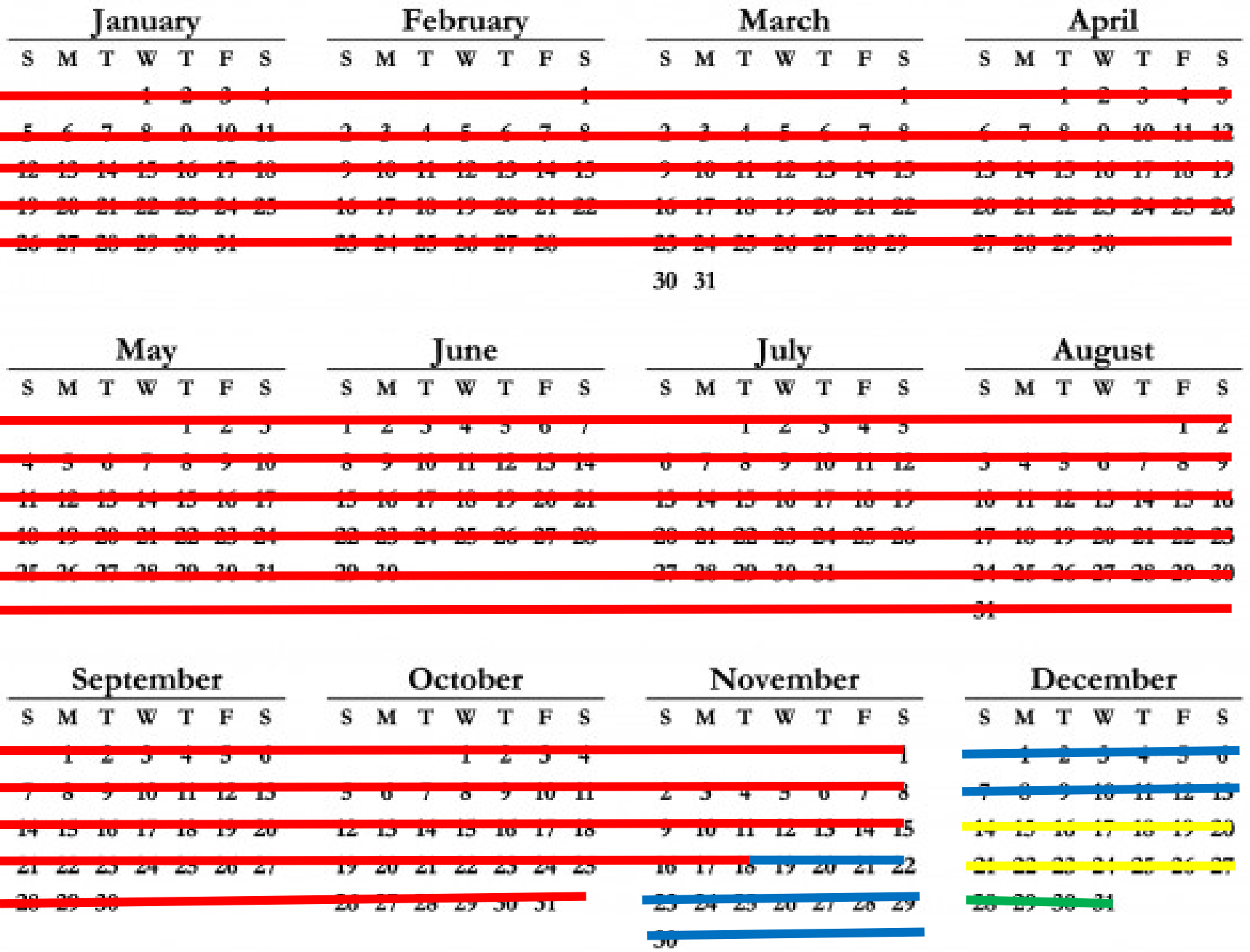
Ratified Subseries/Subepochs are abbreviated as U/L (Upper/Late), M (Middle) and L/E (Lower/Early). Numerical ages for all systems except Quaternary, upper Paleogene, Cretaceous, Jurassic, Triassic, Permian, Cambrian and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012), those for the Quaternary, upper Paleogene, Cretaceous, Jurassic, Triassic, Permian, Cambrian and Precambrian were provided by the relevant ICS subcommissions.

Colouring follows the Commission for the Geological Map of the World (www.ccgm.org)

Chart drafted by K.M. Cohen, D.A.T. Harper, P.L. Gibbard, N. Car
(c) International Commission on Stratigraphy, September 2023

To cite: Cohen, K.M., Finney, S.C., Gibbard, P.L. & Fan, J.-X. (2013; updated) The ICS International Chronostratigraphic Chart. Episodes 36: 199-204.

URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2023-09.pdf



Time

- Precambrian
  - 4 Billion years
- Paleozoic
  - 545-245 Ma
- Mesozoic
  - 245-65 Ma
- Cenozoic
  - 65-2Ma
- Pleistocene
  - 2Ma-11,200

3 hours

The Holocene

About the past 11,200 years

- Hunting/Gathering to self driving tractors
- Civilizations have come and gone
- 266 Catholic Popes
- 47 U.S. Presidencies
- Cubs 3 World Series Championships

About 1 minute

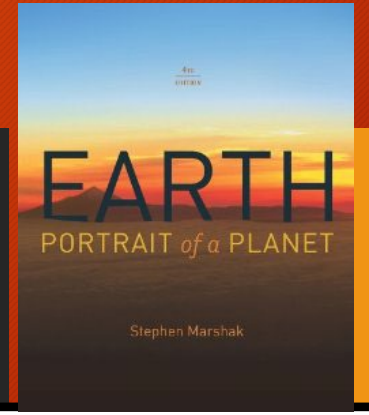
What do we use to interpret Iowa Geologic History?

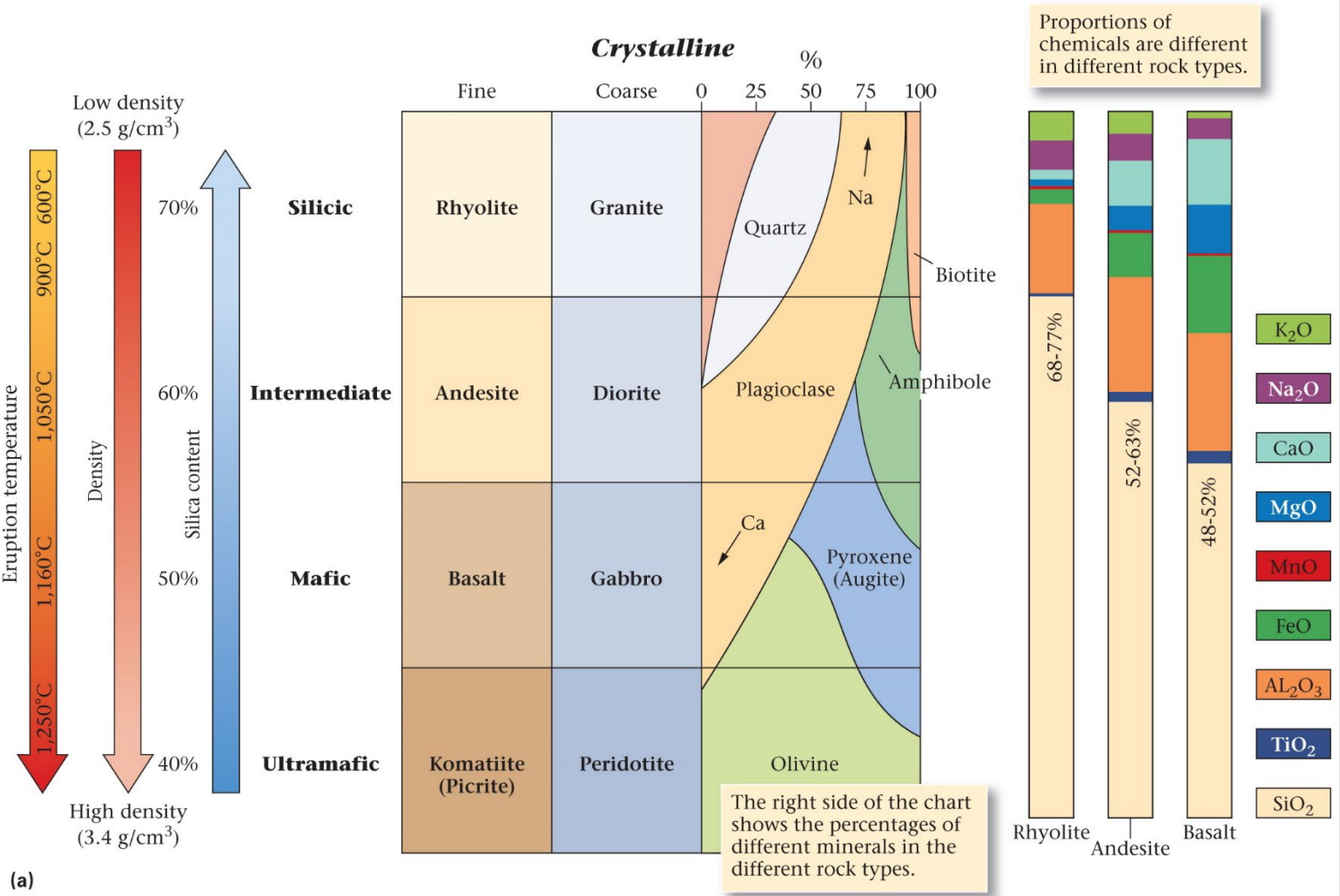
Precambrian – The Oldest Rocks

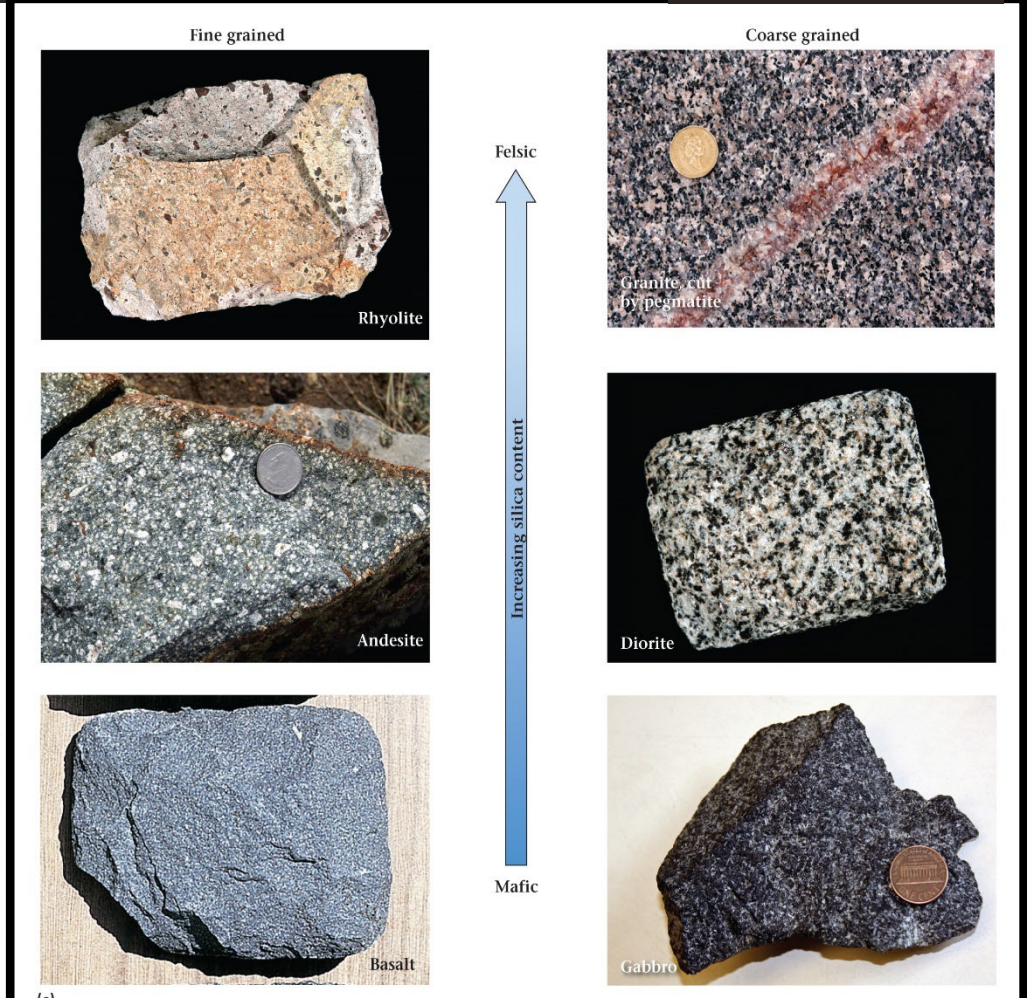
541 Ma
to
4.6 Ga

- Iowa's geologic history began approx. 3Ga ago with igneous and metamorphic rocks.
- Followed by mountain building events: Penokean, Central Plains, and Eastern Granite-Ryholite Province 'orogenies' a product of plate tectonics.
- Iowa's oldest exposed rock is the Sioux Quartzite (approx. 1.6 Ga)
- 1.1Ga North America and Iowa were nearly torn apart by the Mid-continent Rift System

Extended concept (Igneous Intrusive vs Extrusive rocks)

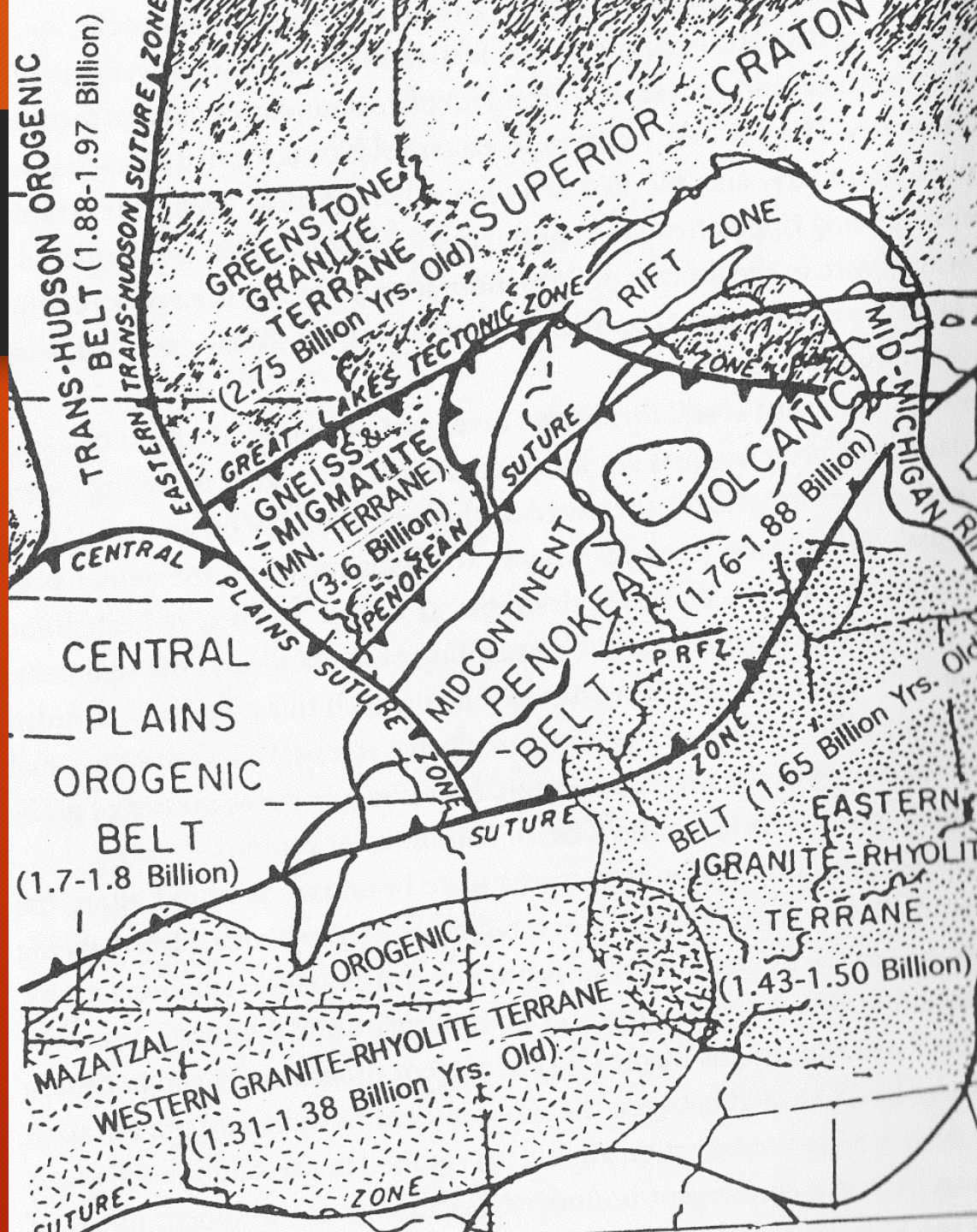






Regional Basement Structure

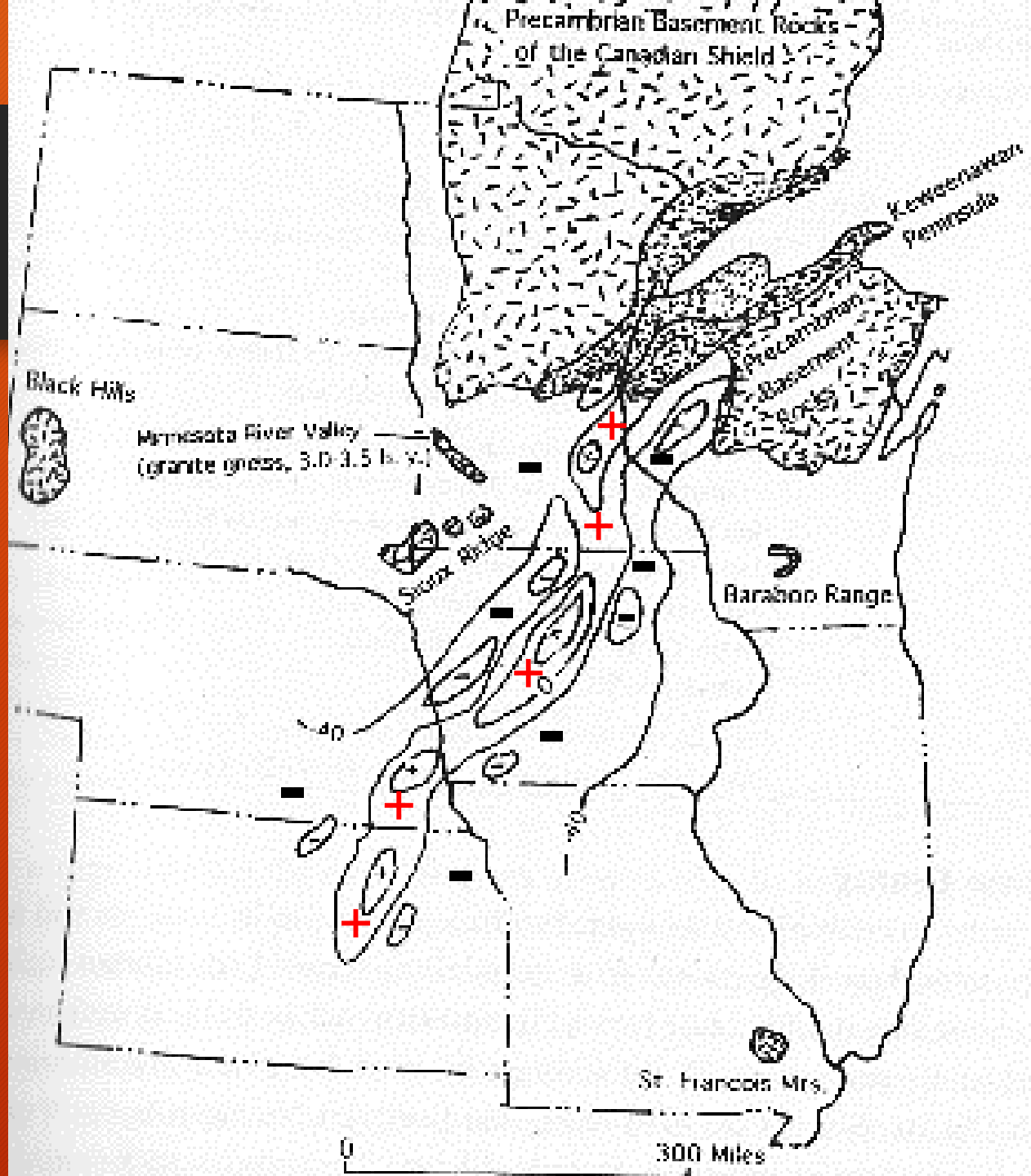
- Oldest rock = Minnesota terrane 3.6Ga, Penokean Volcanic belt 1.8Ga, the Granite provenances in the south approx. 1.4Ga
- Black Hills Granite (famously represented by Mount Rushmore) via a Tertiary uplift/orogeny



Anderson, Iowa's Geological Past

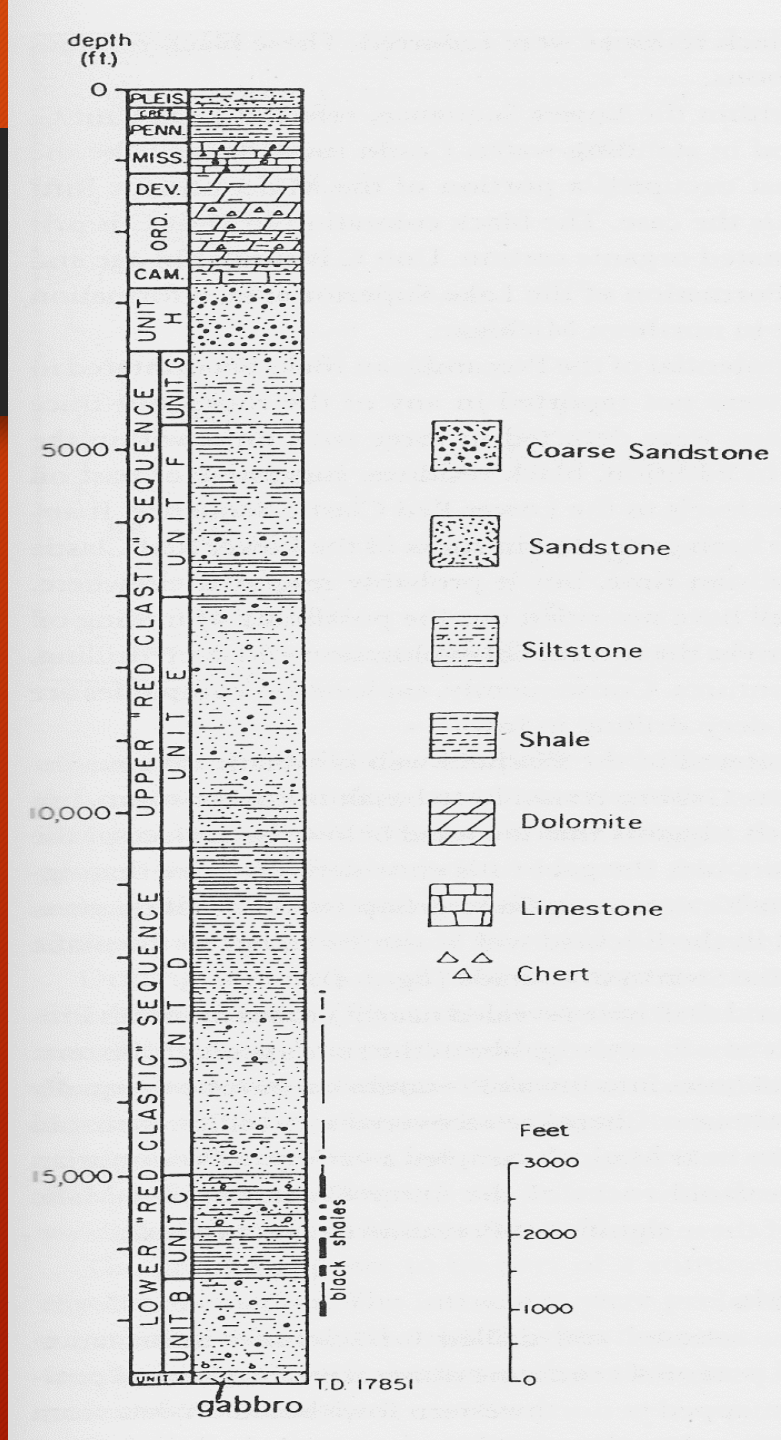
Iowa's Igneous & Metamorphic 'Basement'

- Gravity surveys supplement direct observations (samples)
  - (+) anomalies indicate dense rock bodies i.e. basalt and gabbro
  - (-) anomalies indicate low density rocks i.e. sandstone and shale

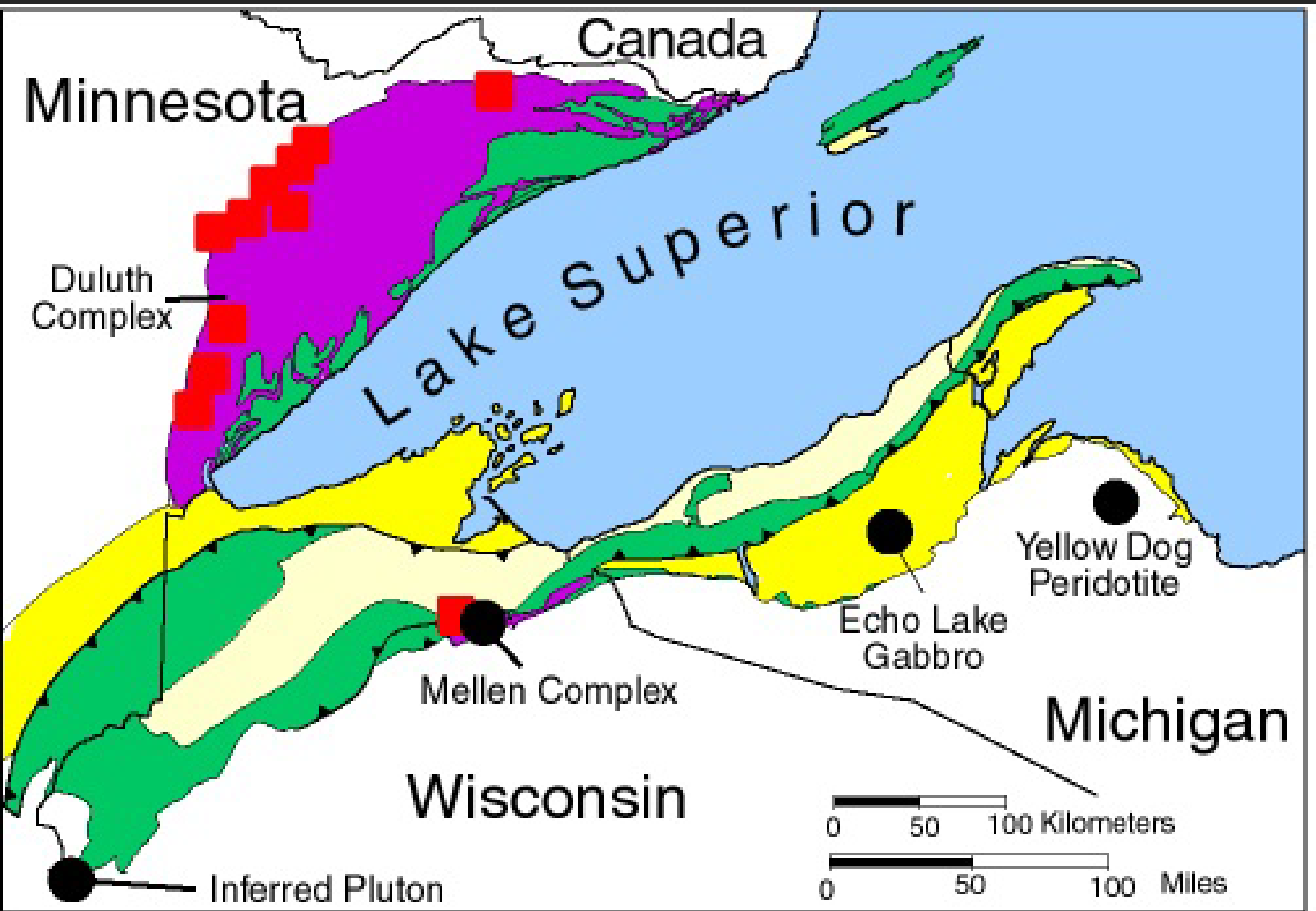


The Eischeid Well – Iowa's Deepest Drilled Well

- Carroll County
- Amoco Production Company
- **208** days of drilling to reach a depth of **17,851**ft (one of the deepest in the Midwest!)
- $20,000,000.00



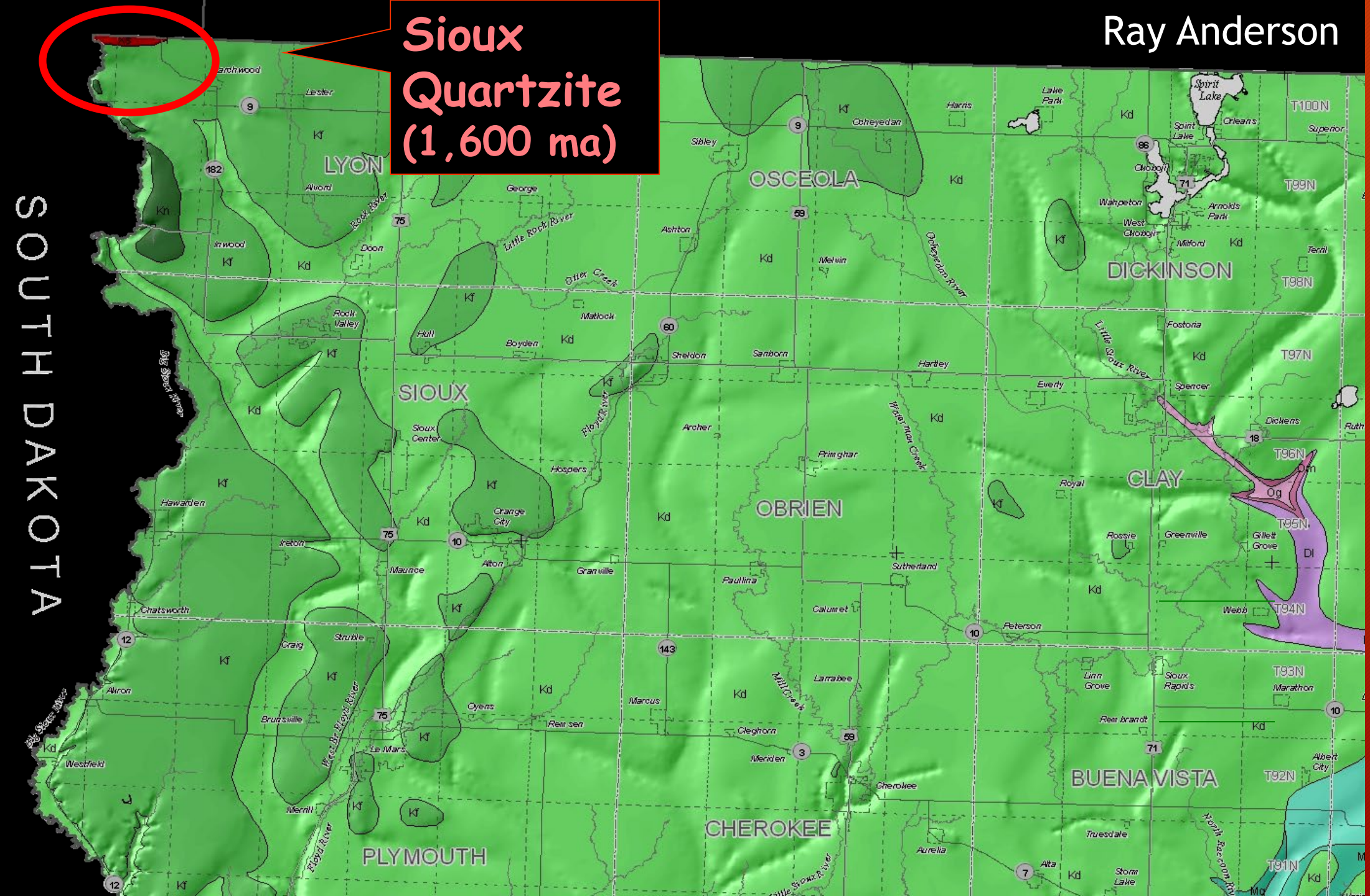
Duluth Complex & North shore Lake Superior



EXPLANATION

- Sandstone
- Gabbro
- Basalt
- Known nickel and copper sulfide mineralization
- Favorable target
- Faults, in part defining the edge of the rift

Ray Anderson



Sioux Quartzite

- Gitchi Manitou State Preserve
  - 1969
- The rock is still quarried near Sioux Falls, SD
- Was mistaking called Sioux Granite
- NOT part of an uplift rather the Sioux Ridge is likely a product of differential weathering

Sioux Quartzite

- Environment of Deposition?
  - Upper portion = tidal/shallow marine
  - Lower portion = fluvial/river
- The formation is up to 7,800ft thick
- Correlated with the Baraboo Quartzite

Federal building in Sioux Falls, SD

Pipestone

- Pipestone National Monument, MN
- Adjacent red to pink mudstones
  - Catlinite (after George Catlin, 1800s)
- Prized by Native Americans and traded throughout the Great Plains and Colombia River Basin

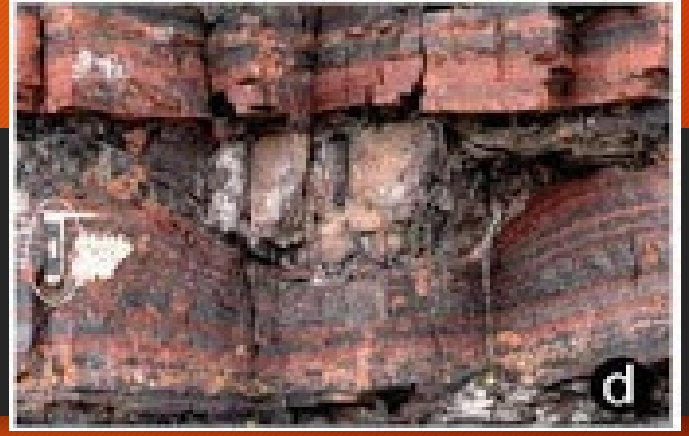
BIF

2.2 Ga

to

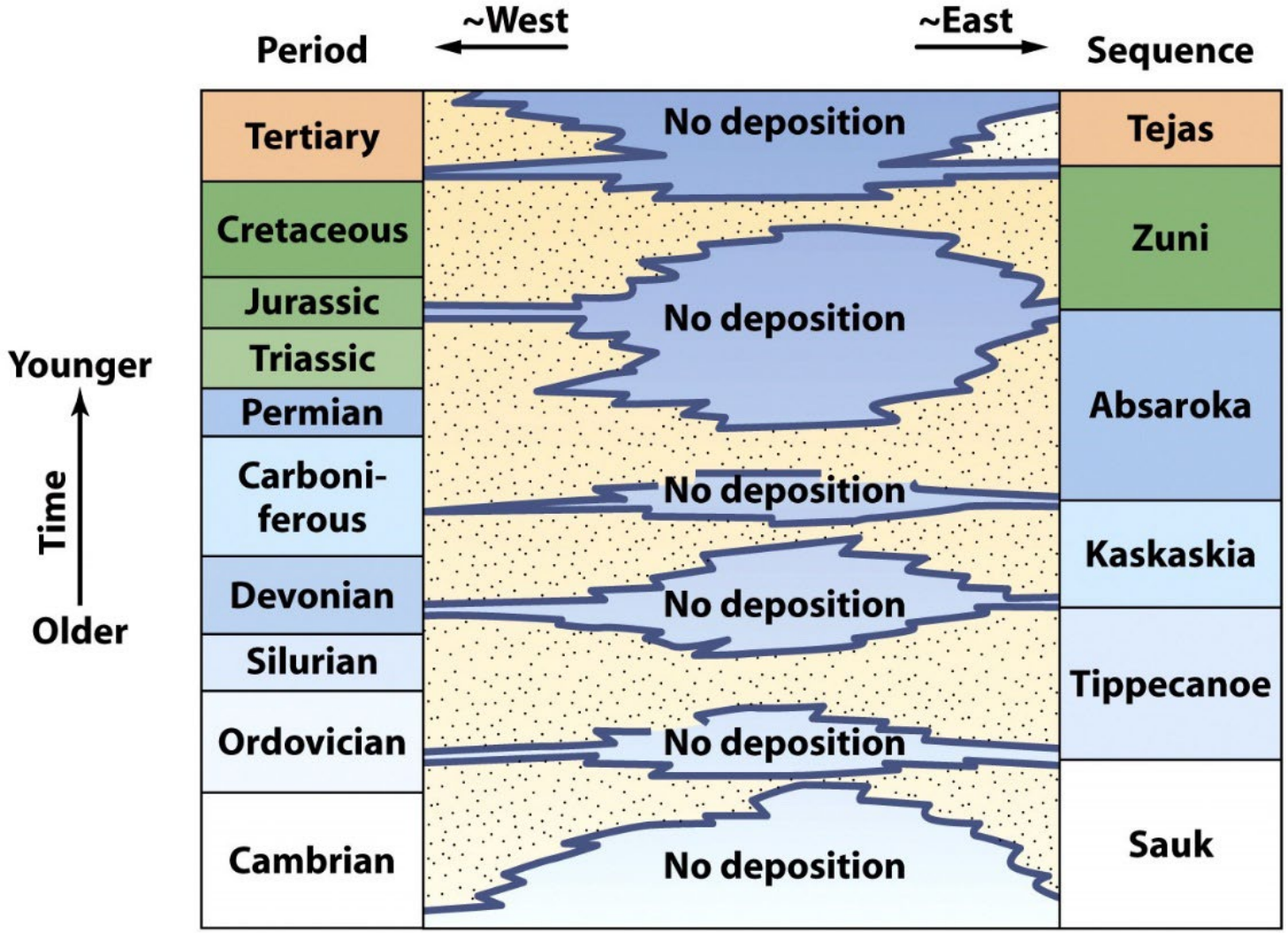
2.4 Ga

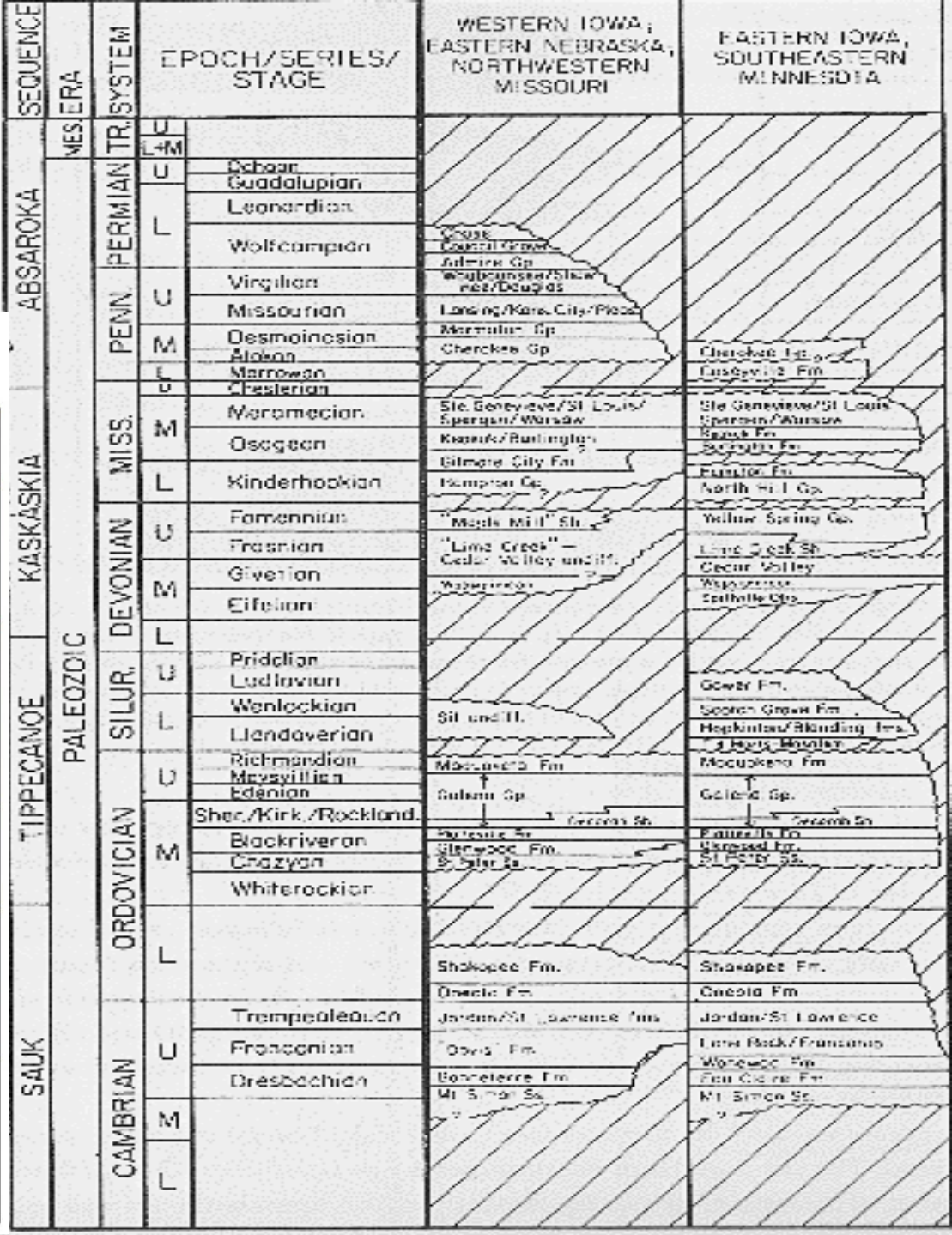
Banded Iron Formations (BIF)
Stopped then began again

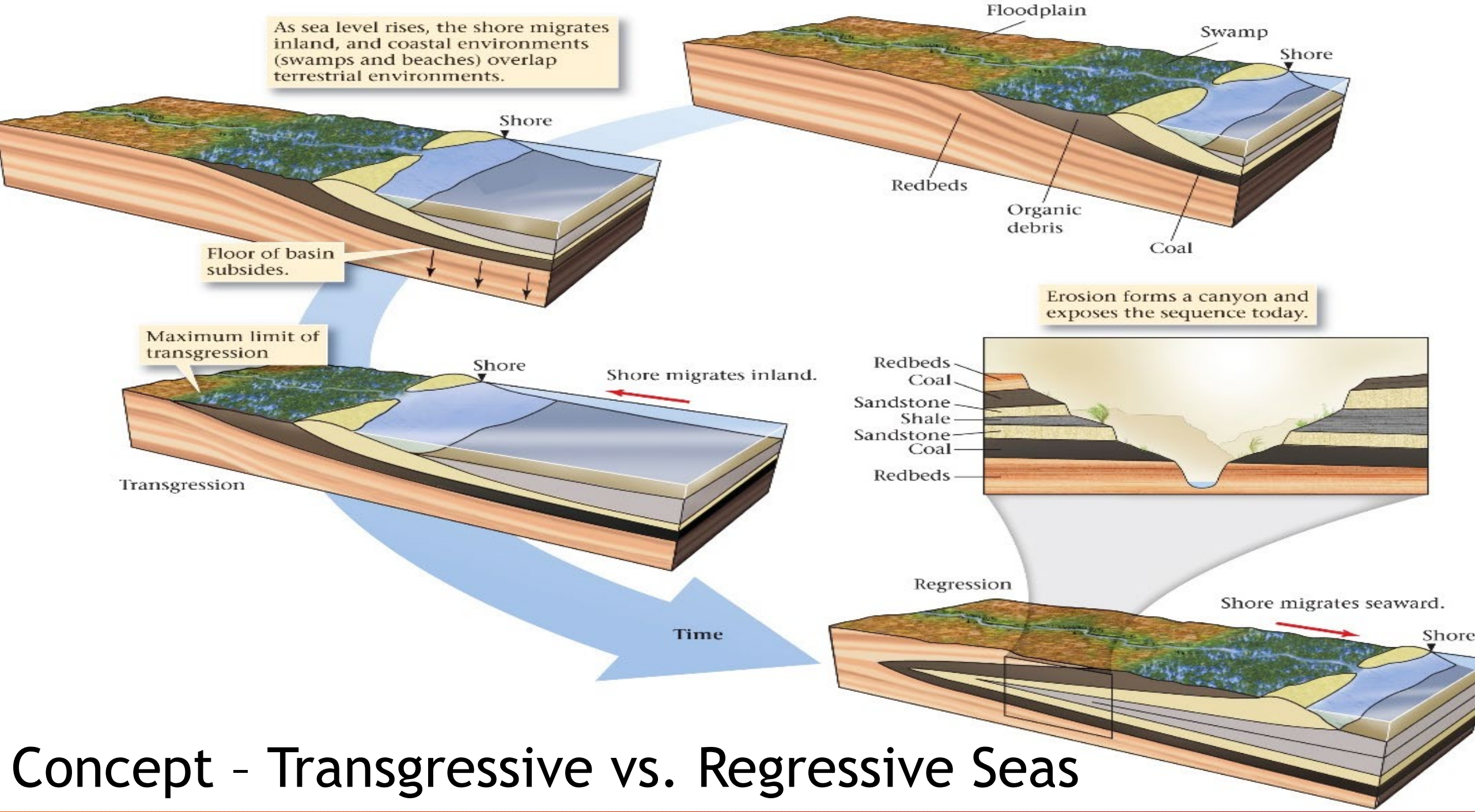


- Initial Hypothesis –
  - Started again in correlation with glaciations because O_2 concentration was low due to increased ice cover' Similar to Archean Seas…
- Current hypothesis
  - O_2 isn't the most important factor, Rather BIF are common during increased seafloor. hydrothermal activity
  - BIFs were developed during glacial retreat, causing sea level to rise

Iowa's Paleozoic







Concept – Transgressive vs. Regressive Seas

Cambrian – Sandy Marine Shelves & Shorelines

485 Ma
to
541 Ma

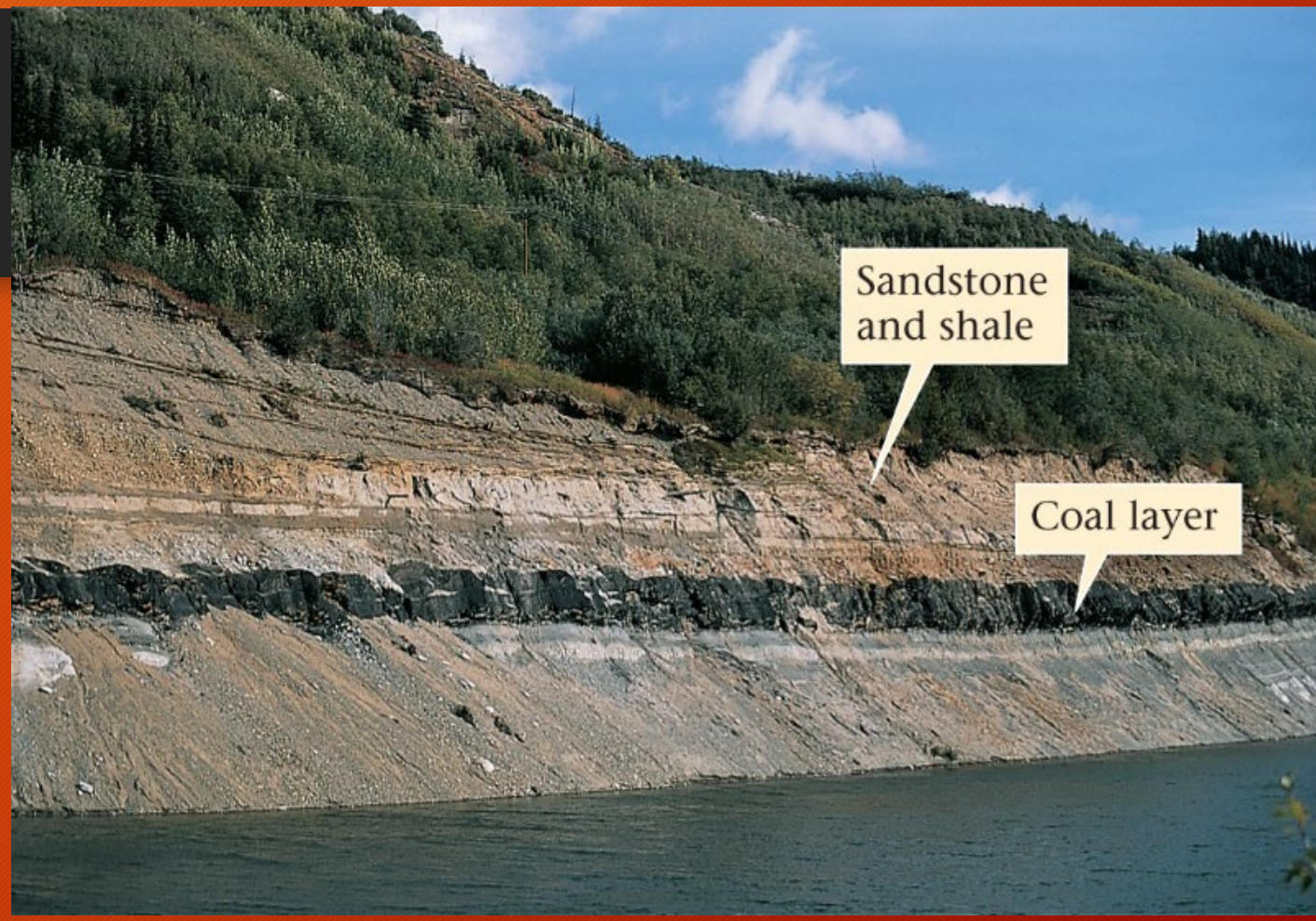
- The Cambrian is generally know as a periods for the Explosion of Life and for a dramatic increase in available/atmospheric O_2
- The early to mid-Cambrian saw massive periods of weathering/erosion and as a product there is a large unconformity until the late Cambrian in Iowa
- During the Late Cambrian, shallow seas encroached upon Iowa and reworked the eroded (Precambiran & Early Cambrian) sediments including resistant quartz, feldspar, clay minerals, and trace amounts of zircon, tourmaline and garnet.

Late Cambrian Sandstone

- Throughout the Midwest there are numerous sandstone formations that are mature:
  A. Physically
     - Well rounded
     - Well sorted
  B. Chemically
     - Mostly quartz
     - Some areas rich in feldspar too

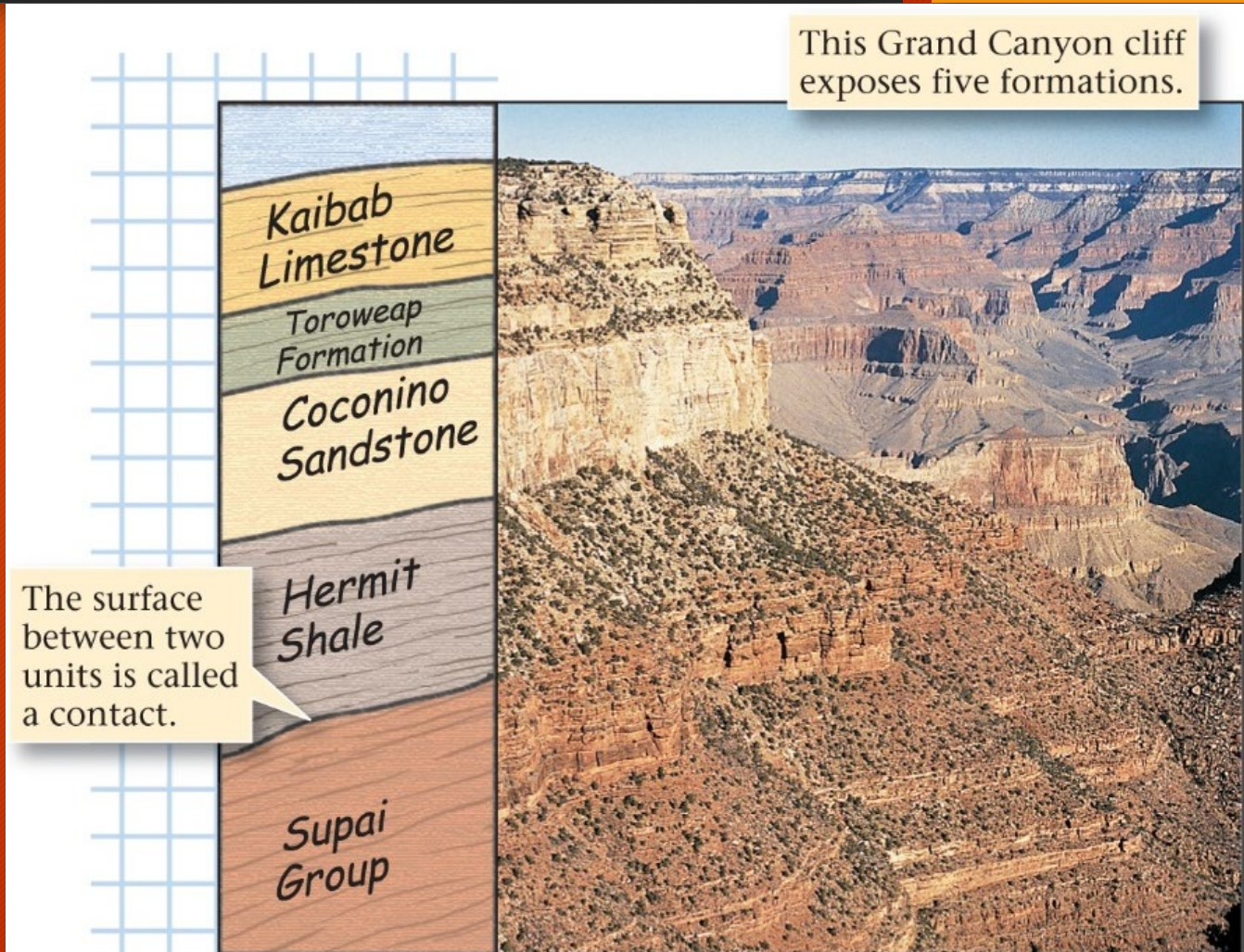
Geologic *Formations*

- A body/layer of rock that consists dominantly of a certain lithologic rock type
- Maybe combined into *Groups*
- Or maybe divided into *Members*

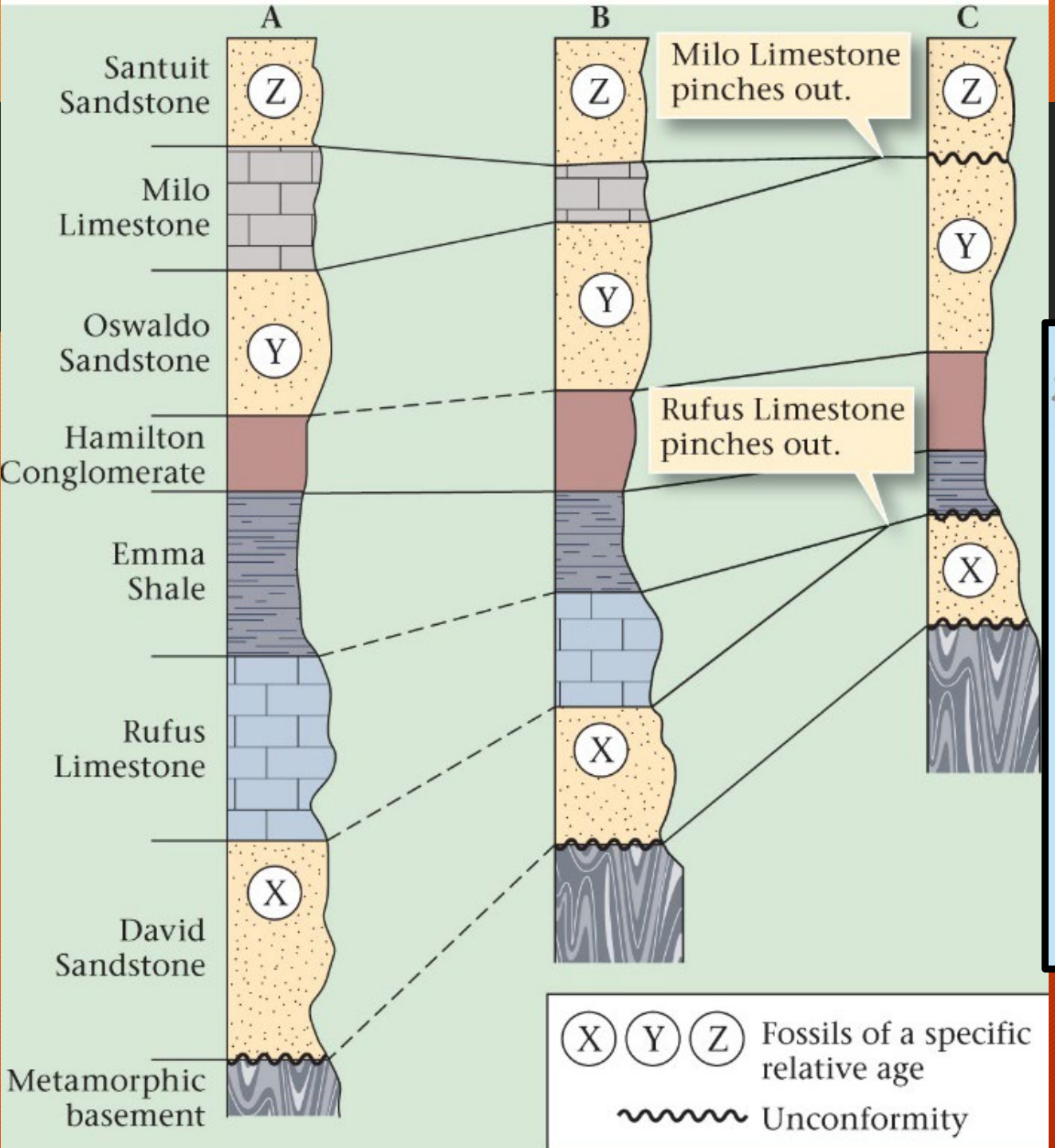


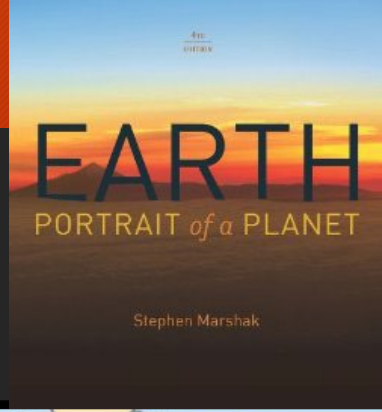
Stratigraphy – The science of rock layers

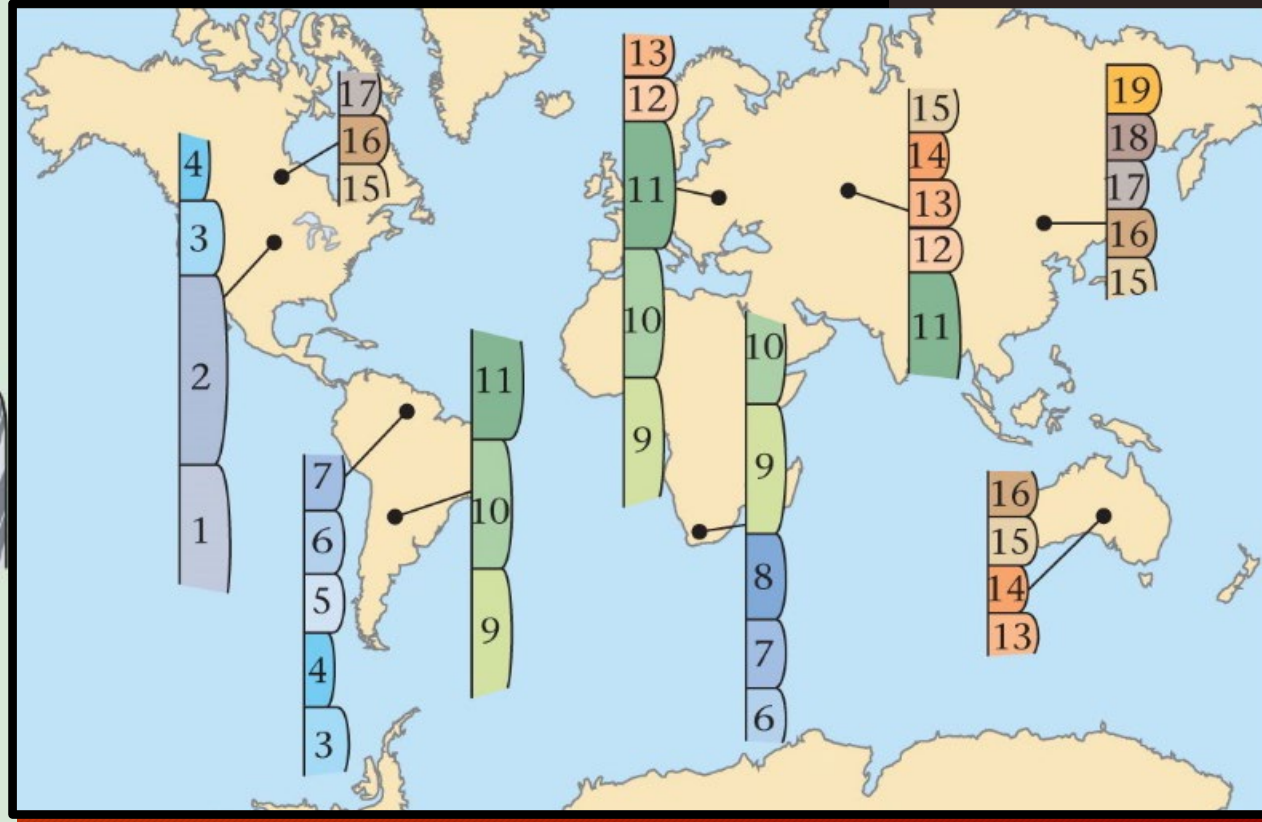
- Concerned with all characters and properties (physical, chemical and/or biological)
- Enables geologists to trace rock formations from one place to another
- Helps geologists to interpret modes of origin and history

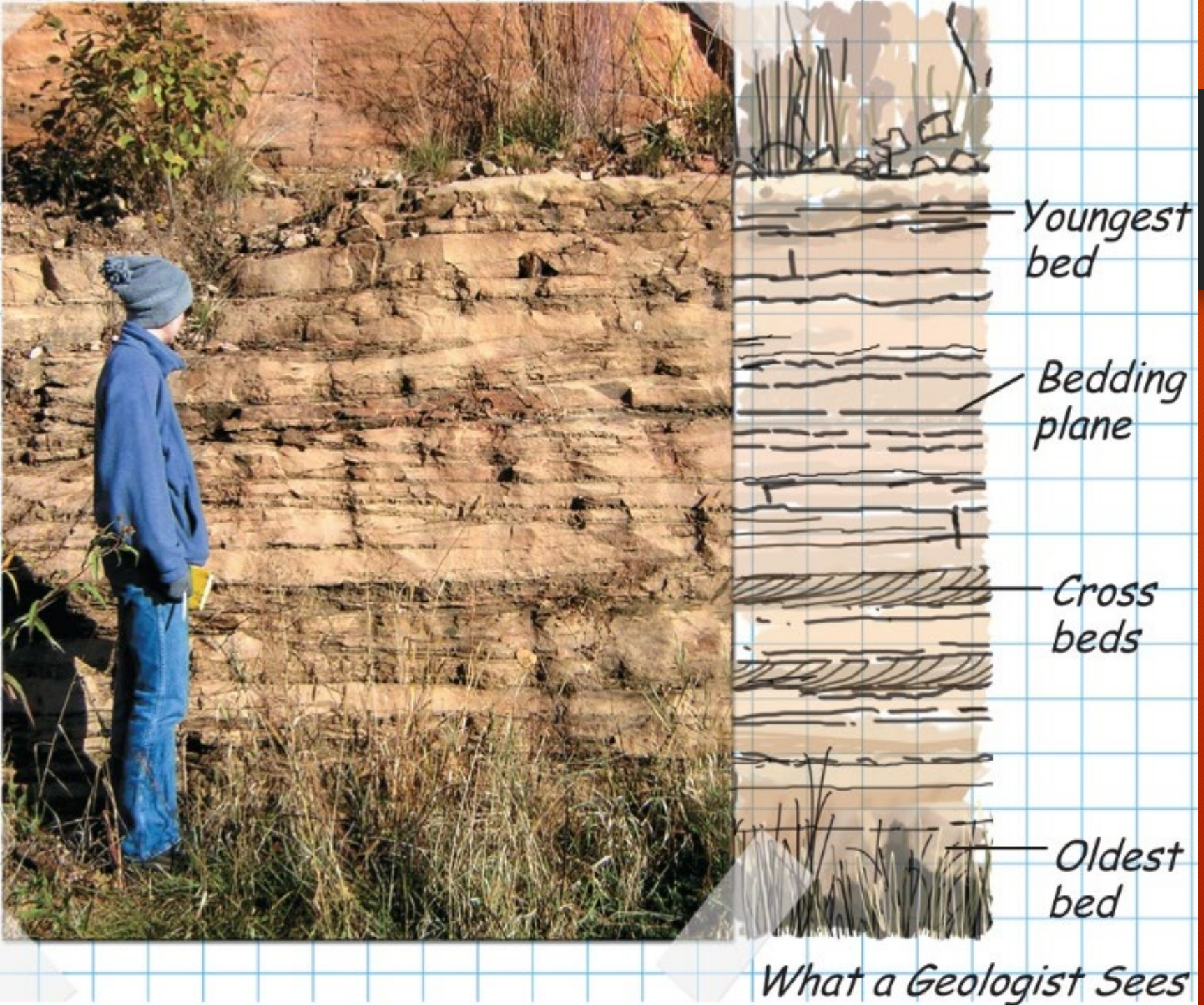


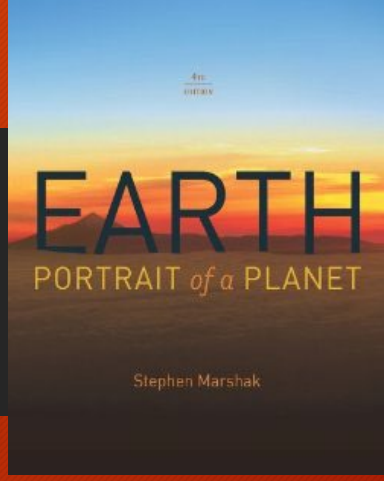
Correlation











Relative dating
Superposition

The Jordan Sandstone

- Some layers are cemented with dolomite
- Formed on a shallow marine shelf and shoreline
- High porosity and moderate permeability
  - Serves as one of the Iowa's best groundwater/aquifers

Location

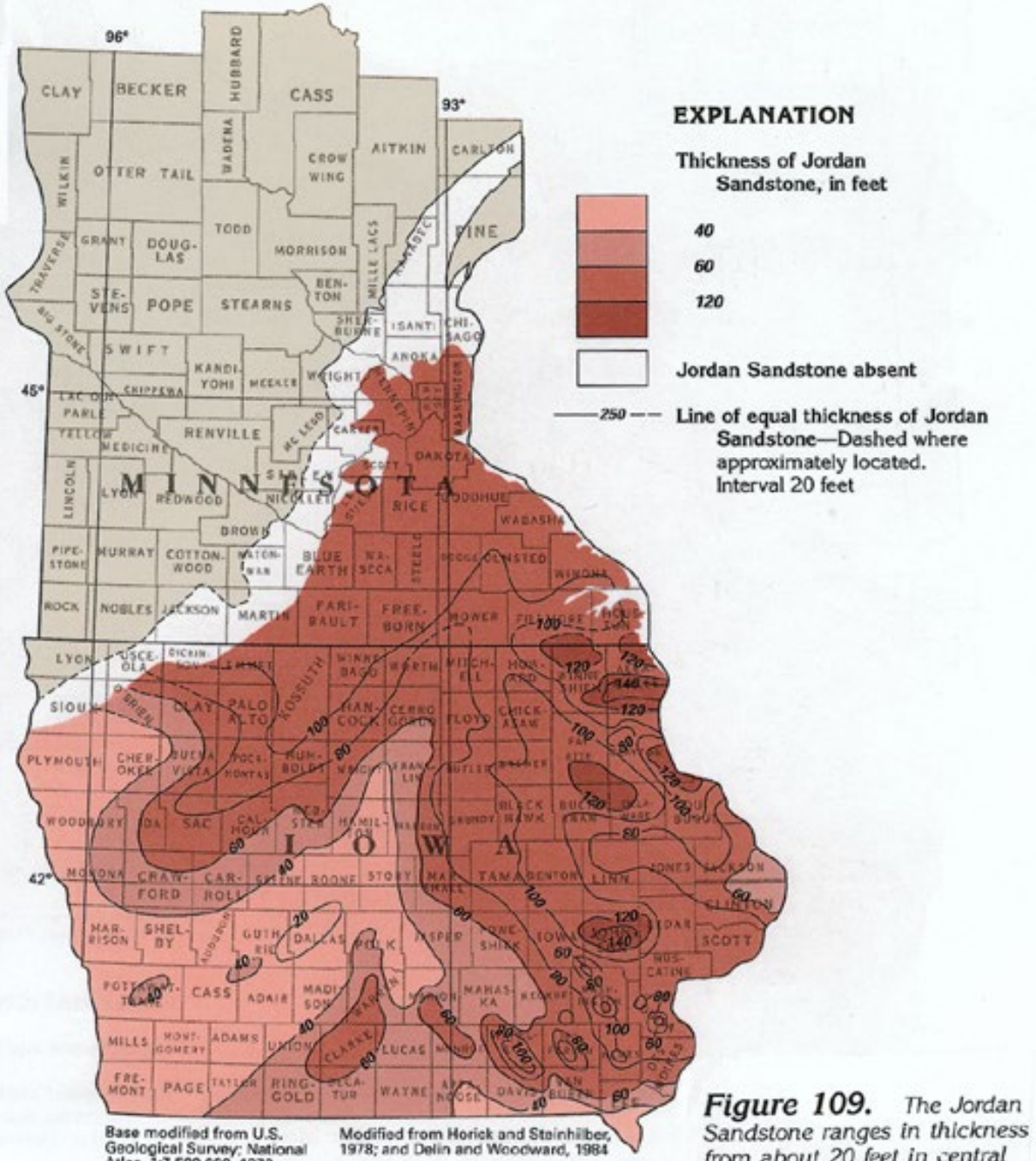
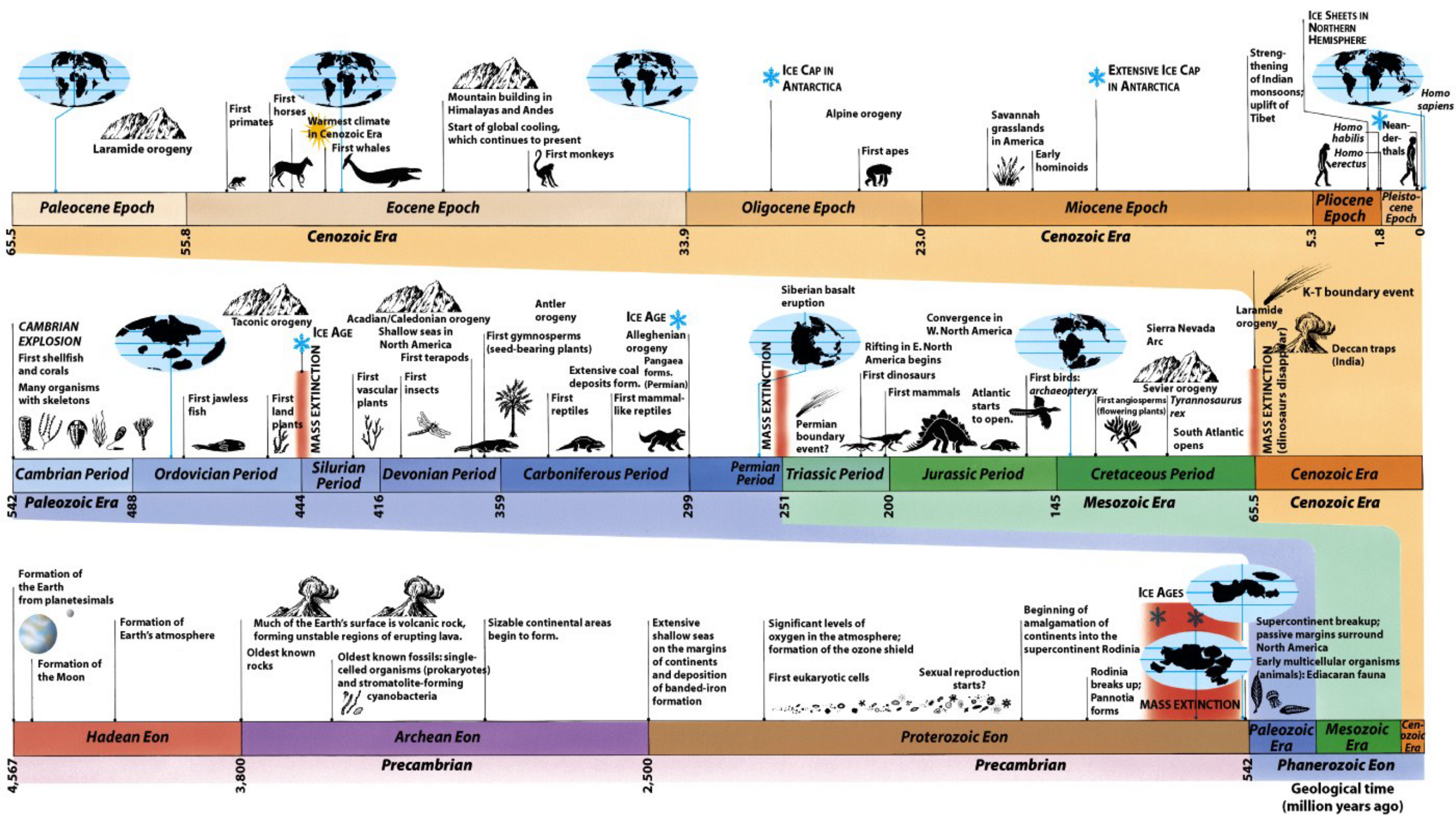


Figure 109. *The Jordan Sandstone ranges in thickness from about 20 feet in central Iowa to about 140 feet in northeastern and east-central Iowa.*

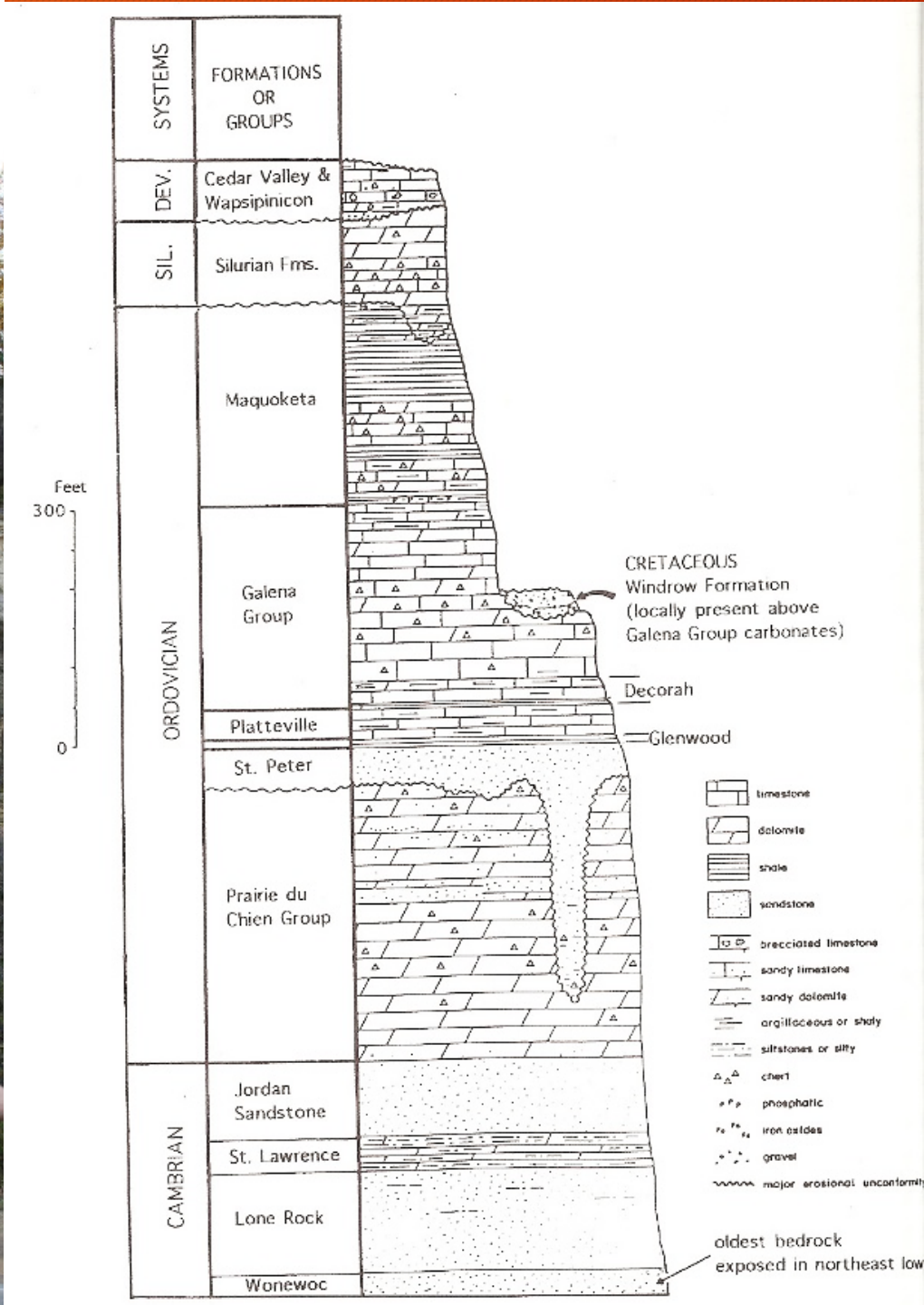
Ordovician – Warm, Shallow Seas

443 Ma
to
485 Ma

- Early Ordovician – Again on the edge of a shallow sea depositing carbonate, sandy carbonate, and quartz sandstones (Prairie du Chien Group) before another series of weathering and erosion!
- Mid-Ordovician – Major sea transgression changed a sandy shallow sea to carbonate shelf. Ash layers appear in the Decorah and Dunleith Formations.
- Late Ordovician – Increasingly muddy depositional environments forming the carbonate-rich shale layers (e.g. the Maquoketa Shale).
- Towards the end of the Ordovician the seas regress and weathering and erosion begin again, creating an ???


Laramide orogeny
First primates
First horses
Warmest climate in Cenozoic Era
First whales
Mountain building in Himalayas and Andes
Start of global cooling, which continues to present
First monkeys
Ice Cap in Antarctica
Alpine orogeny
First apes
Savannah grasslands in America
Early hominoids
Extensive Ice Cap in Antarctica
Strengthening of Indian monsoons; uplift of Tibet
Ice Sheets in Northern Hemisphere
Homo sapiens
Homo habilis
Homo erectus
Neanderthals
Paleocene Epoch
Eocene Epoch
Oligocene Epoch
Miocene Epoch
Pliocene Epoch
Pleistocene Epoch
65.5
55.8
33.9
23.0
5.3
1.8
0
Cenozoic Era
Cenozoic Era
CAMBRIAN EXPLOSION
First shellfish and corals
Many organisms with skeletons
First jawless fish
First land plants
Taconic orogeny
Ice Age
MASS EXTINCTION
Acadian/Caledonian orogeny
Shallow seas in North America
First terapods
First vascular plants
First insects
First gymnosperms (seed-bearing plants)
Antler orogeny
Extensive coal deposits form.
Ice Age
Alleghenian orogeny
Pangaea forms. (Permian)
First reptiles
First mammal-like reptiles
Siberian basalt eruption
MASS EXTINCTION
Permian boundary event?
Convergence in W. North America
Rifting in E. North America begins
First dinosaurs
First mammals
Atlantic starts to open.
First birds: archaeopteryx
Sierra Nevada Arc
Sevier orogeny
First angiosperms (flowering plants)
Tyrannosaurus rex
South Atlantic opens
Laramide orogeny
K-T boundary event
Deccan traps (India)
MASS EXTINCTION (dinosaurs disappear)
Cambrian Period
Ordovician Period
Silurian Period
Devonian Period
Carboniferous Period
Permian Period
Triassic Period
Jurassic Period
Cretaceous Period
Cenozoic Era
542
488
444
416
359
299
251
200
145
65.5
Paleozoic Era
Mesozoic Era
Cenozoic Era
Formation of the Earth from planetesimals
Formation of the Moon
Formation of Earth's atmosphere
Much of the Earth's surface is volcanic rock, forming unstable regions of erupting lava.
Oldest known rocks
Oldest known fossils: single-celled organisms (prokaryotes) and stromatolite-forming cyanobacteria
Sizable continental areas begin to form.
Extensive shallow seas on the margins of continents and deposition of banded-iron formation
Significant levels of oxygen in the atmosphere; formation of the ozone shield
First eukaryotic cells
Sexual reproduction starts?
Beginning of amalgamation of continents into the supercontinent Rodinia
Rodinia breaks up; Pannotia forms
Ice Ages
MASS EXTINCTION
Supercontinent breakup; passive margins surround North America
Early multicellular organisms (animals): Ediacaran fauna
Hadean Eon
Archean Eon
Proterozoic Eon
Paleozoic Era
Mesozoic Era
Cenozoic Era
4,567
3,800
2,500
542
Precambrian
Precambrian
Phanerozoic Eon
Geological time (million years ago)

Ordovician Stratigraphy

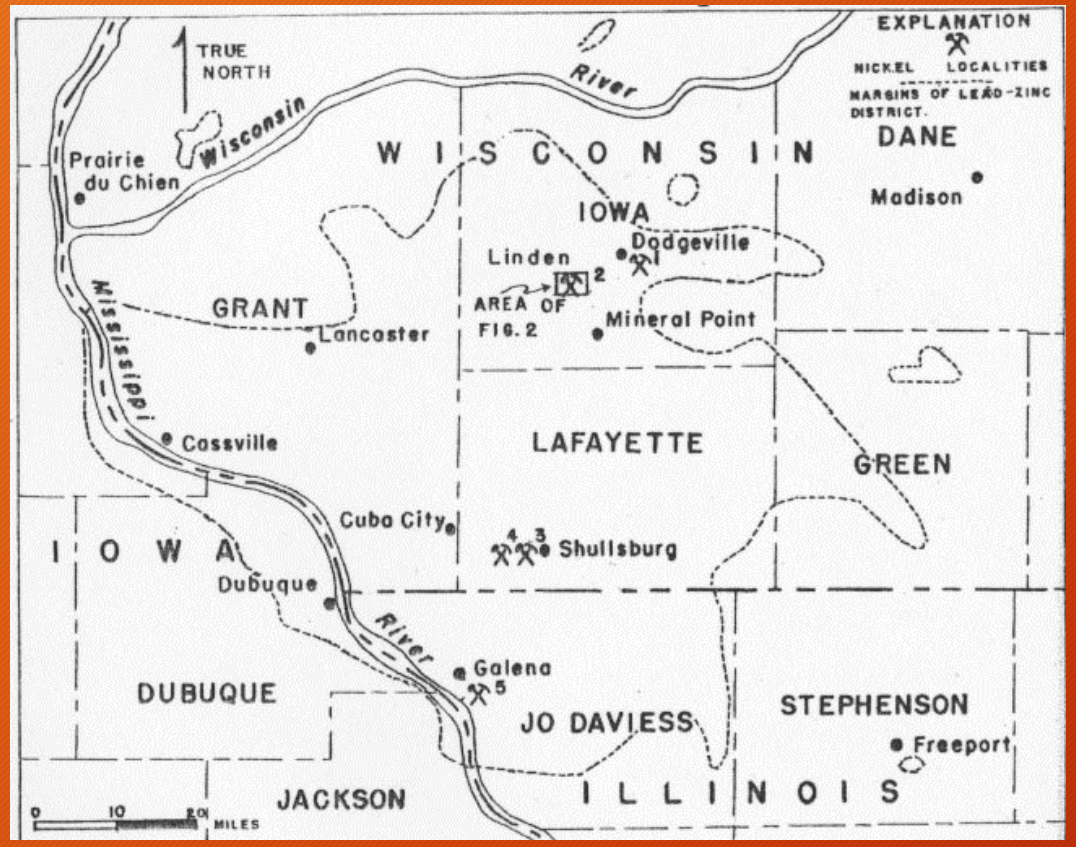


St. Peter Formation

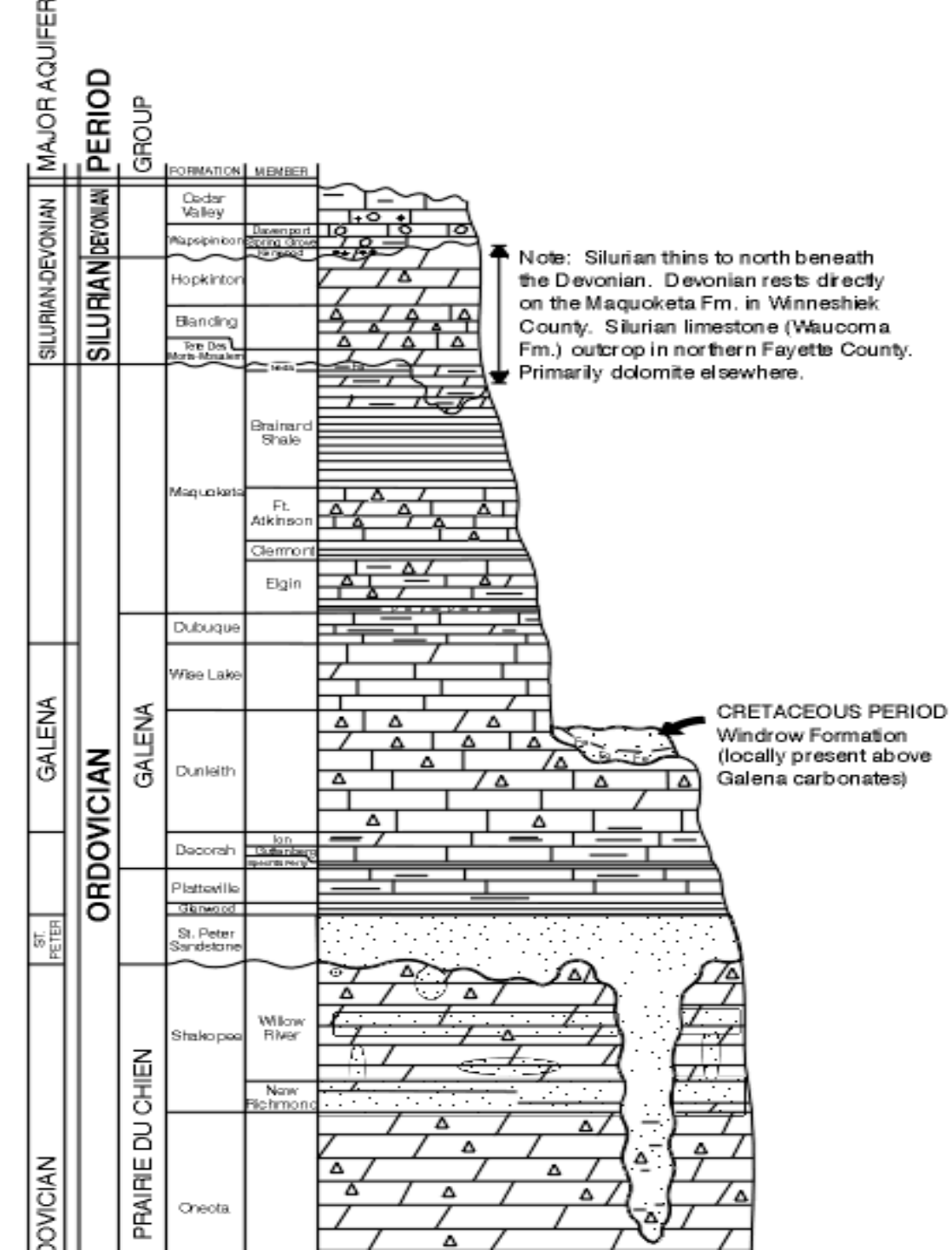
- Quartz Sandstone (super mature)
  - But, In NW Iowa the St. Peter contains a lot of shale from the then exposed Transcontintal Arch
- Well exposed in Pikes Peak St. Park
- An important economic resources for glass and fracking
- 1960's served as a fall out shelter with supplies to meet the needs of 44,000 residents for two weeks

Galena Group

- Dunleith, Wise Lake, and Dubuque Formations

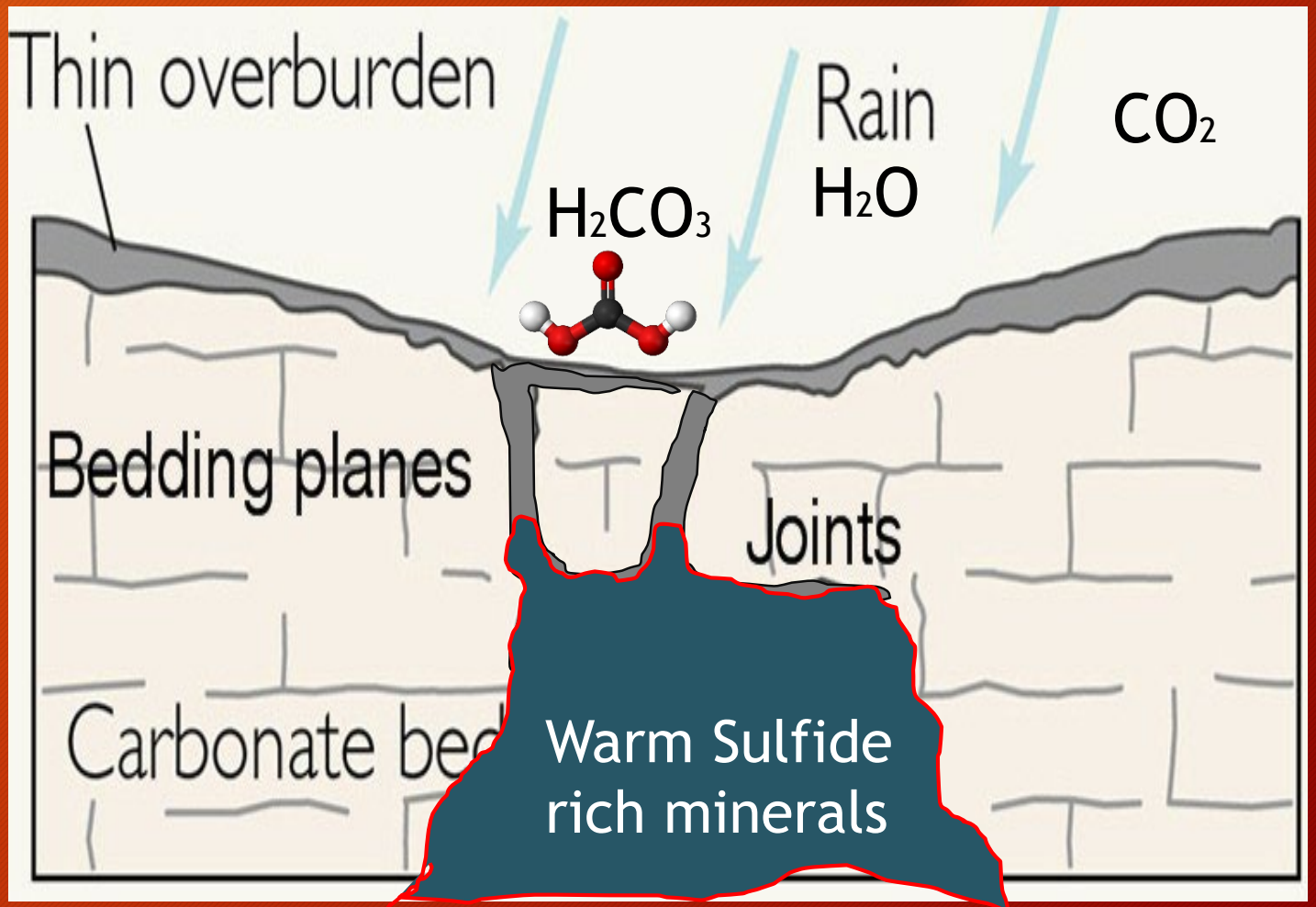


Upper Mississippi Valley Zinc and Lead District



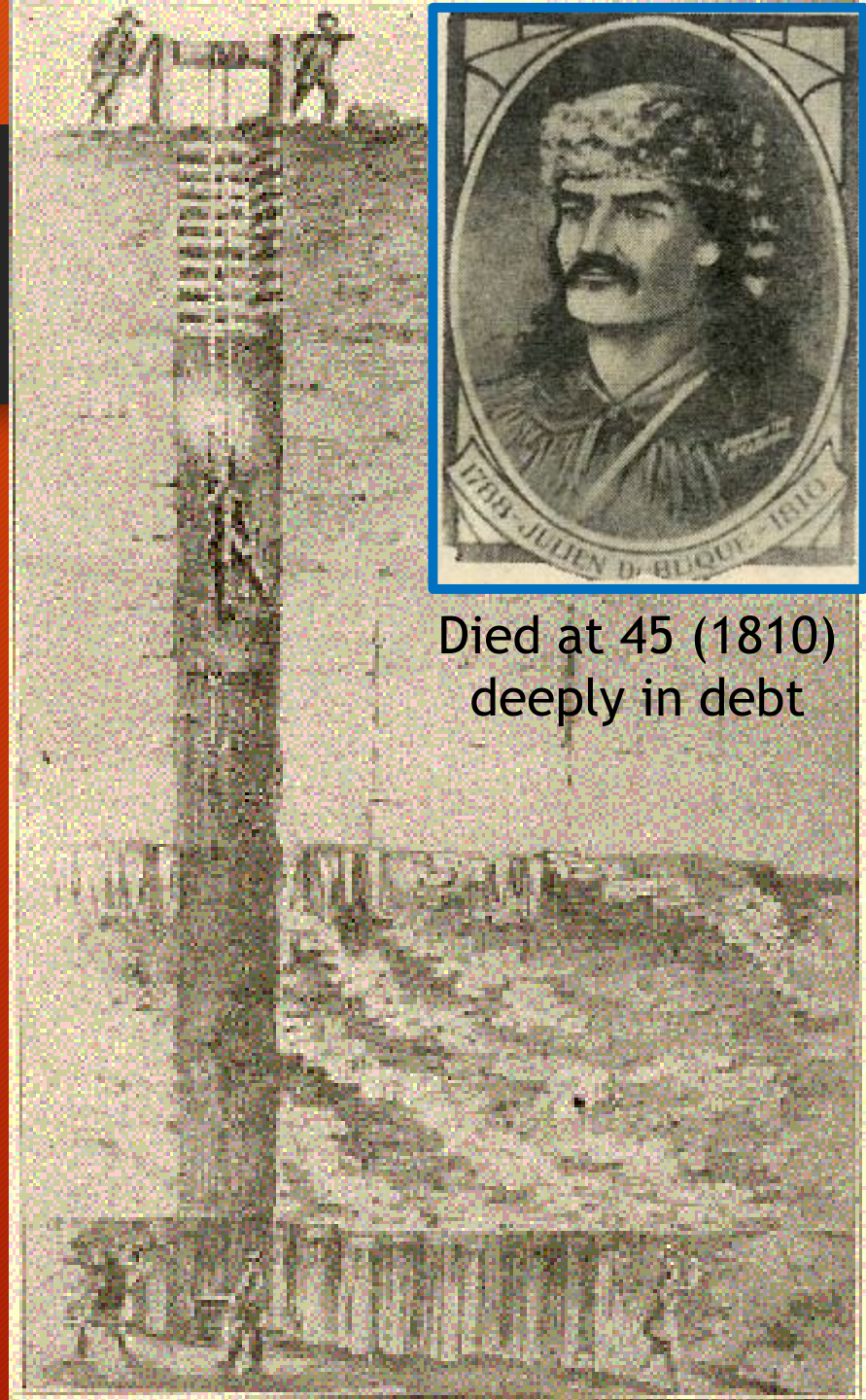
How does Galena & Zinc form in Limestone?

- Space is created, through karst processes
- Warm sulfide-rich solutions migrate upwards and infiltrate the new space
- Sulfide minerals precipitate out of solution and along the edges of these new spaces
- The Mississippi cuts its channel into the landscape and lowers the water table
- Exposing the sulfide minerals, creating Iron sulfide, Lead sulfide, and Zinc sulfides



Lead and Zinc Mining 1788-1810

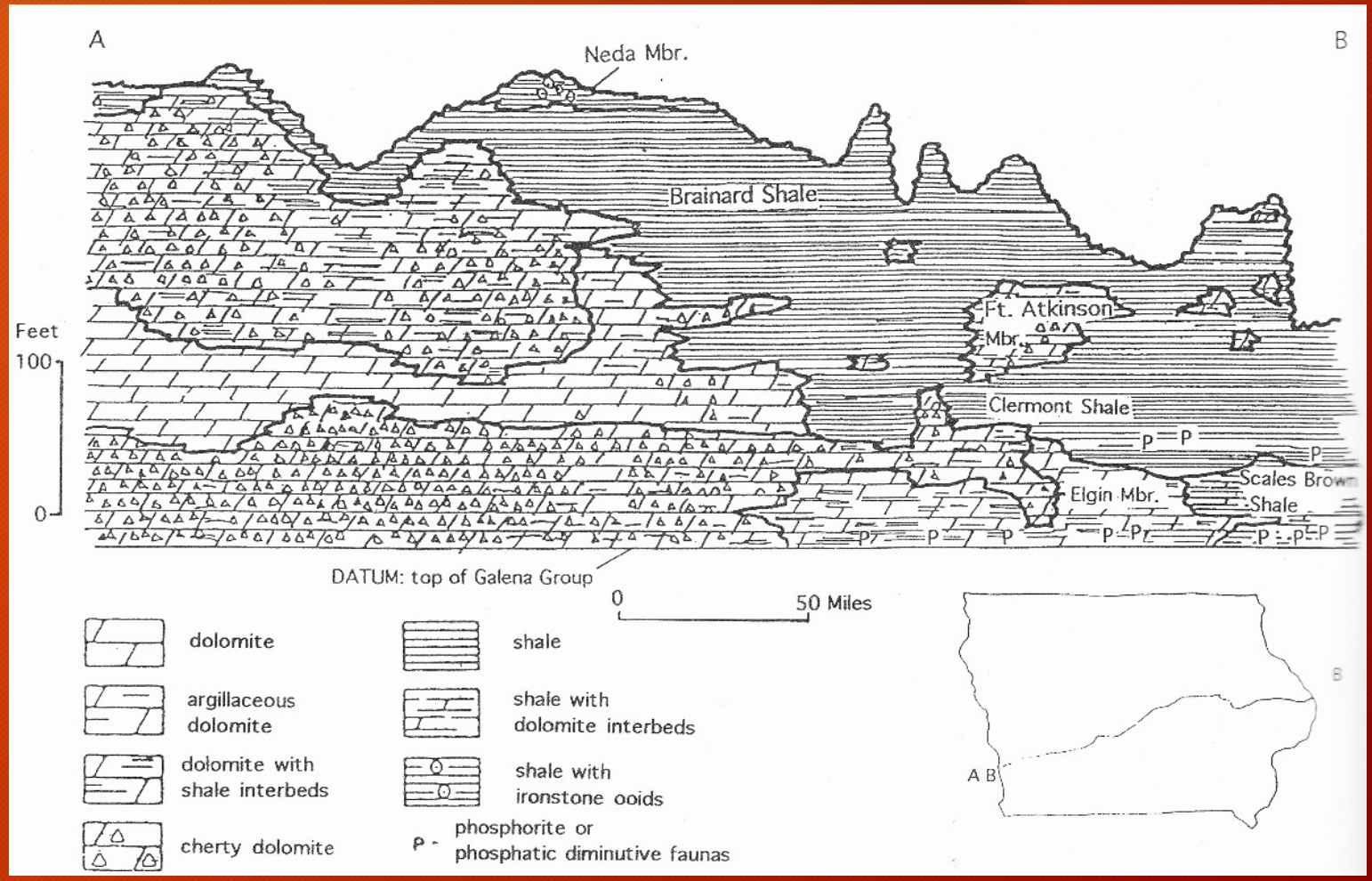
- Spain ruled Iowa via the Treaty of Paris (1763) as a product of the French and Indian War (1756-1763)
- Julien Dubuque became friends with the local Meskwaki, eventually marrying Potosa and entering their culture as *Little Night*.
- Julien, identified the mineral recourses and with the Meskwaki's permission began mining
- Julien, requested ownership/confirmation of his land from the Spain, and it was granted in 1796. 'The Mines of Spain'



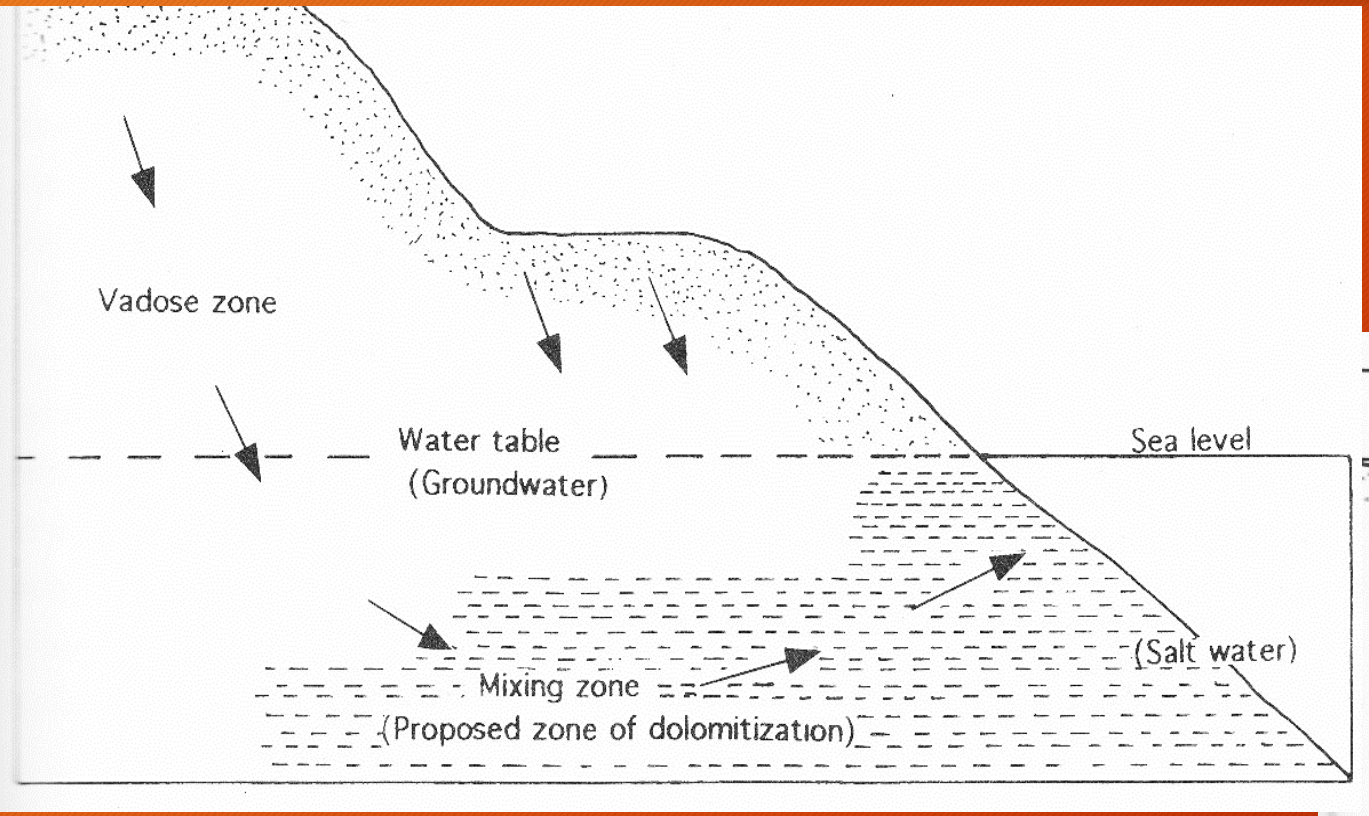
Died at 45 (1810) deeply in debt

Maquoketa Formation

- Thick impermeable shale
- Large caverns were excavated under Johnson and Polk counties to seasonally store liquefied petroleum gas
- Enables the pipeline industry to store their product so that they can meet demand during the winter



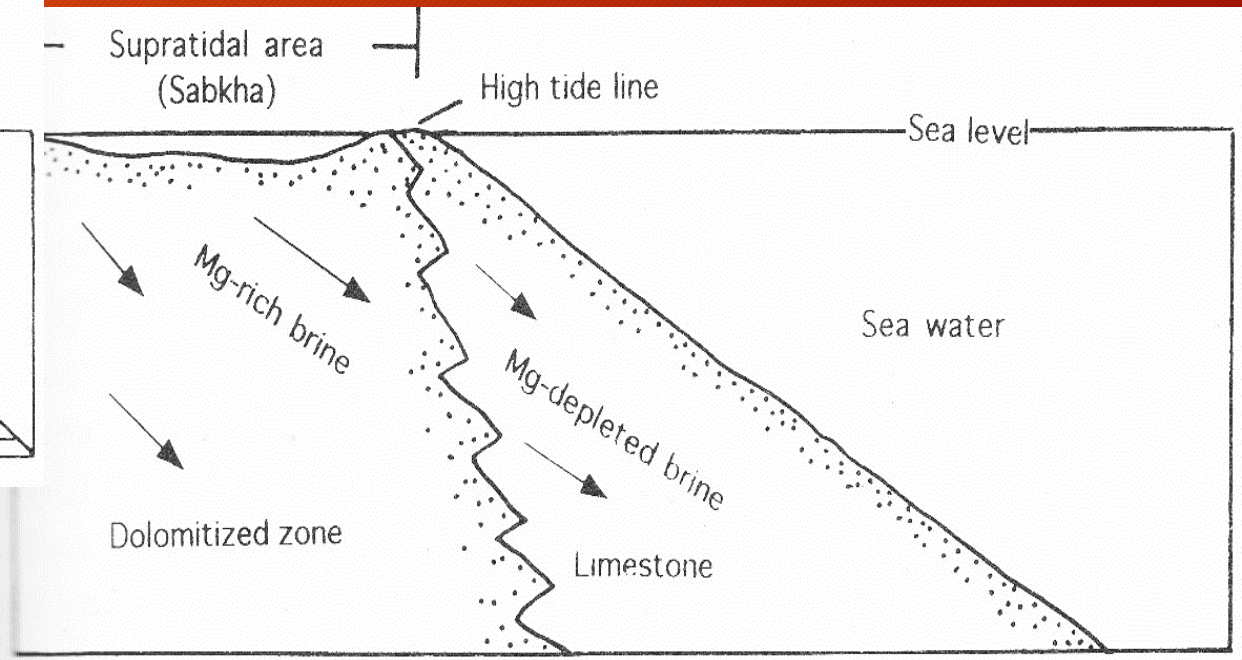
Process of Dolomitization

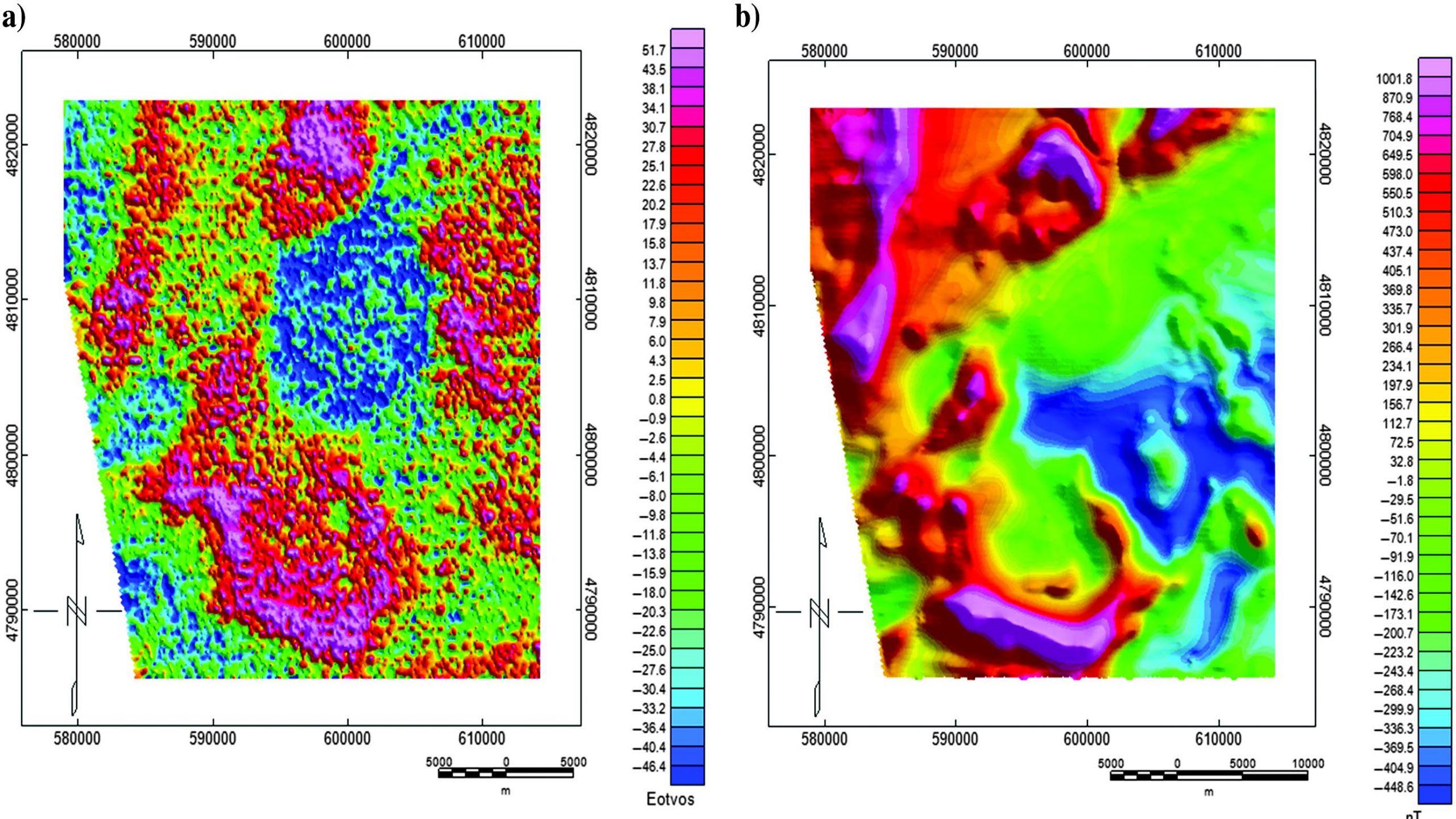


$CaCO_3$

Mg replaces some Ca

$CaMg(CO_3)_2$

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20.2
17.9
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13.7
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9.8
7.9
6.0
4.3
2.5
0.8
−0.9
−2.6
−4.4
−6.1
−8.0
−9.8
−11.8
−13.8
−15.9
−18.0
−20.3
−22.6
−25.0
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−30.4
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550.5
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437.4
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301.9
266.4
234.1
197.9
156.7
112.7
72.5
32.8
−1.8
−29.5
−51.6
−70.1
−91.9
−116.0
−142.6
−173.1
−200.7
−223.2
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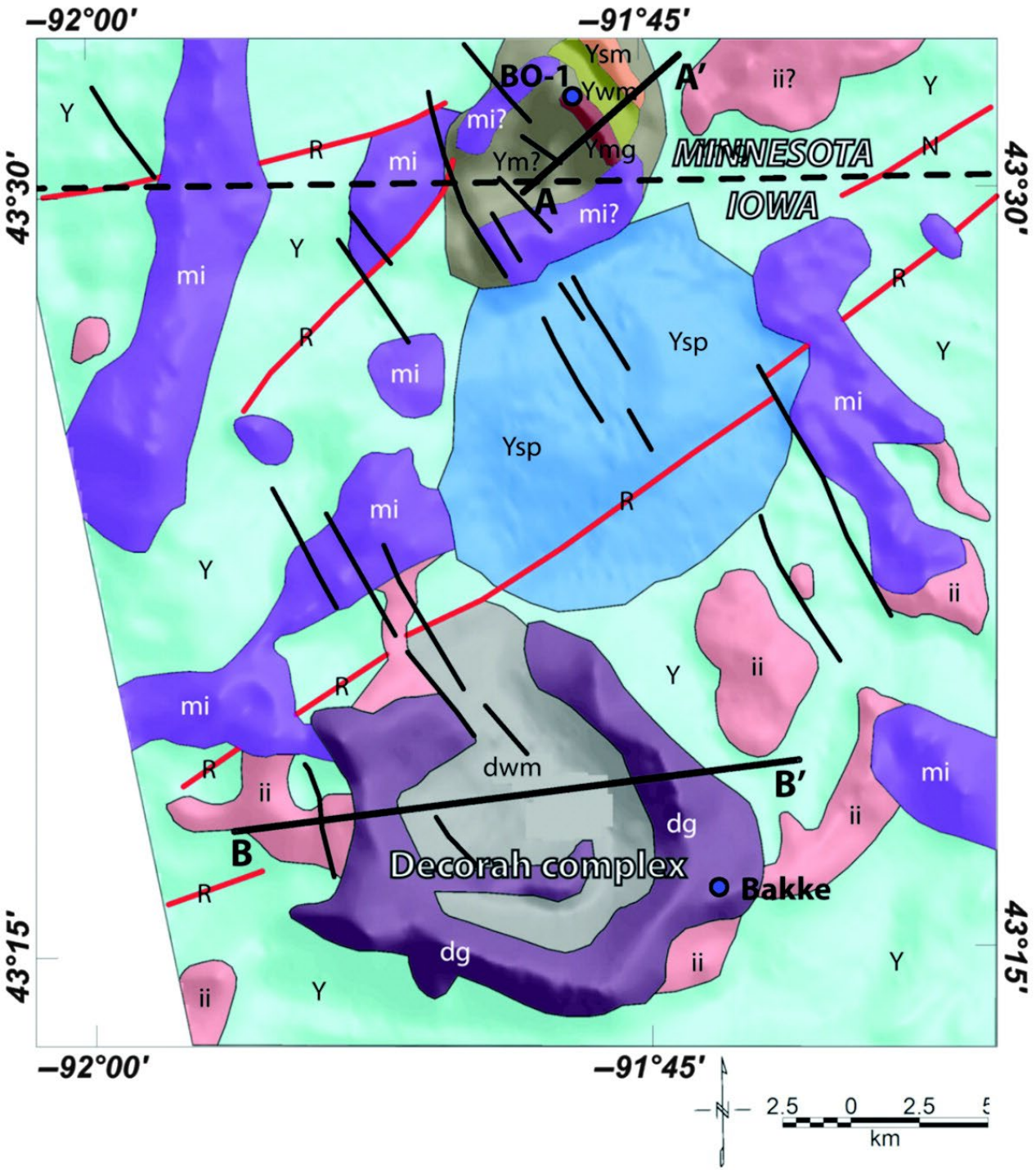
−268.4
−299.9
−336.3
−369.5
−404.9
−448.6
nT



Possible Keweenawan (~1.1 Ga) rocks, largely undeformed

- ii — intermediate or silicic intrusive rocks (strongly magnetized but not dense)
- mi — mafic intrusive rocks (strongly magnetized and dense)
- N — N-polarized diabase dike
- R — R-polarized diabase dike
- dwm — weakly magnetized rocks of Decorah complex (possibly 1500-1430 Ma)
- dg — gabbro of Decorah complex (possibly Mesoproterozoic)

Yavapai province (1.8-1.72 Ga) rocks, some presumed

- Ysm — strongly magnetized part of subvertically-dipping layered intrusion
- Ywm — weakly magnetized part of subvertically dipping layered intrusion
- Ymg — 1760 Ma metagabbro; part of subvertically dipping layered intrusion
- Ym? — undifferentiated mafic rocks, spatially related to layered intrusion
- Ysp — silicic pluton: S-type granite?
- Y — undifferentiated Yavapai province rocks: metavolcanics, plutons, & metasediments

A —— A' line of cross section model

borehole penetrating Proterozoic rocks

possible fault


a

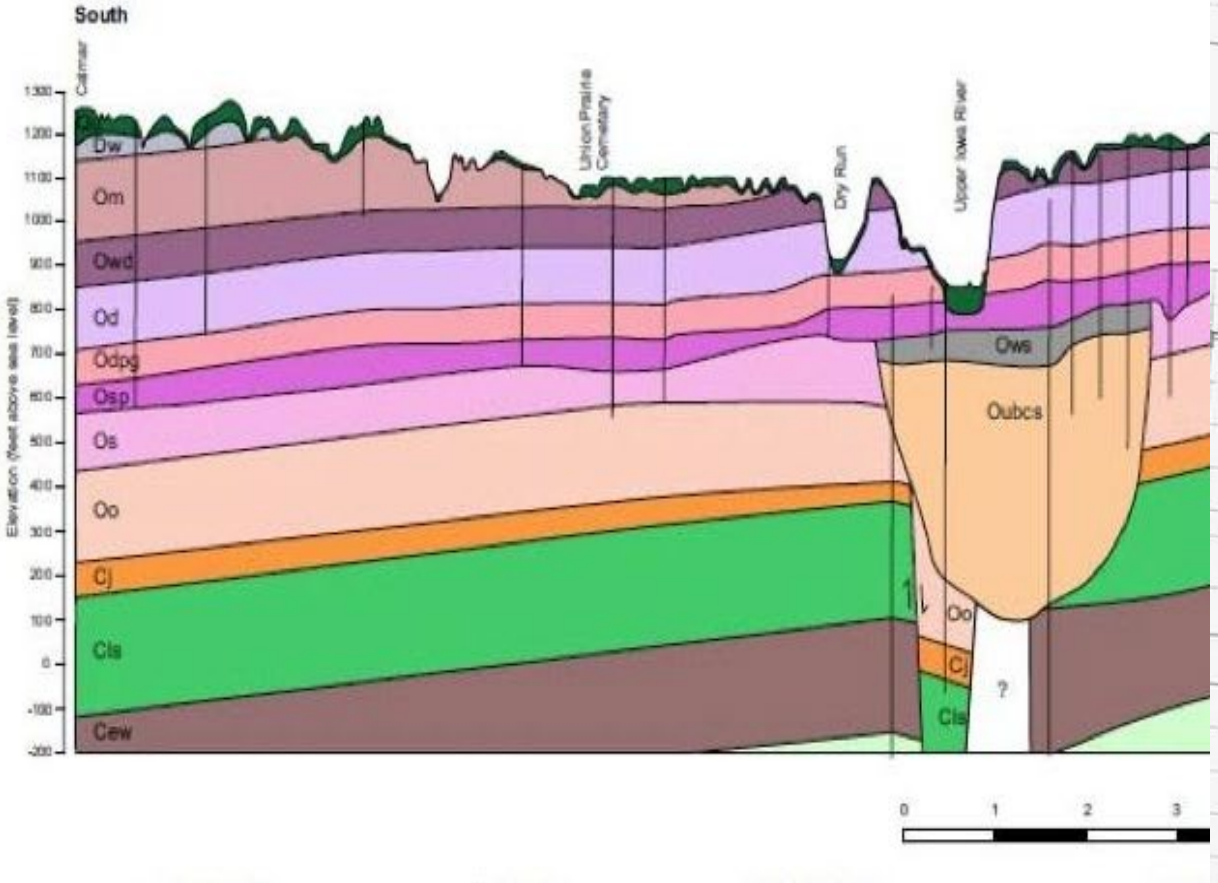

b

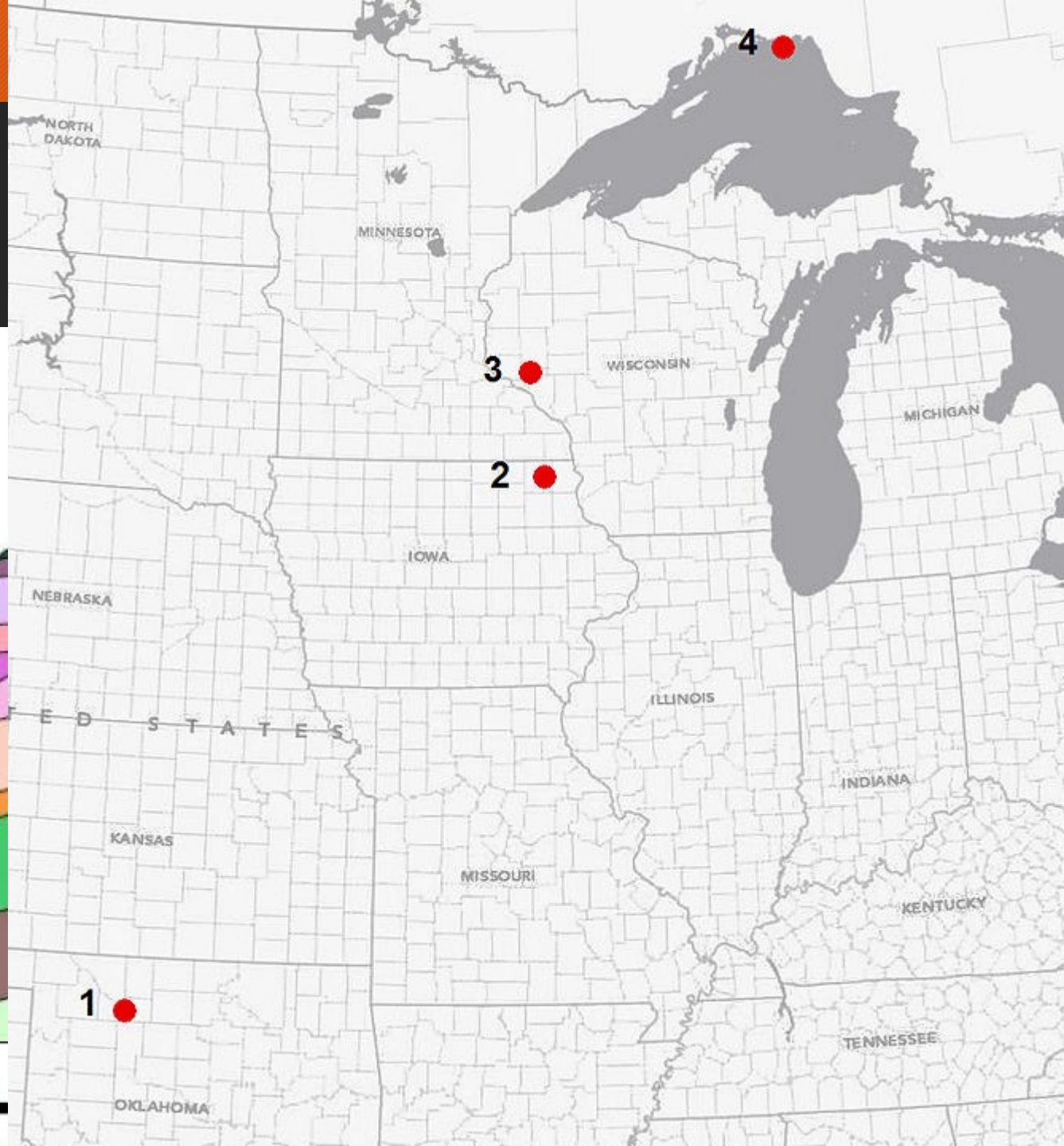

c


d
5cm

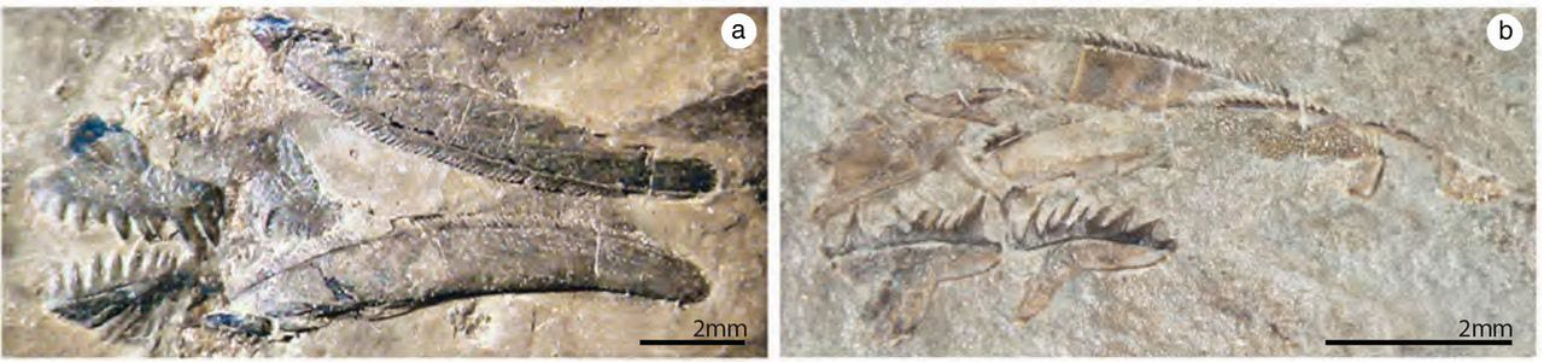

e

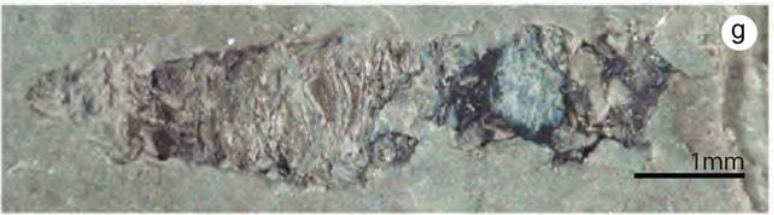
Decorah Impact Structure

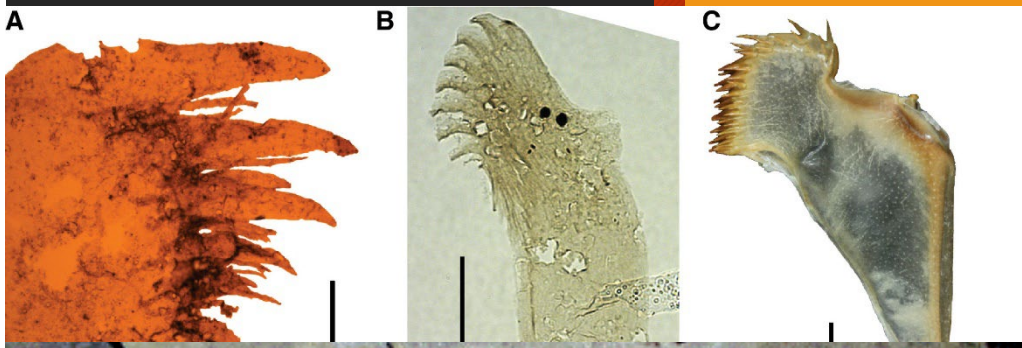




Decorah Lagerstätten







Eurypterids – Sea Scorpions

Extinct arthropods

Silurian – Dolomite and Carbonate Mounds

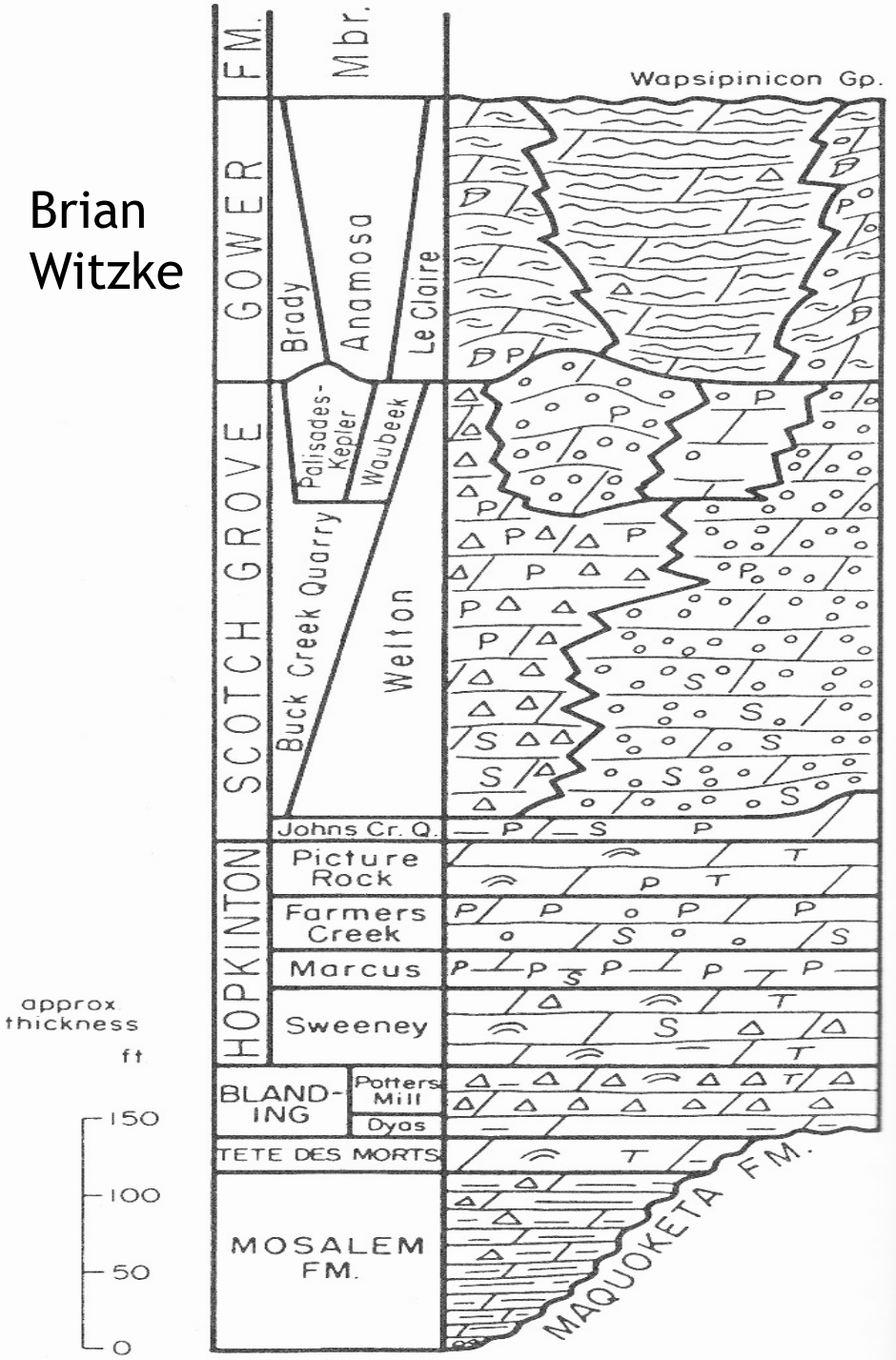
419 Ma
To
443 Ma

- Six Dolomite and two limestone formations, that provide the foundation for many of Eastern Iowa's State parks.
- There are five marine Transgression to Regression phases recorded in Iowa's Silurian Formations.
- These Silurian rocks have great economic value (agricultural lime, road aggregate, aggregate for concrete, building stone and as bedrock aquifers.
- Towards the end of the Silurian there was another period of weathering and erosion that created an unconformity between the Silurian and Devonian.

Silurian stratigraphy

- Dolostone formations
  - Mosalem
  - Tete des Morts
  - Blanding
  - Hopkinton
  - Scotch Grove
  - Gower
- Limestone formations
  - Waucoma
  - Le Porte City

Brian Witzke



Hopkinton Formation

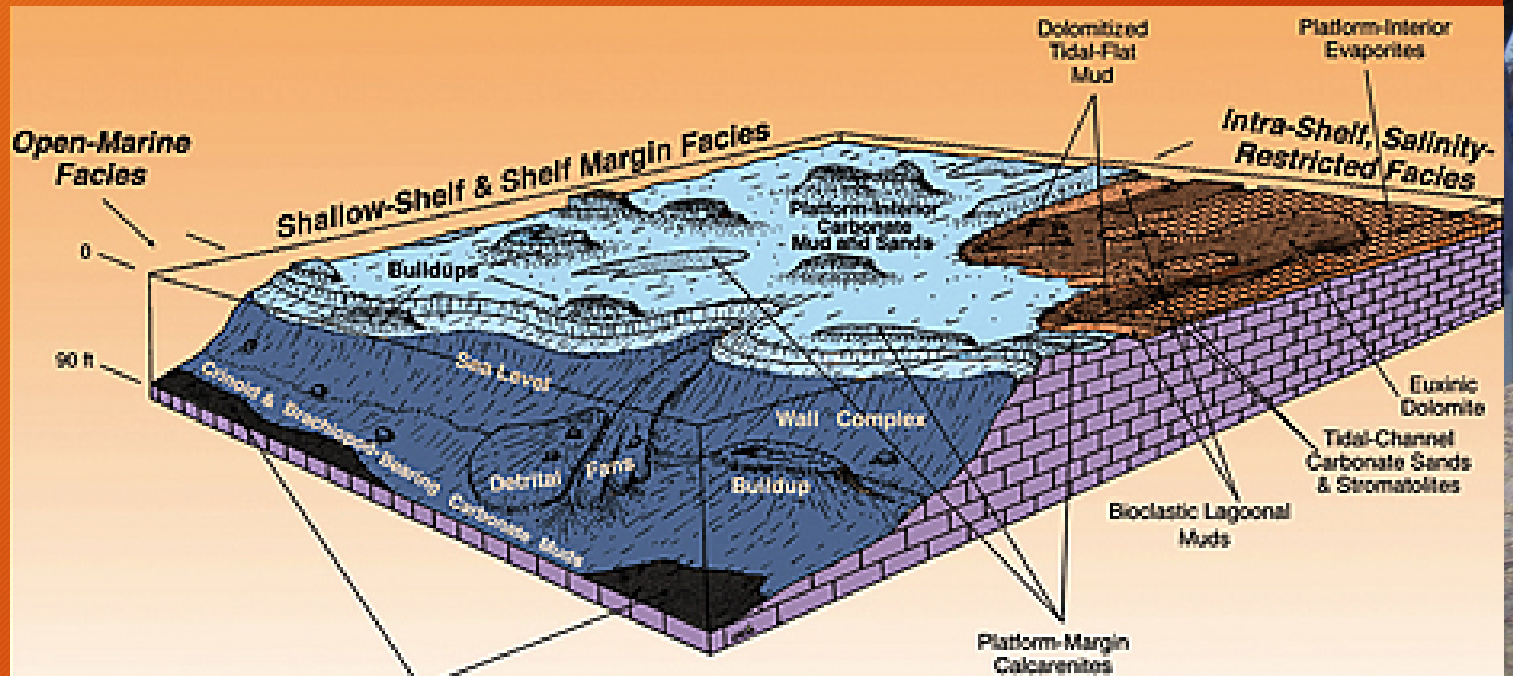
- Common in eastern Iowa
- Very-fine to coarsely crystalline dolostones with areas of nodular chert
- Contains four members
  - Sweeney
  - Marcus
  - Farmers Creek
  - Picture Rock

State Parks

- Maquoketa Caves State Park
- Backbone State Park
- Mississippi Palisades State Park
- Picture Rock County Park (Jones Co.)

Scotch Grove Formation

- Overlies the Hopkinton Fm. as dolostone with cherty intervals
- Represented by the natural bridge feature at Maq. Caves State Park



Anamosa Facies – Ideal building stone

- Uniform bedding
- Fine consistent texture
- Used for many of Iowa's early buildings
  - Rock Island Arsenal (IL)
  - Anamosa Prison
  - Stone City, IA
  - Cornell College
  - Herbert Hoover Presidential Lib.
  - Three large buildings in downtown Minneapolis

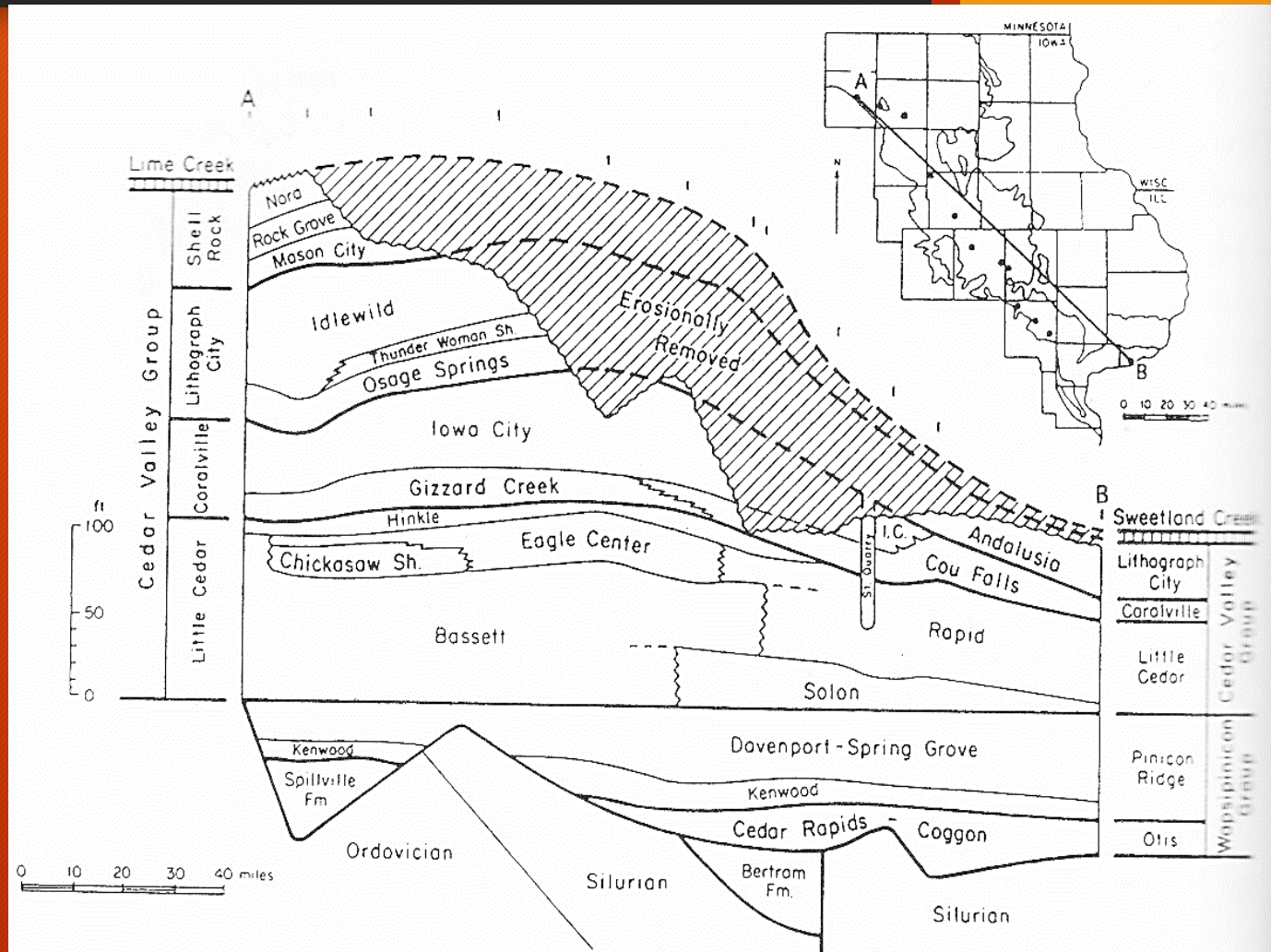
Devonian – A Marine Extravaganza ☺

358 Ma
To
419 Ma

- The Devonian System contains 13 formations.
- Economically valuable resource for road and concrete aggregate in eastern Iowa and gypsum is mined southeastern and north-central Iowa for Portland Cement.
- The Devonian System also serves as an important aquifer/water source for eastern and north-central Iowa.
- These formations also contain significant and well preserved fossils

Little Cedar Formation

- Basal Fm. of the Cedar Valley Group
- Solon Member is mostly limestone with abundant fossils
- Rapid Member fine-grained argillaceous limestone that is also fossil rich

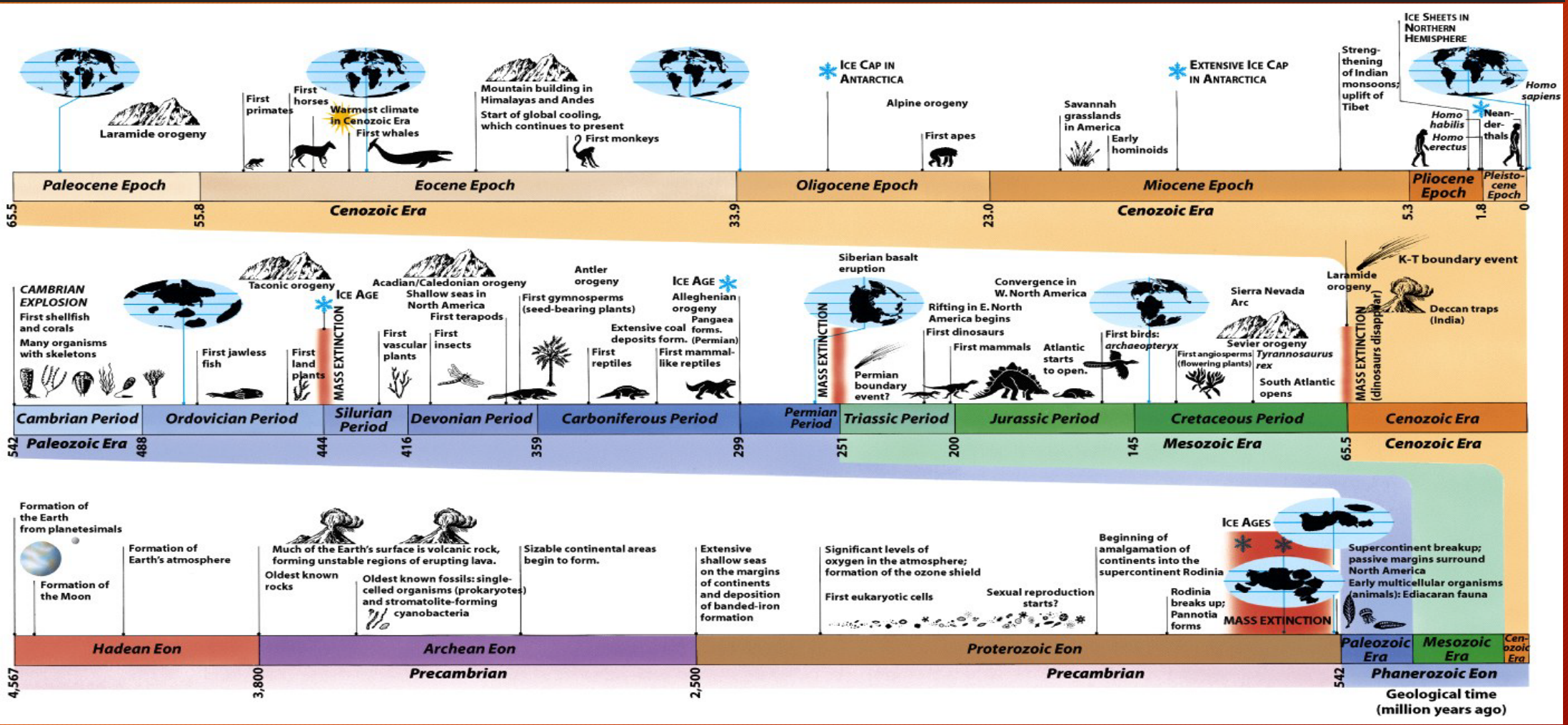


Lithograph City Formation

- An extremely fine grained / pure limestone
- Used for Lithography in the early 1900. Lithography City – Floyd-Mitchell county line
- Quarried extensively for road and concrete aggregate as well as Portland Cement

Carboniferous – Mississippian – Last major sea

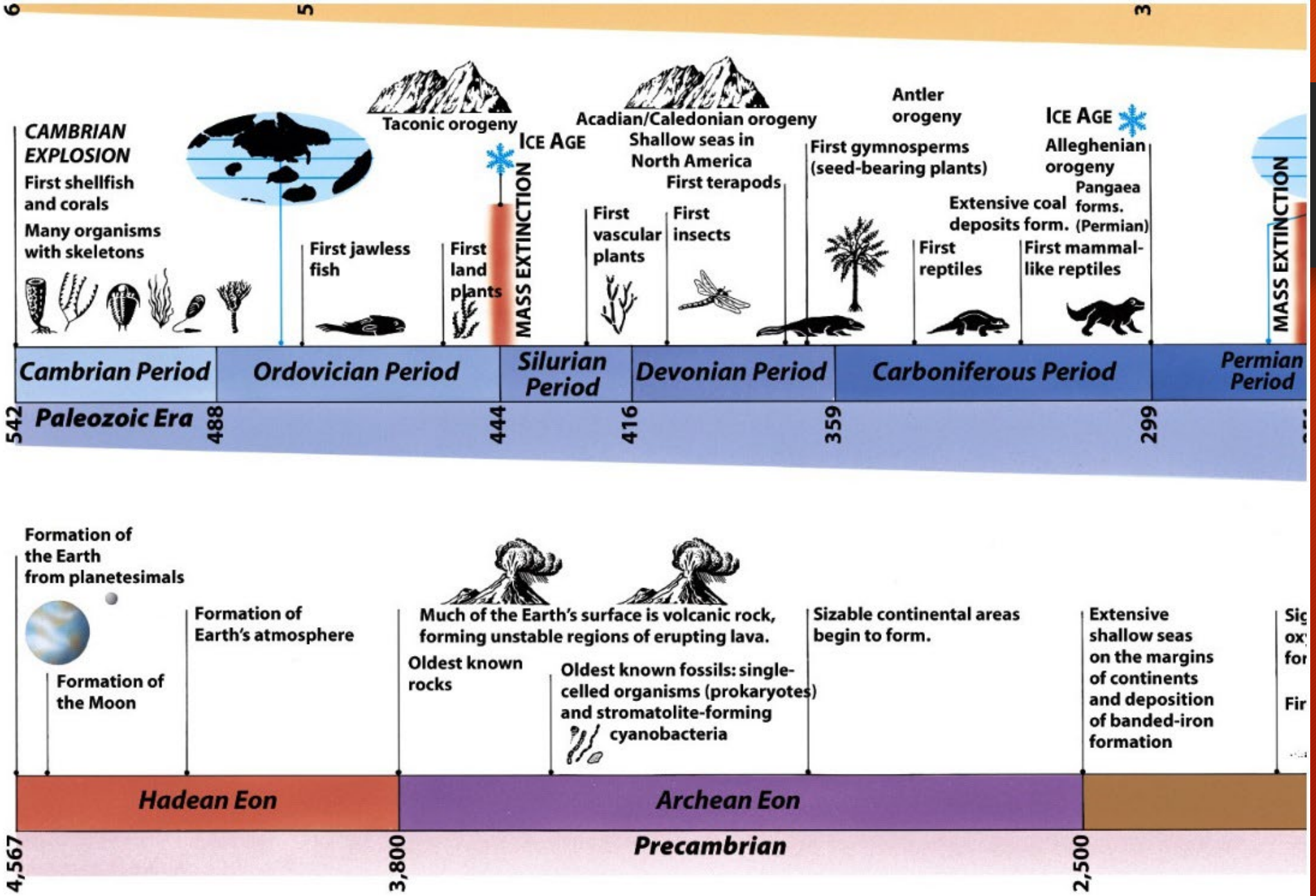
323 Ma
To
358 Ma



Carboniferous – Mississippian – Last major sea

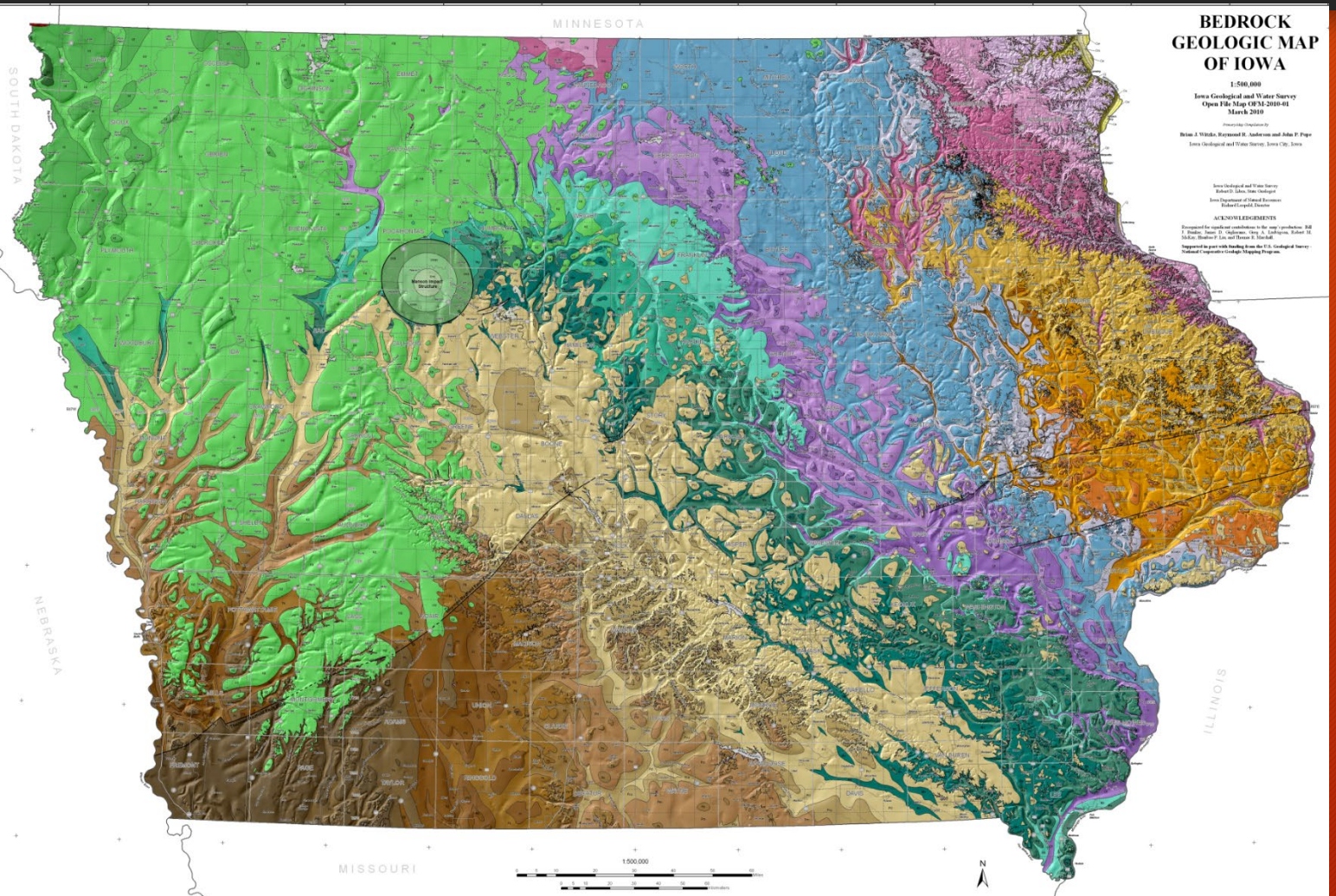
323 Ma
To
358 Ma

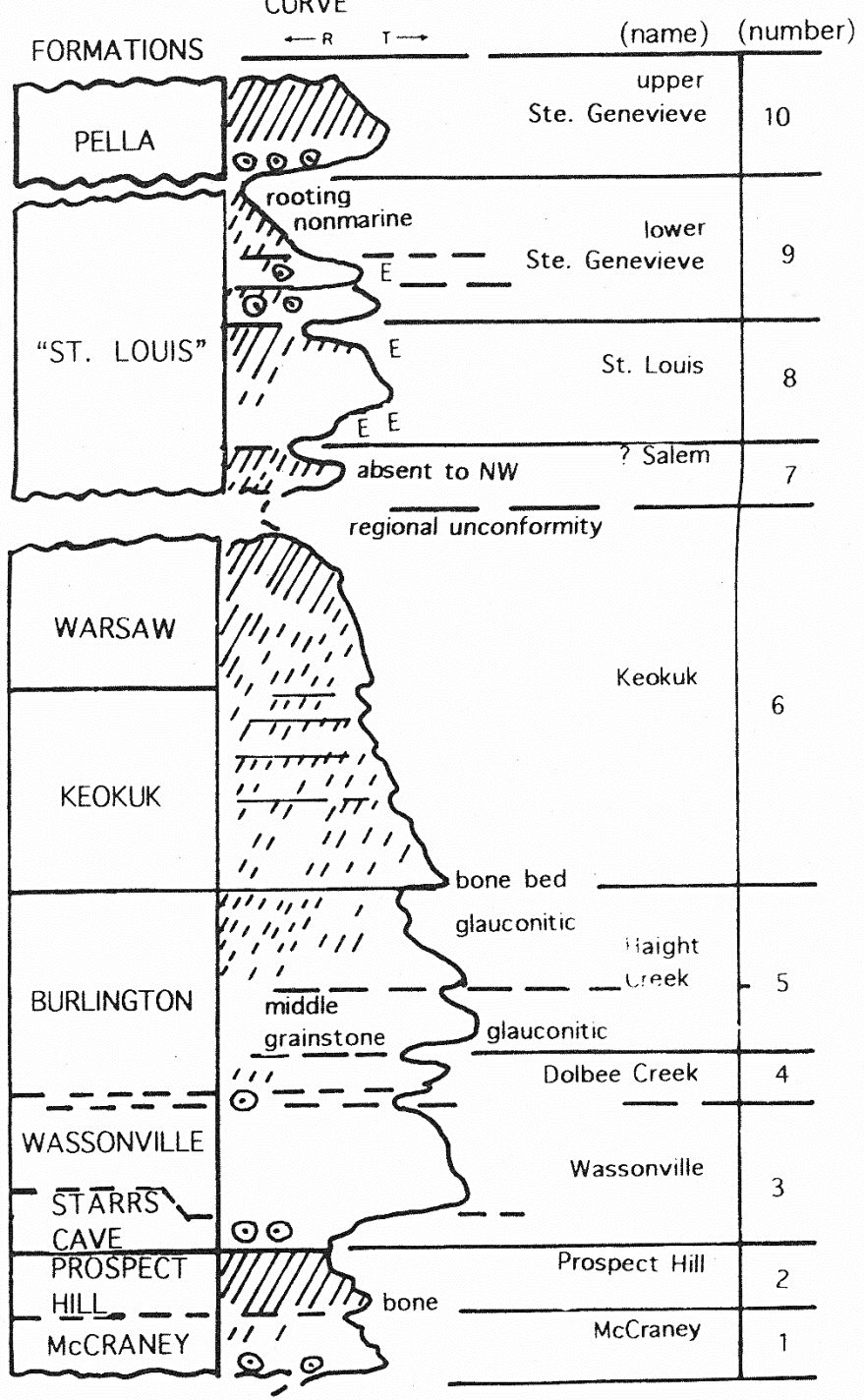
- The stratigraphic record contains TEN Transgression-Regression (T-R) Cycles
- Oolites and sand-sized fossil fragments are abundant
  - Exceptionally preserved fossils!
- Likely similar to the Bahama Banks environment of deposition today
  - Uniformitarianism
- Is as an important groundwater reservoir for north central Iowa


6
5
3
Taconic orogeny
Acadian/Caledonian orogeny
Antler orogeny
ICE AGE
ICE AGE
CAMBRIAN EXPLOSION
First shellfish and corals
Many organisms with skeletons
First jawless fish
First land plants
MASS EXTINCTION
Shallow seas in North America
First terapods
First vascular plants
First insects
First gymnosperms (seed-bearing plants)
Extensive coal deposits form.
Pangaea forms. (Permian)
Allegheny orogeny
First reptiles
First mammal-like reptiles
MASS EXTINCTION
Cambrian Period
Ordovician Period
Silurian Period
Devonian Period
Carboniferous Period
Permian Period
Paleozoic Era
542
488
444
416
359
299

Formation of the Earth from planetesimals
Formation of the Moon
Formation of Earth's atmosphere
Much of the Earth's surface is volcanic rock, forming unstable regions of erupting lava.
Oldest known rocks
Oldest known fossils: single-celled organisms (prokaryotes) and stromatolite-forming cyanobacteria
Sizable continental areas begin to form.
Extensive shallow seas on the margins of continents and deposition of banded-iron formation
Hadean Eon
Archean Eon
Precambrian
4,567
3,800
2,500

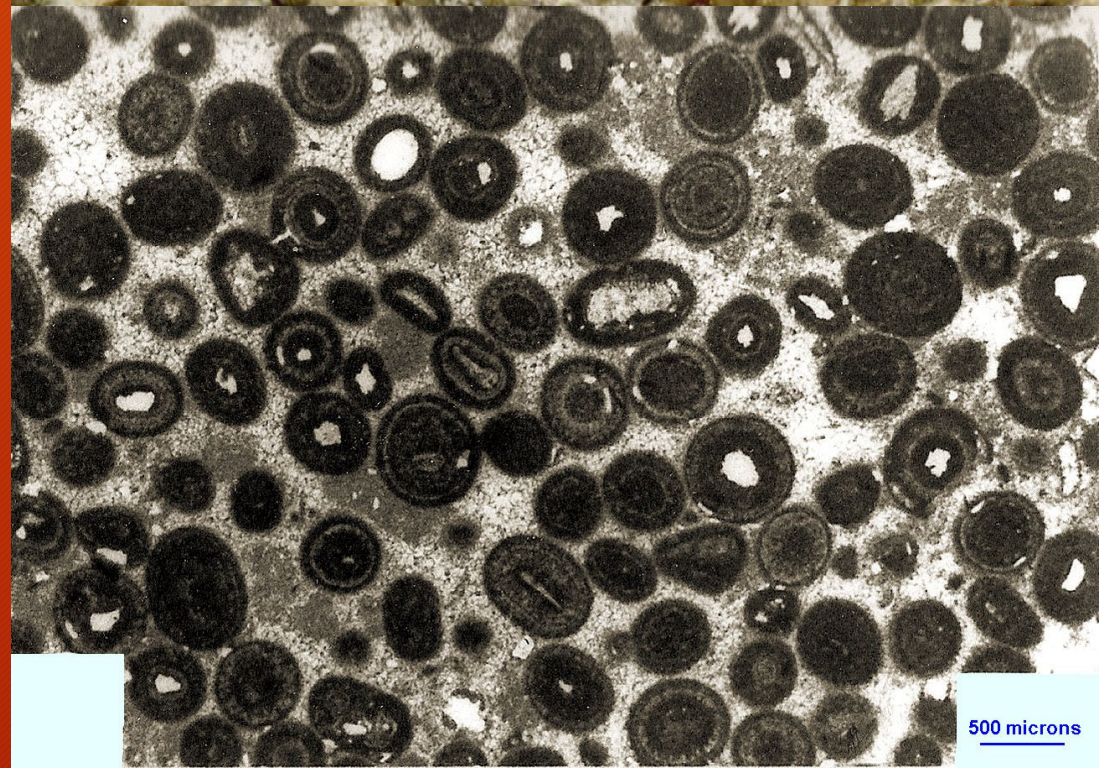
Mississippian





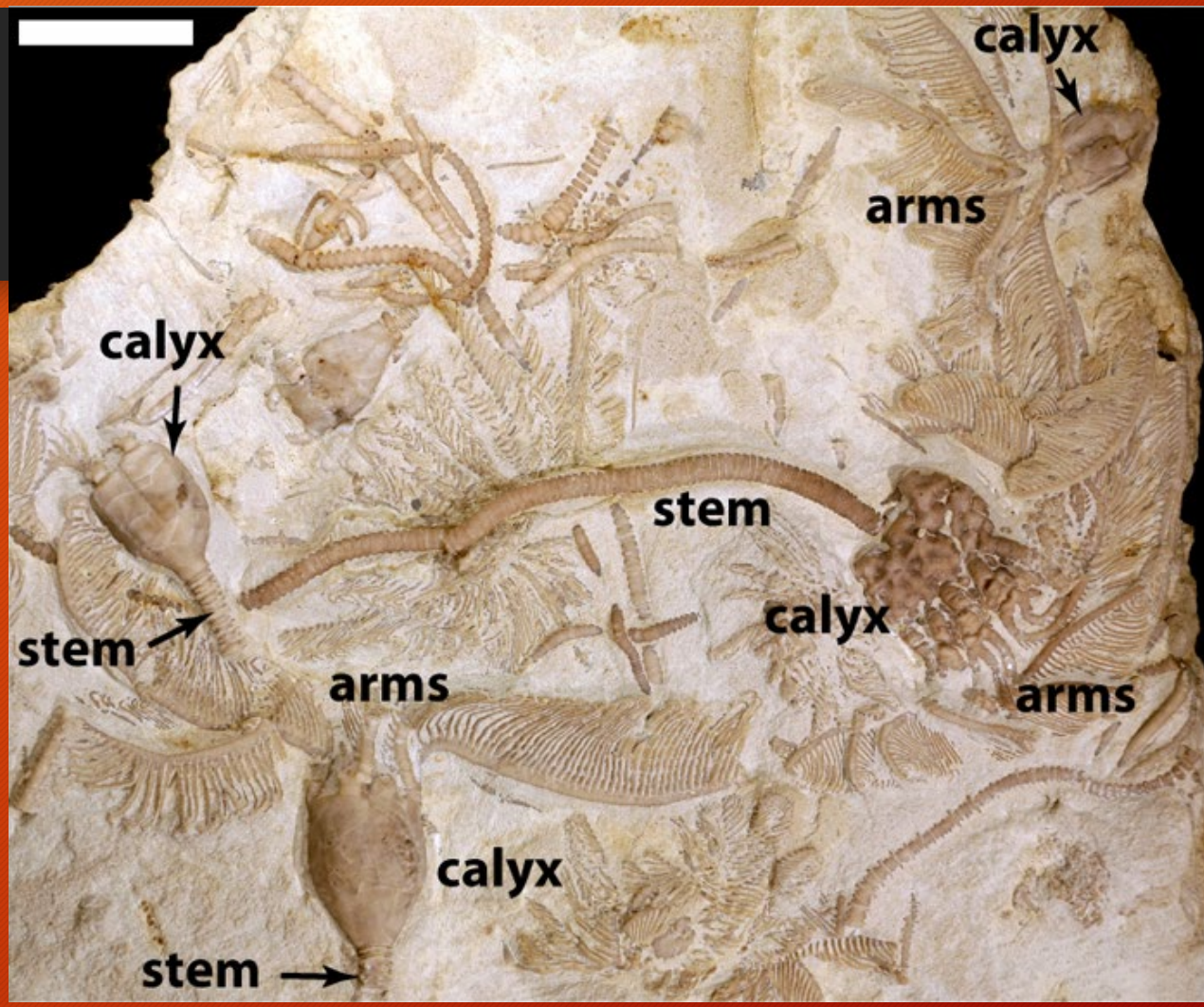
Starrs Cave Formation

- Burlington, Iowa along Flint Creek
- Oolitic grainstone



Burlington Formation

- One of Iowa's most well-known formations
- Excellent source for flint/chert used by native Americans
- Crinoidal limestone (packstone and grainstone)



Warsaw Formation

- First described by James Hall near Warsaw, Illinois
- Southeastern Iowa
- Lower clay-rich dolostone unit yields abundant geodes

Carboniferous – Pennsylvanian – Coal swaps

232 Ma
to
298 Ma

- Coastal shorelines
  - Coal deposits
  - Cliff-forming Sandstone
    - Dolliver Memorial State Park
    - Ledges State Park
    - Wildcat Den State Park
    - Red Rock Reservoir
    - Pilot Knob County Park
- Deltas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1:500,000
Iowa Geological and Water Survey
Open File Map OFM-2010-01
March 2010
Brian J. Witzke, Raymond R. Anderson and John F. Pope
Iowa Geological and Water Survey, Iowa City, Iowa
Iowa Geological and Water Survey
Robert D. Libra, State Geologist
Iowa Department of Natural Resources
Richard Leopold, Director
ACKNOWLEDGEMENTS
Supported in part with funding from the U.S. Geological Survey - National Cooperative Geologic Mapping Program.
Manson Impact Structure
Forest City Basin
MINNESOTA
SOUTH DAKOTA
NEBRASKA
MISSOURI
ILLINOIS
1:500,000
N

Cherokee Group

Stratigraphy, petrology, and paleogeography of the upper portion of the

Cherokee Group

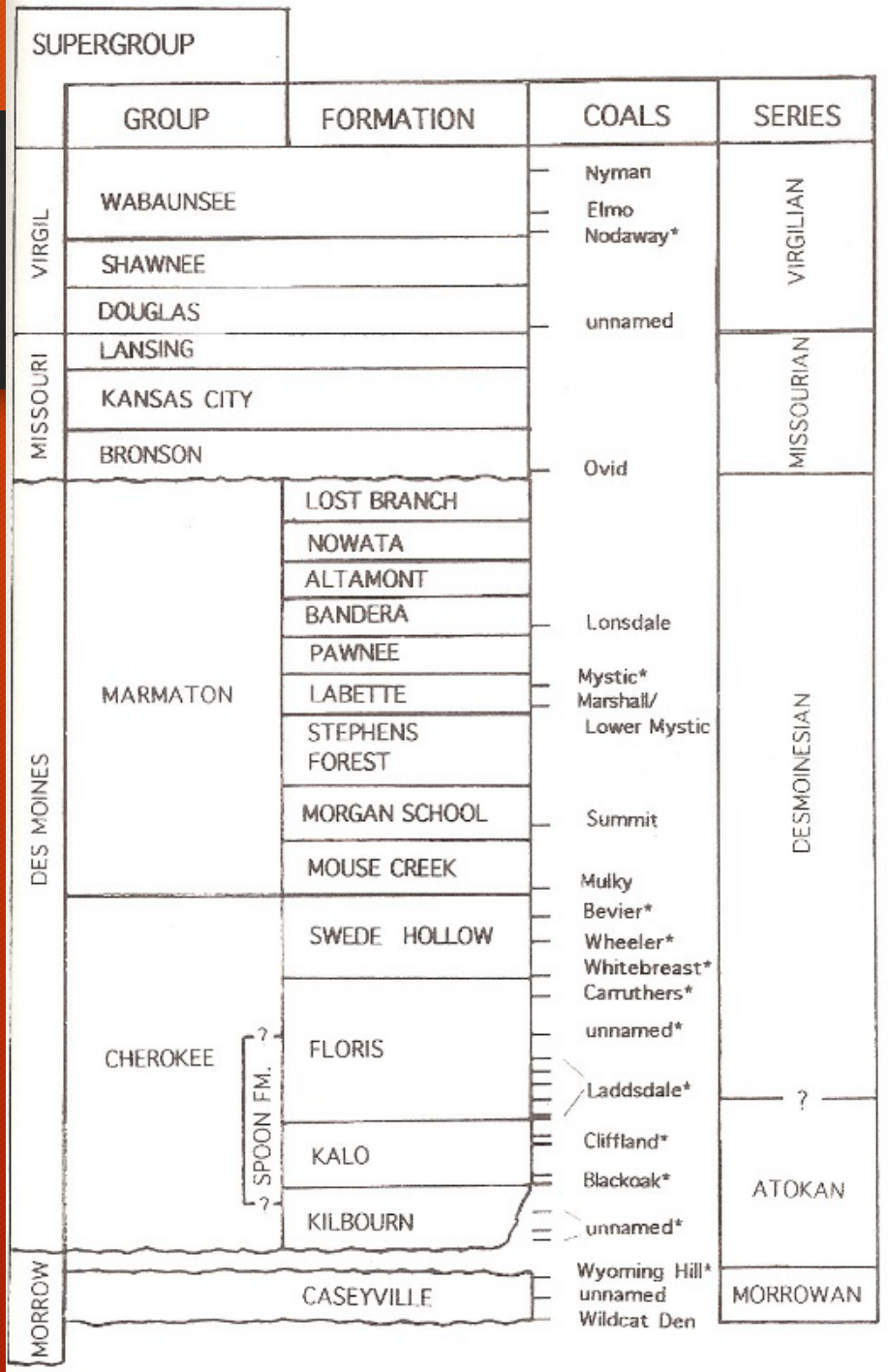
(Middle Pennsylvanian), eastern Kansas and northeastern Oklahoma

Robert L. Brenner

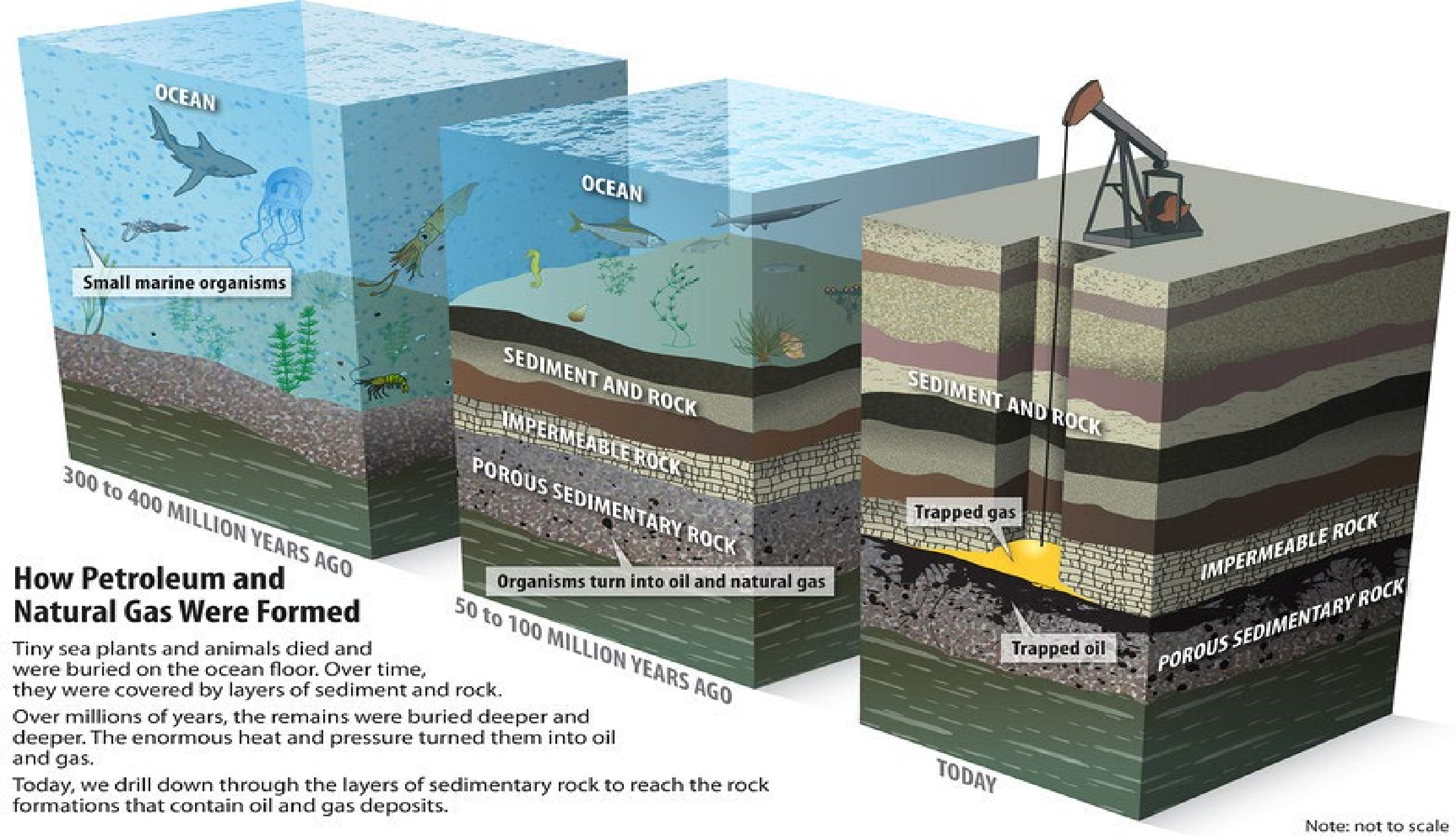
Geology Series 3 1989

Kansas Geological Survey

INTEGRATIVE STRATIGRAPHY
Concepts and Applications



Lepidodendron



How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sediment and rock.

Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

Today, we drill down through the layers of sedimentary rock to reach the rock formations that contain oil and gas deposits.

Note: not to scale

Types of Coal

- Anthracite
- Bituminous
- Sub-Bituminous
- Lignite

Iowa Coal

- Sub-Bituminous to Bituminous
- High ash and sulfur content
  - Ash results from sediment (impurities) that were washed into the swamps
  - Sulfur occurs as pyrite (FeS_2)
- Iowa coal is not considered a natural resources because it is not economically feasible to extract.

Mesozoic – Evaporite Deposits
Last of the Shallow Inland Seas

66 Ma
to
232 Ma

66
to
252

- Massive weathering and erosion
  - Large unconformity between the Mesozoic and Cenozoic
  - Iowa has no Permian or Triassic rock record!
- Fort Dodge Formation contains thick evaporate deposits of rock gypsum with minor red, green, and gray clastic rocks.
- Manson Impact Structure at 73.8 Ma

Fort Dodge Formation

- First thought to be Permian, because of association with western USA gypsum and ‘red-bed’ deposits
- Jurassic – based on fossil plant remains
- Fort Dodge Gypsum
  - $CaSO_4 * H_20$

The Cardiff Giant

- 1866 – George Hull visits his sister in Ackley, Iowa and goes to church
- 1868 – One dark night the Gypsum Giant is buried on his Brother-in-laws farm near Cardiff, New York
- 1869 – The Giant was ‘discovered’, a tent was set up, droves of people came to see the giant @ 50 cents a person
- James Hall – The most remarkable object yet brought to light in this country’

“People are gullible”
- George Hull


The photograph published in *Strand* Magazine in 1895.

Cretaceous

- Dakota Formation
  - Western Iowa
    - Sandstone, mudstone, conglomerate
    - Fluvial environments

THE MANSON IMPACT STRUCTURE

IOWA'S GREATEST CATASTROPHE

Viva Ray Anderson

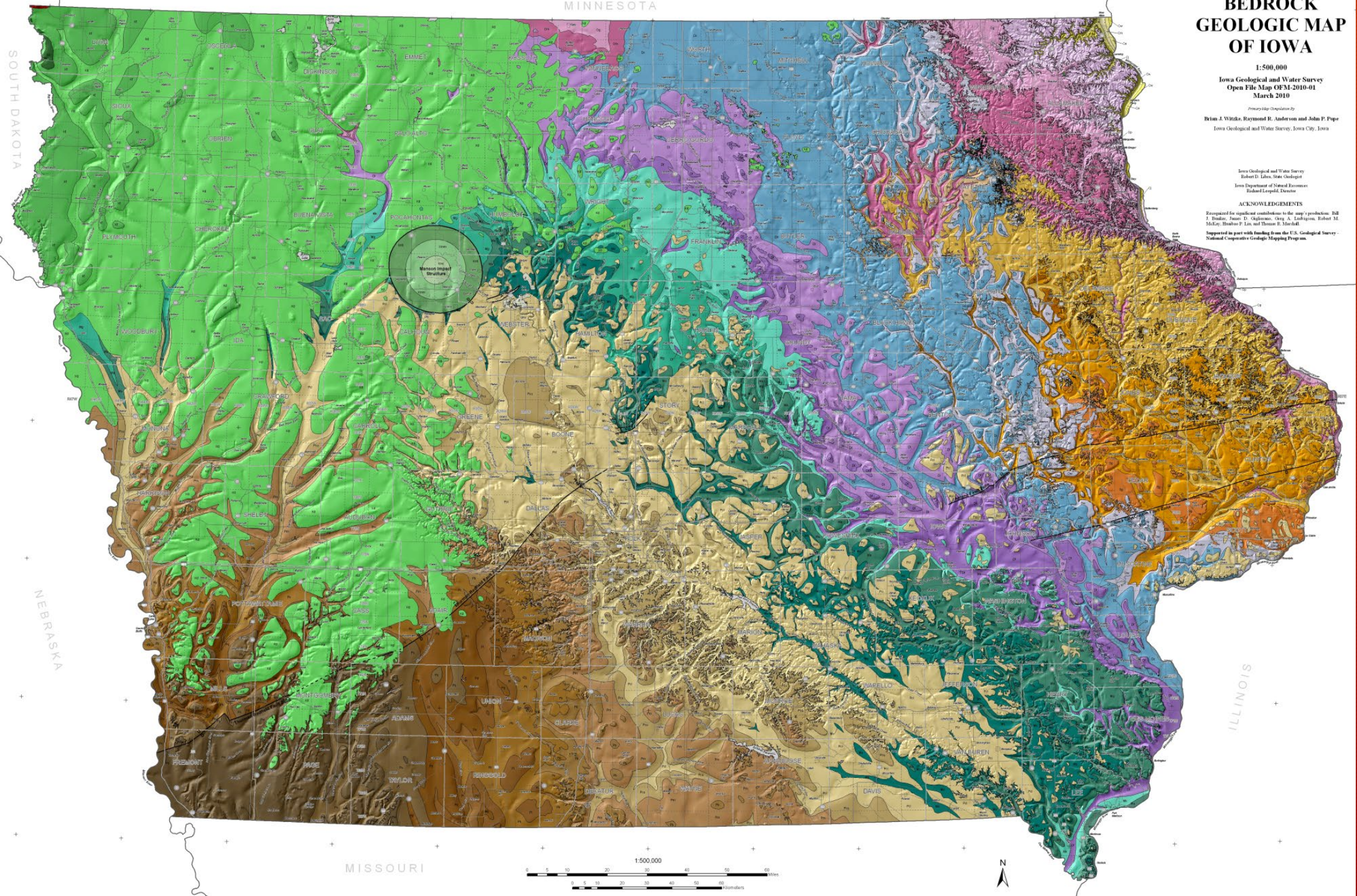
4 principal factors that created Iowa's Landscapes

BEDROCK

GLACIAL

DRAINAGE DEVELOPMENT

Humans



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March 2010

Primary Map Compilation By

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Iowa Geological and Water Survey, Iowa City, Iowa

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Iowa Department of Natural Resources
Richard Leopold, Director

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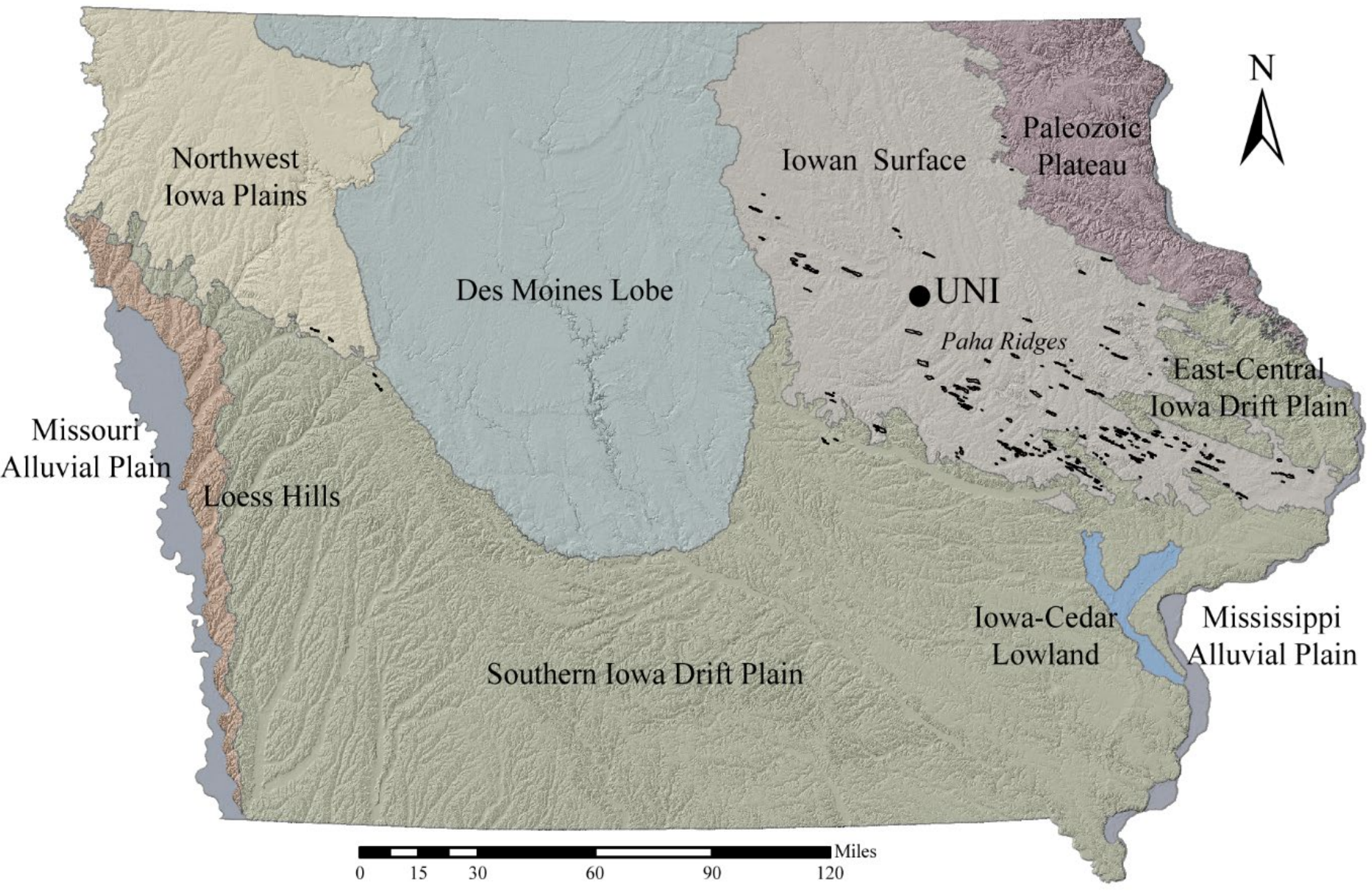
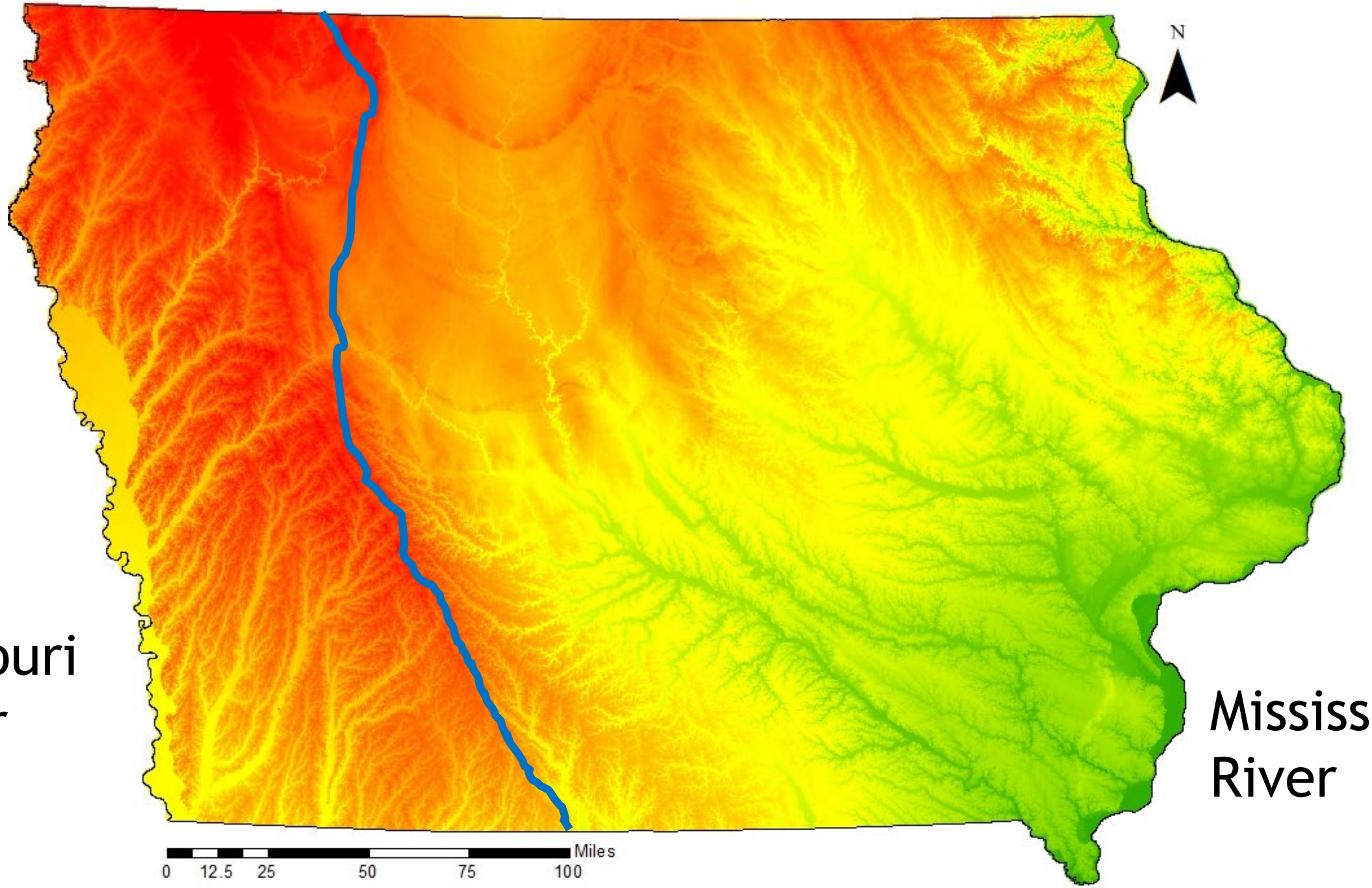
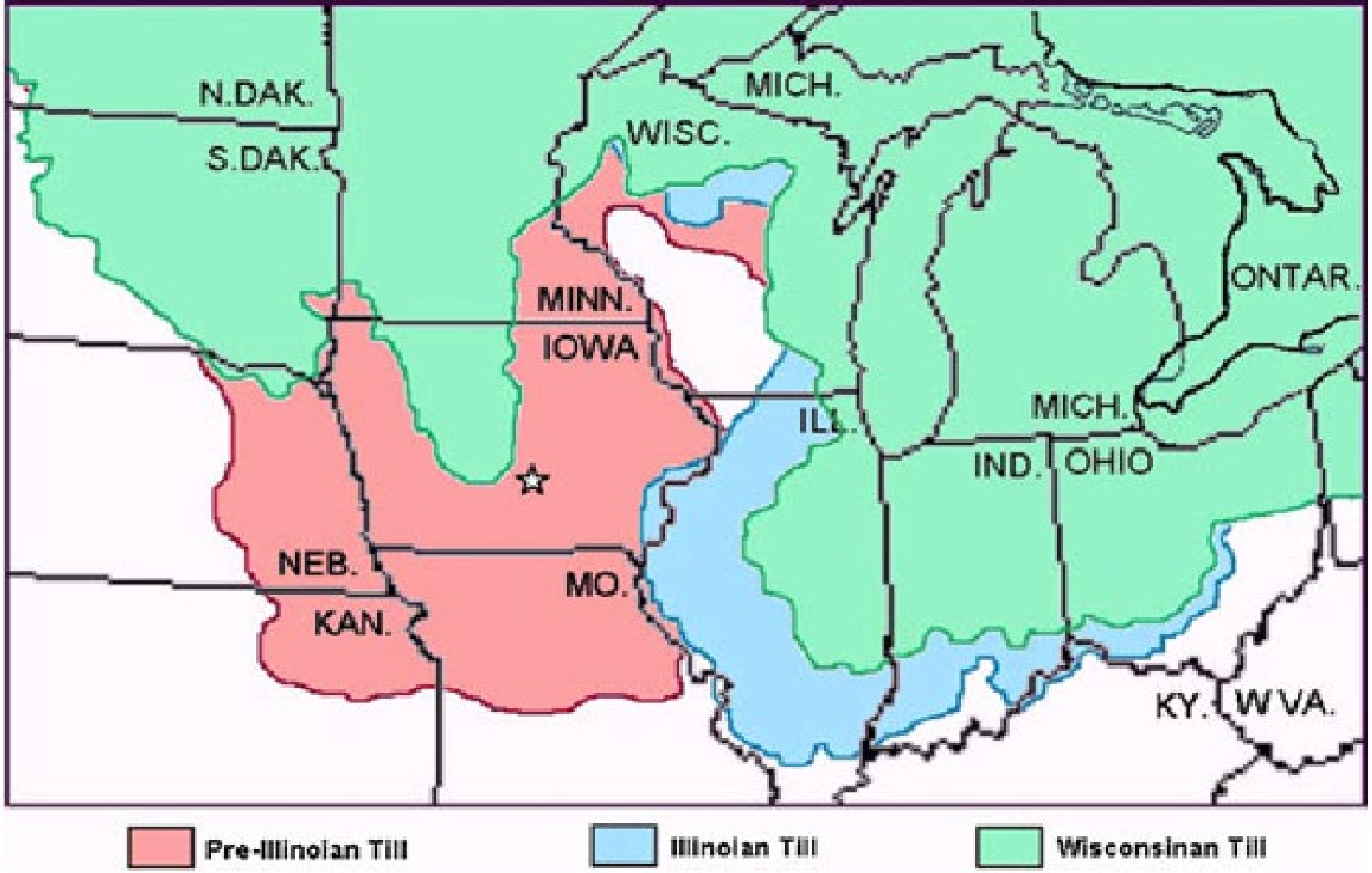

N
Northwest
Iowa Plains
Des Moines Lobe
Iowan Surface
Paleozoic
Plateau
UNI
Paha Ridges
East-Central
Iowa Drift Plain
Missouri
Alluvial Plain
Loess Hills
Iowa-Cedar
Lowland
Mississippi
Alluvial Plain
Southern Iowa Drift Plain
Miles
0
15
30
60
90
120



Missouri River

Mississippi River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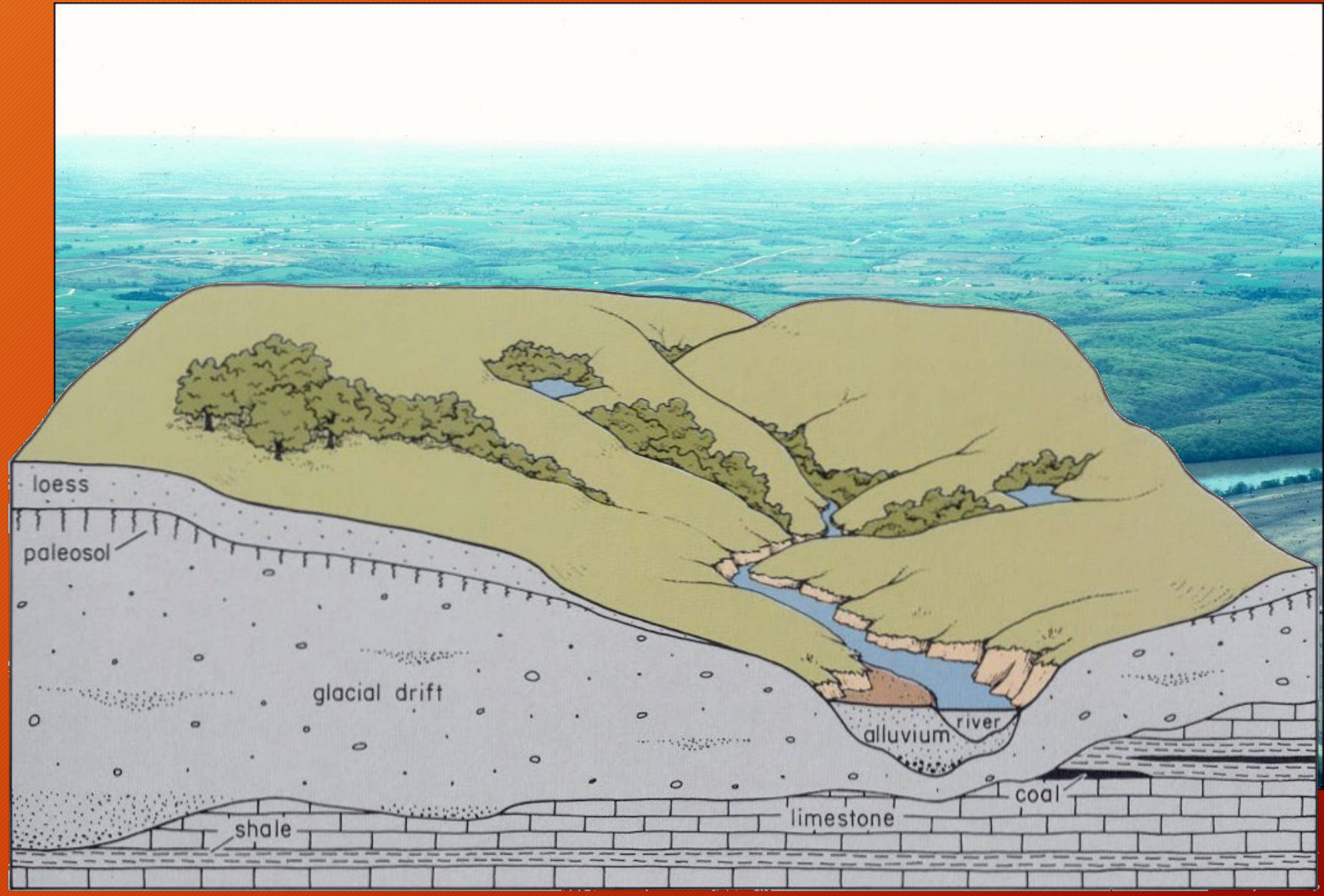
S.DAK.
MICH.
WISC.
MINN.
IOWA
ONTAR.
ILL.
MICH.
IND.
OHIO
NEB.
MO.
KAN.
KY.
W.VA.
Pre-Illinoian Till
Illinoian Till
Wisconsinan Till

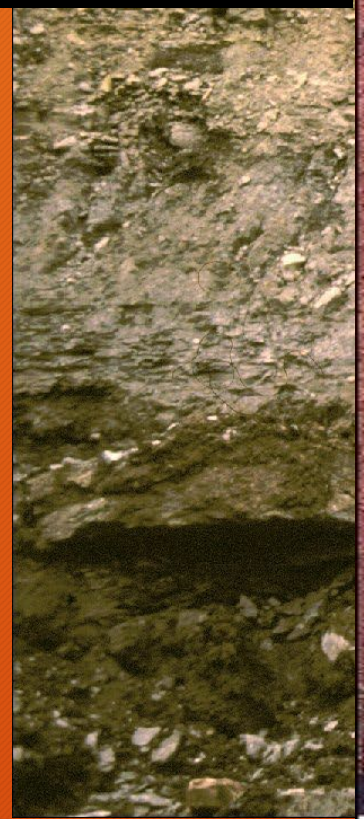
Southern Iowa Drift Plain



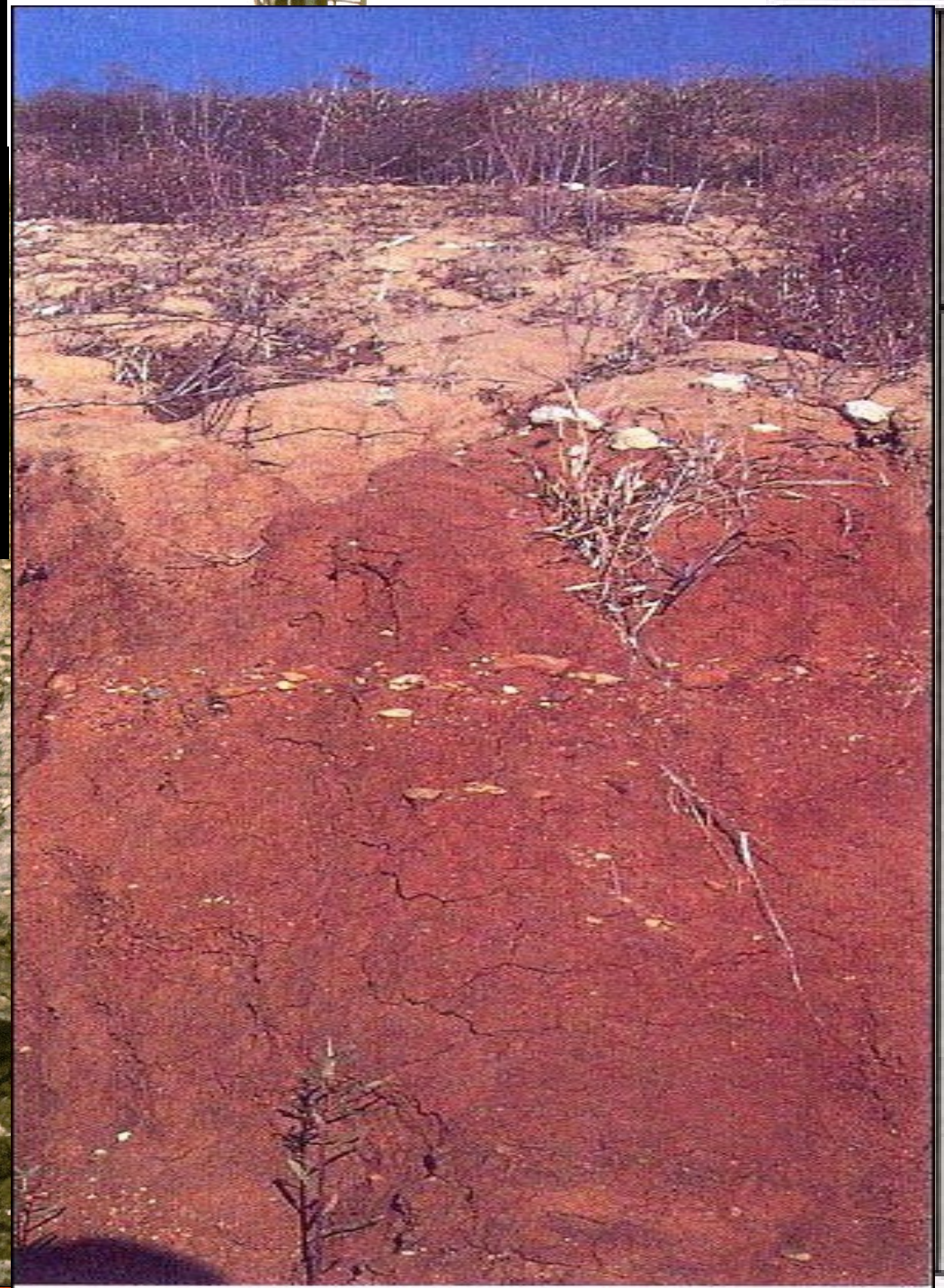
Terrain Characteristics

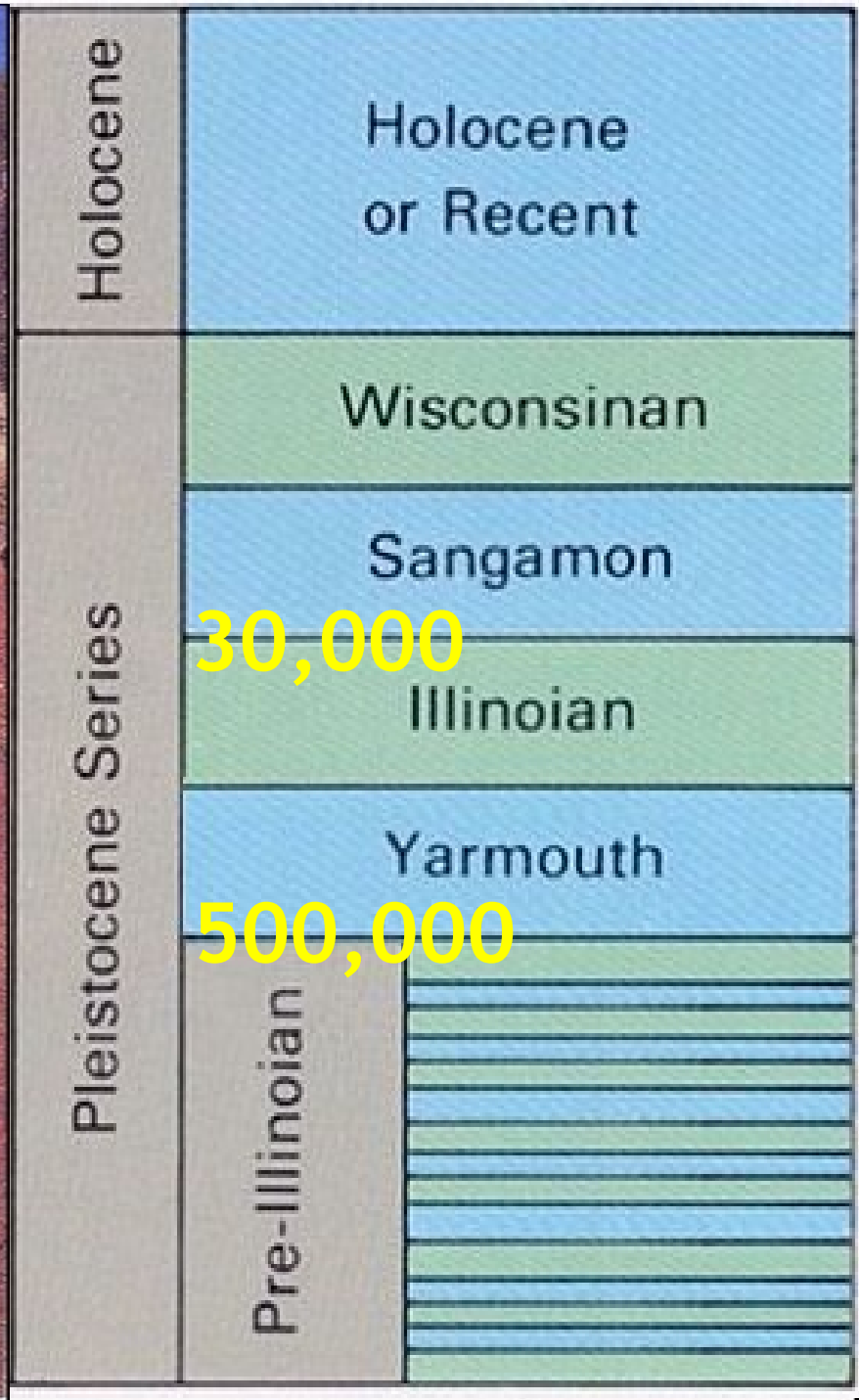
* moderate loess cover
* weathered glacial drifts with paleosols
* integrated drainage network
* bedrock exposed in deeper valleys

Weathered glacial drift with paleosols



Two Pre-Illinoian tills at the Braddyville Quarry, Yarmouth-Sangamon Paleosol "gumbo till", Pot

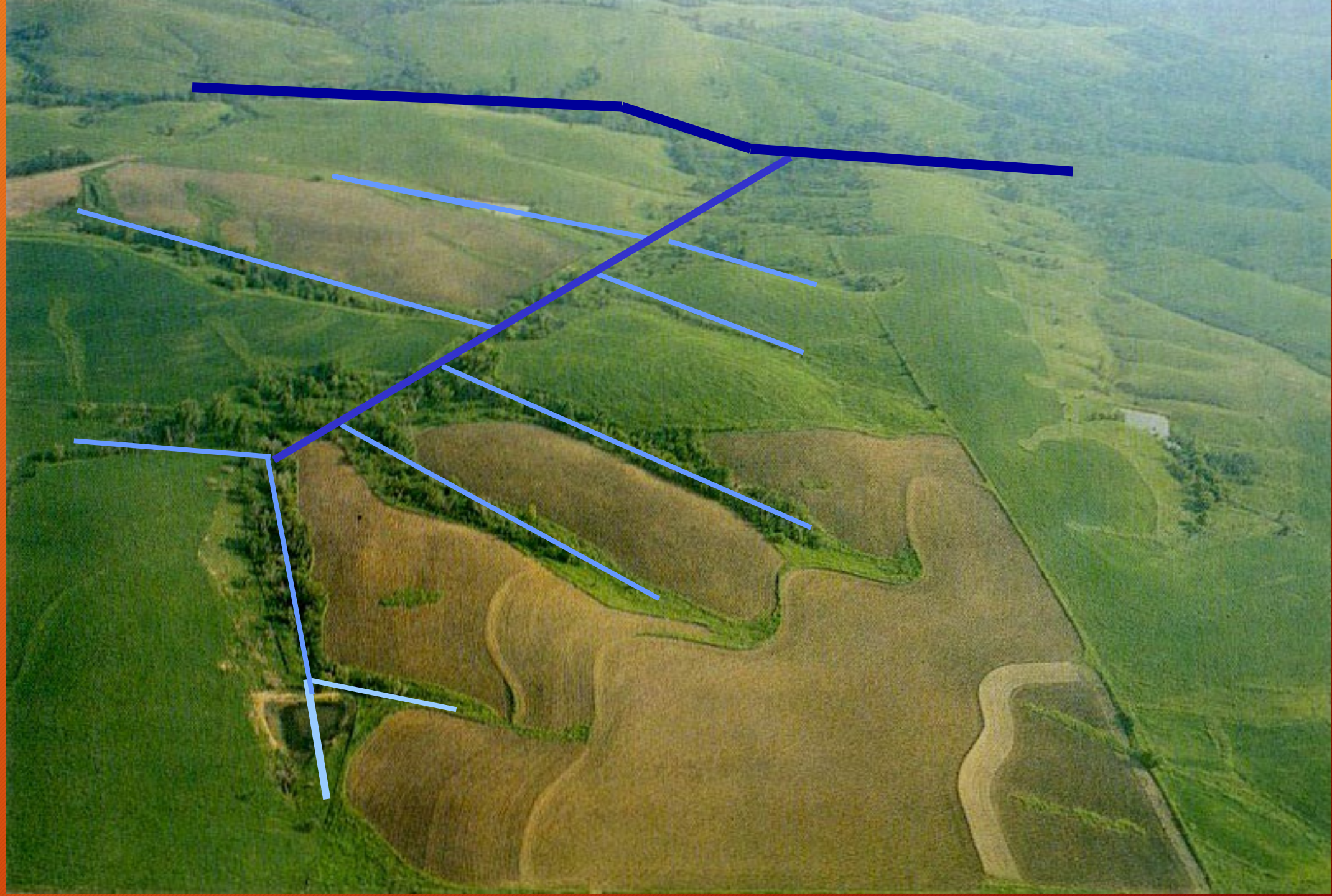




moderate loess cover

loess-capped hills, Iowa County *photo by Gary Hightshoe*

Integrated drainage network



Monona County

Iowan Surface

Terrain Characteristics

* gently rolling terrain
* thin, discontinuous loess
  or loam over glacial drift
* bedrock near surface
* local karst conditions
* scattered glacial boulders
* integrated drainage network
* isolated elongate hills (paha)

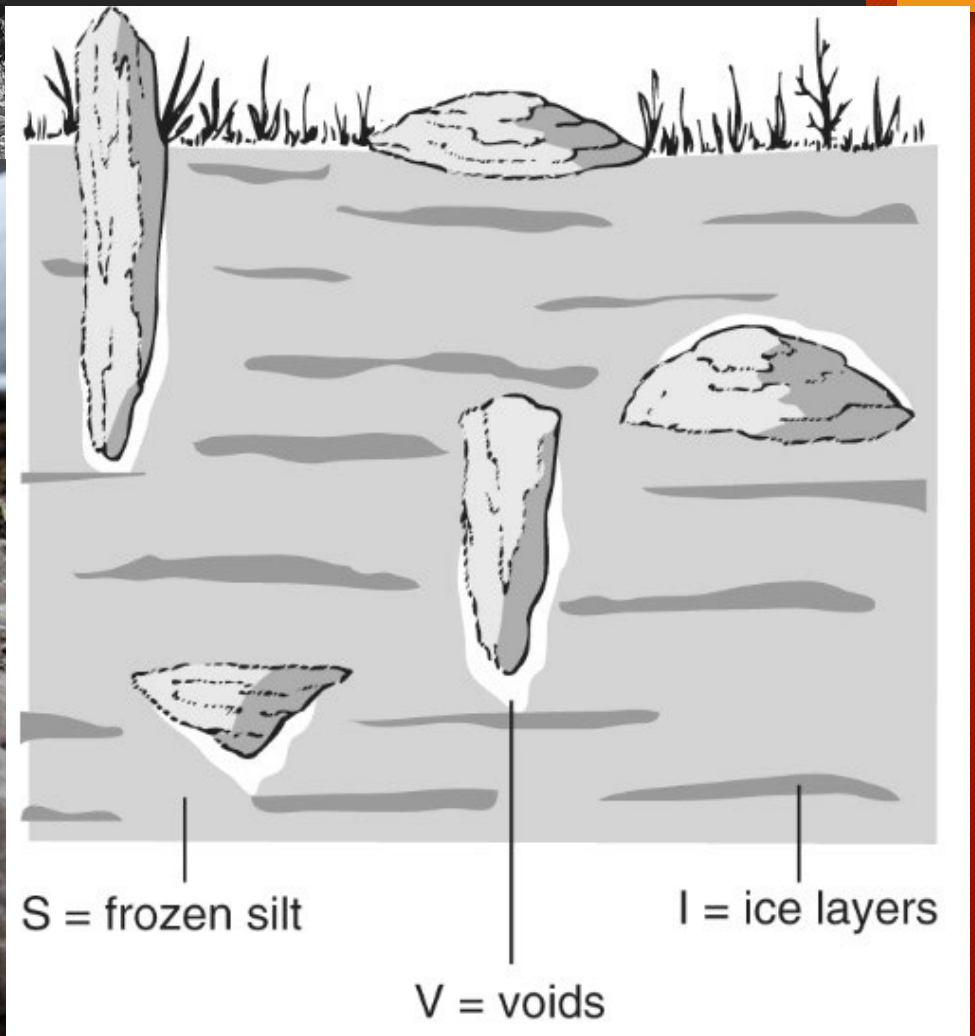
Iowa Surface/respect to other Iowa regions?

- Why is the Iowan Surface gently rolling/ flat?
- Why is bedrock closer to the surface?
- Why are there localized karst conditions?

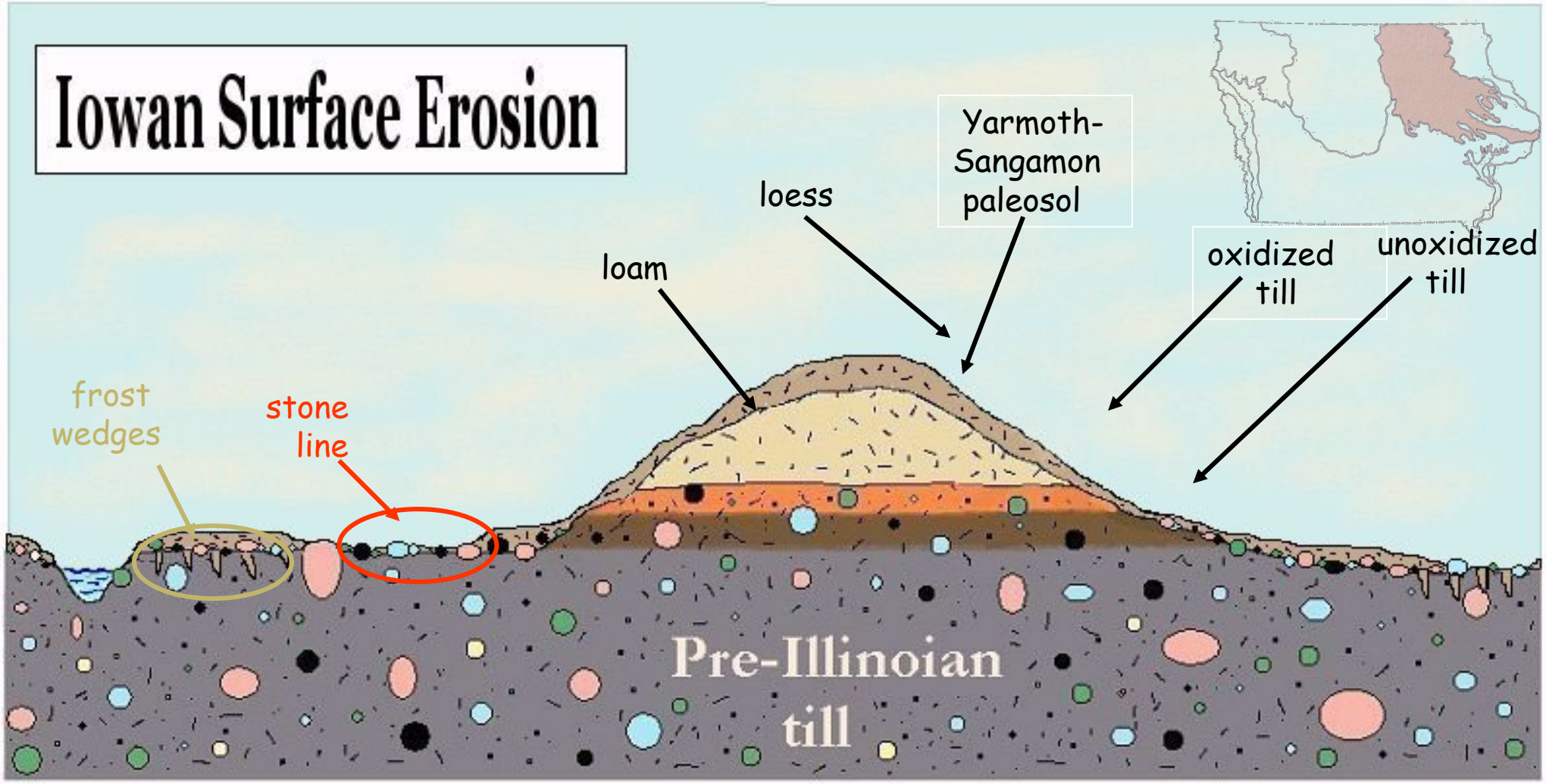
Permafrost

Or **cryotic soil** is at or below the freezing point of water 0 °C (32 °F) for two or more years. Most permafrost is located in high latitudes (i.e. land close to the North and South poles), but **alpine permafrost** may exist at high altitudes in much lower latitudes

Frost Sorting



Formation of the Iowan Surface 16,500 – 21,000 ybp

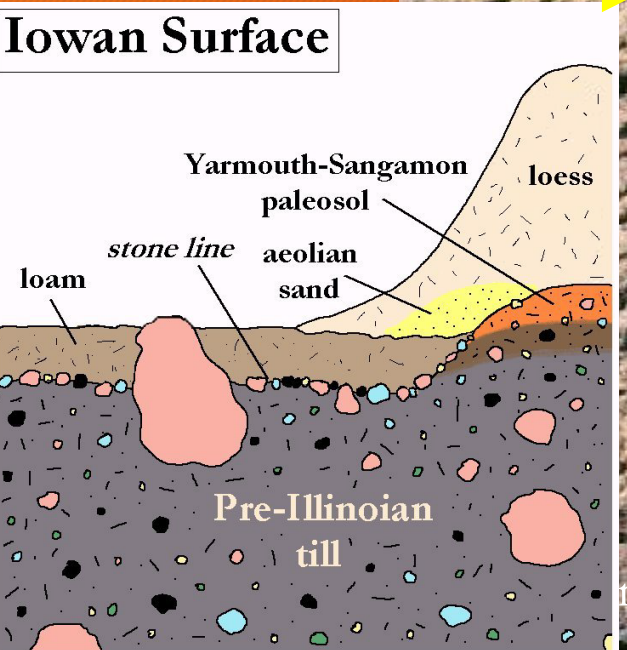


2b

loam

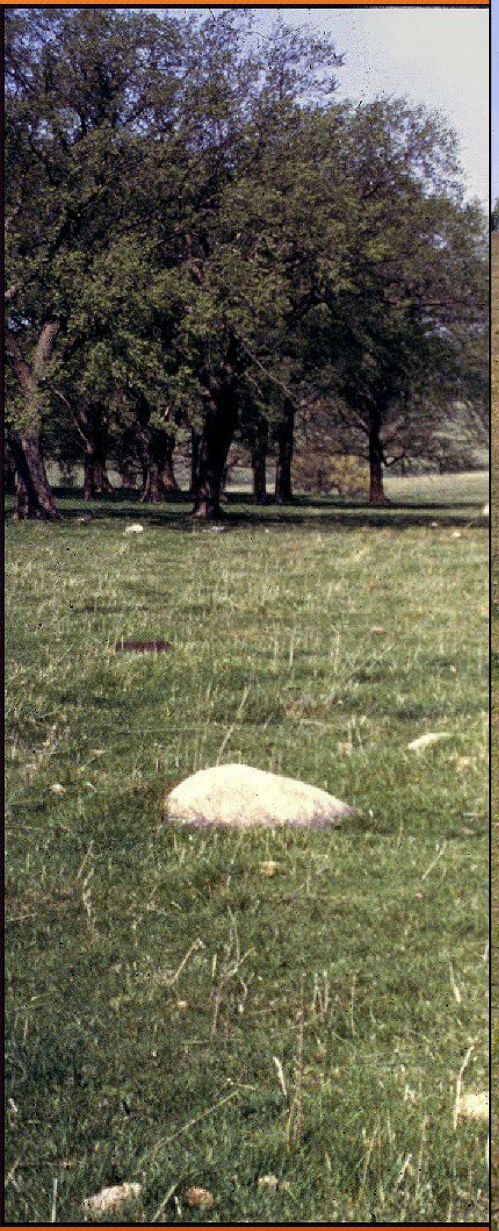
stone line

PreIllinoian till



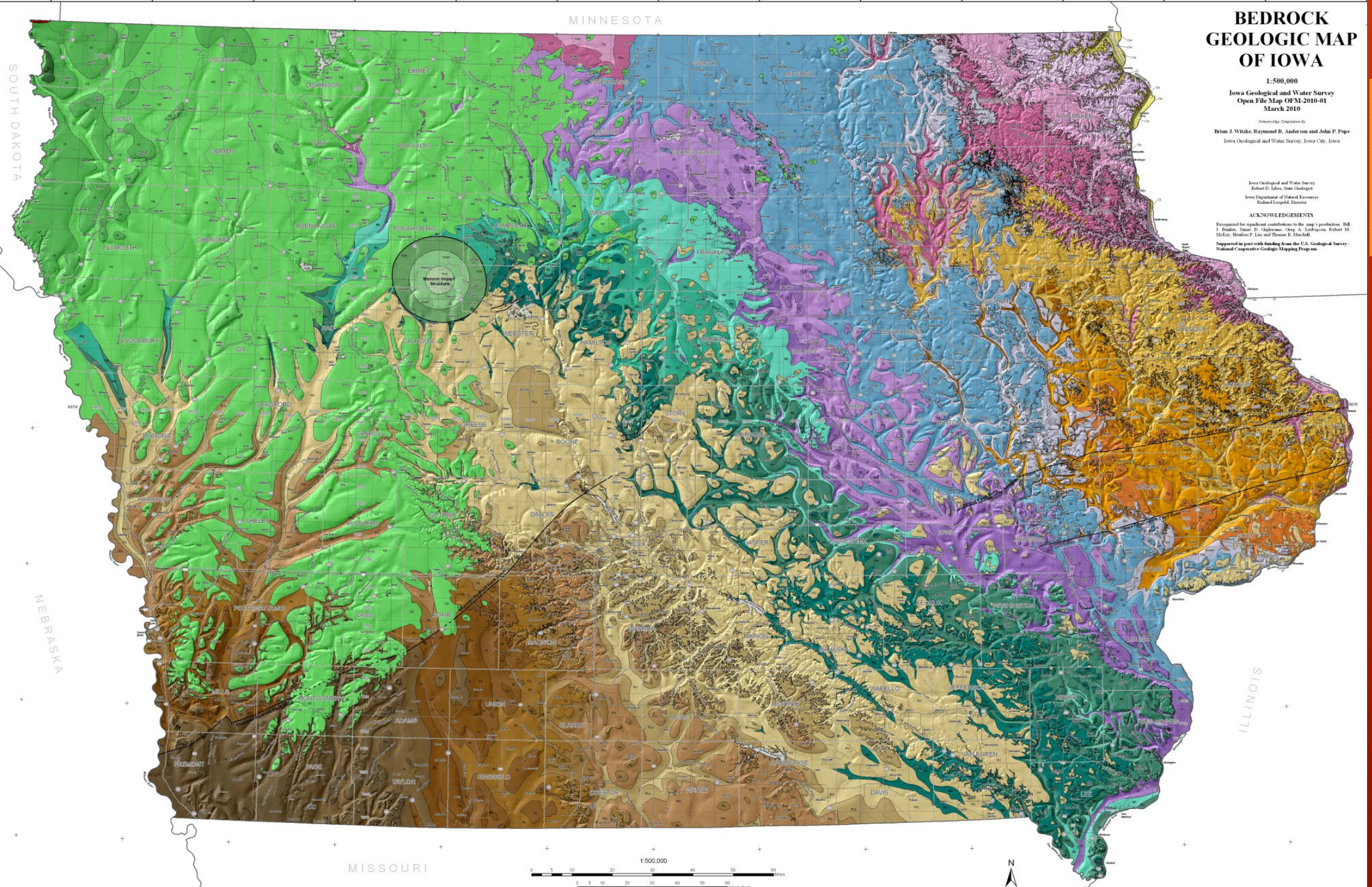
n Surface soil profile in south Cedar Falls *photo by Jim Walters*

Glacial boulders



Karst

Sink holes in pasture, Floyd County *photo by Stan Grant*



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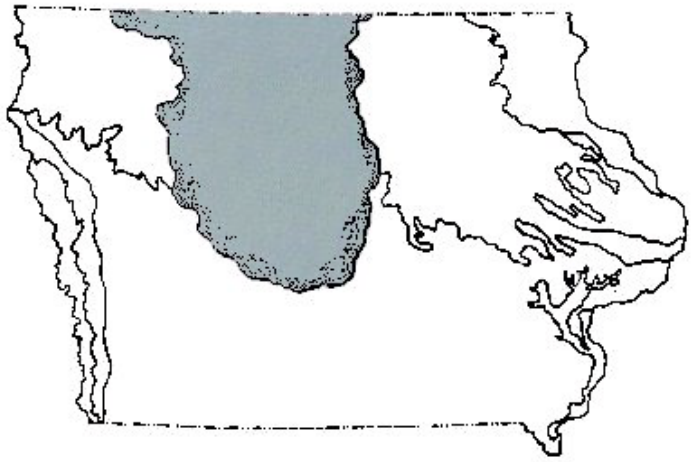
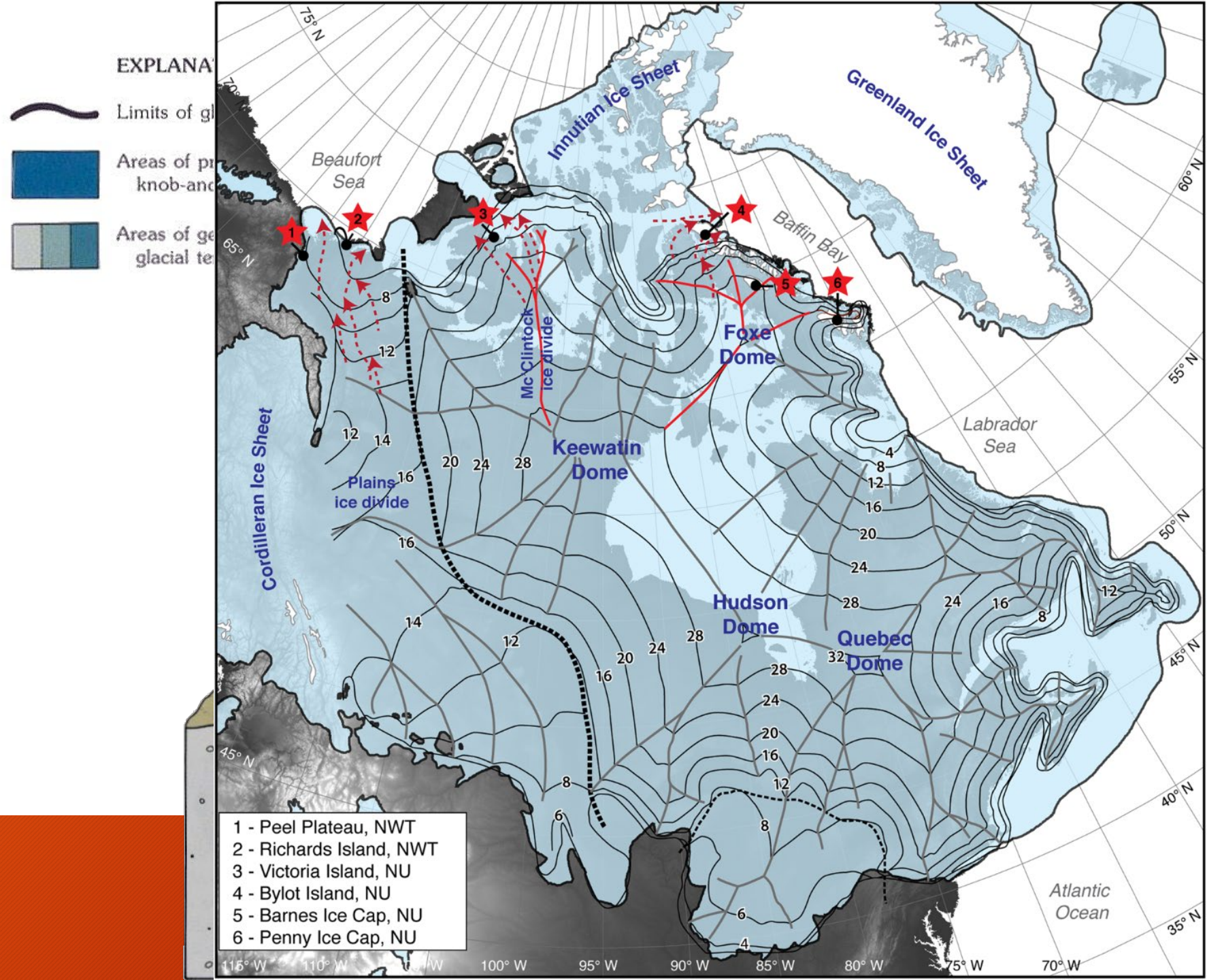
Des Moines Lobe

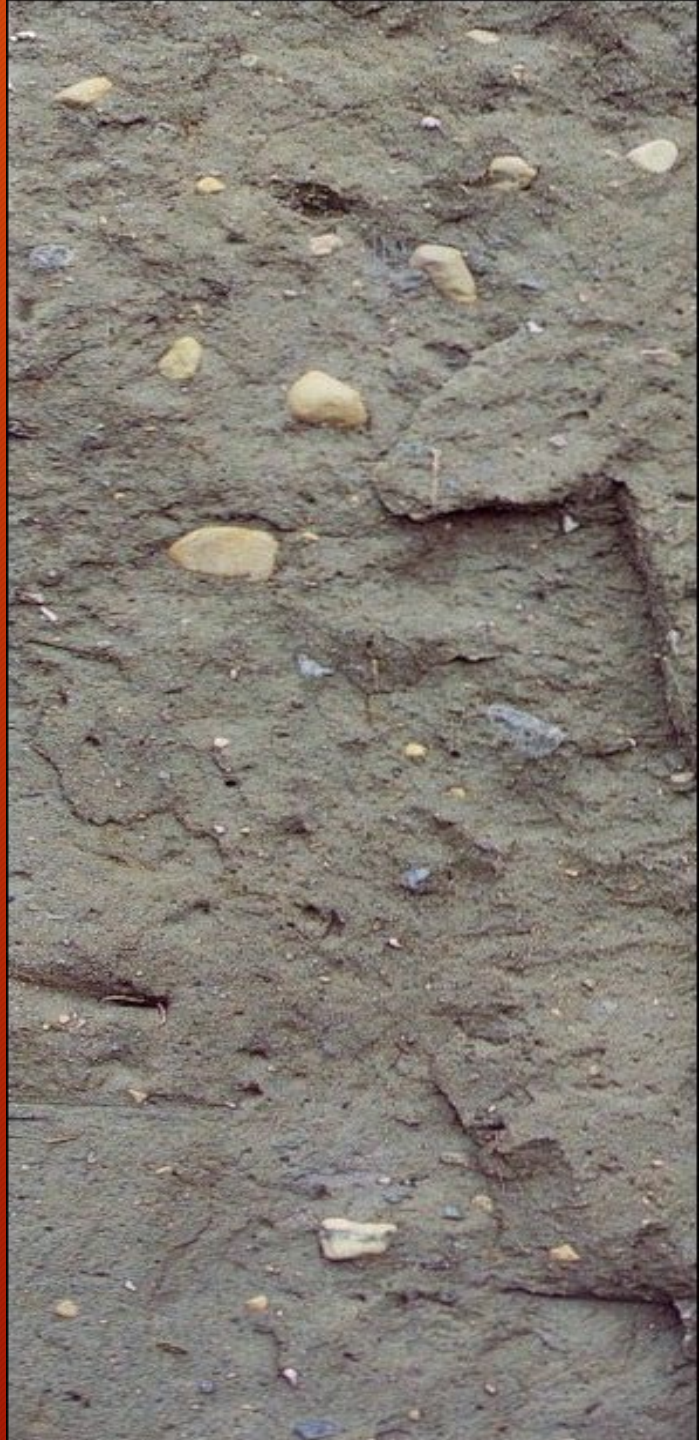


Terrain Characteristics

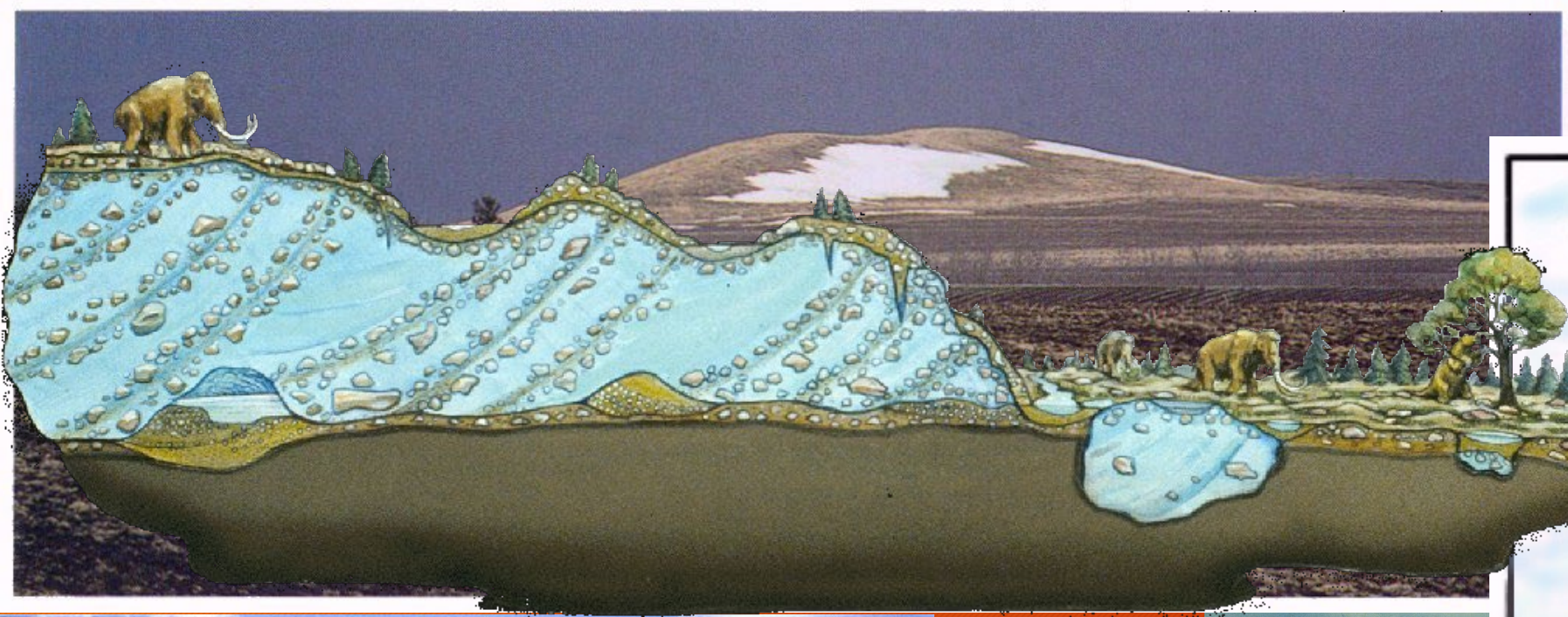
* fresh glacial till
* no loess cover
* bands of knob and kettle terrain
* areas of level terrain
* poor surface drainage
* natural lakes, wetlands



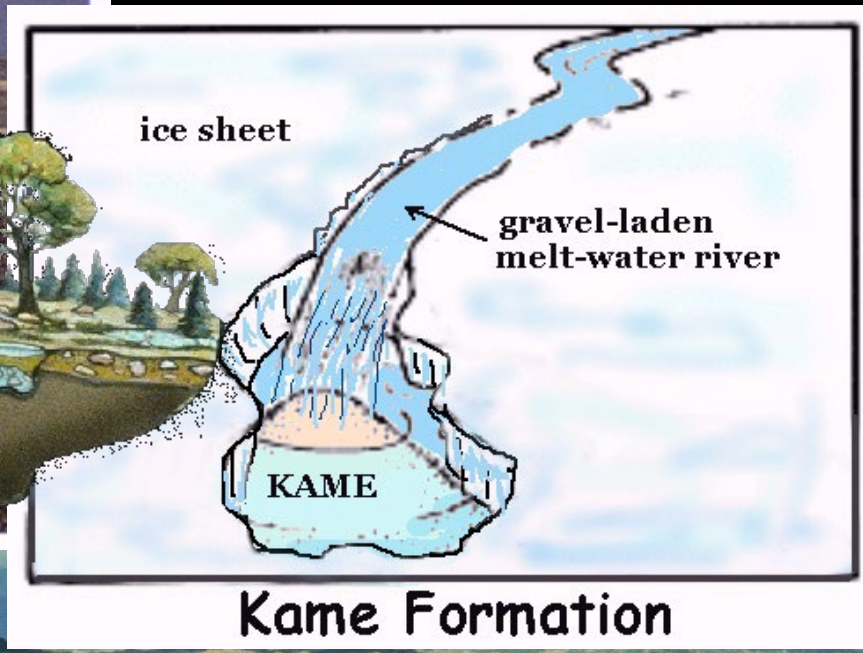
Till



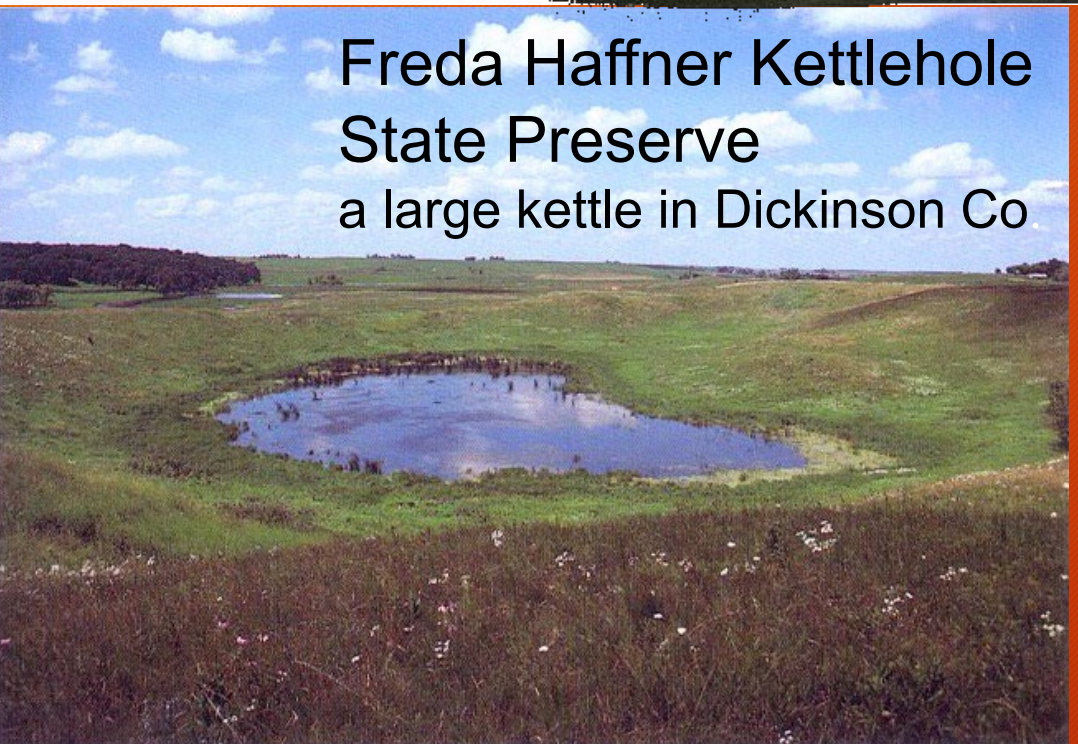
exposures of Des Moines Lobe till *photos by Tim Kemmis*



Ocheyeden Mound a large Kame in Osceola Co.

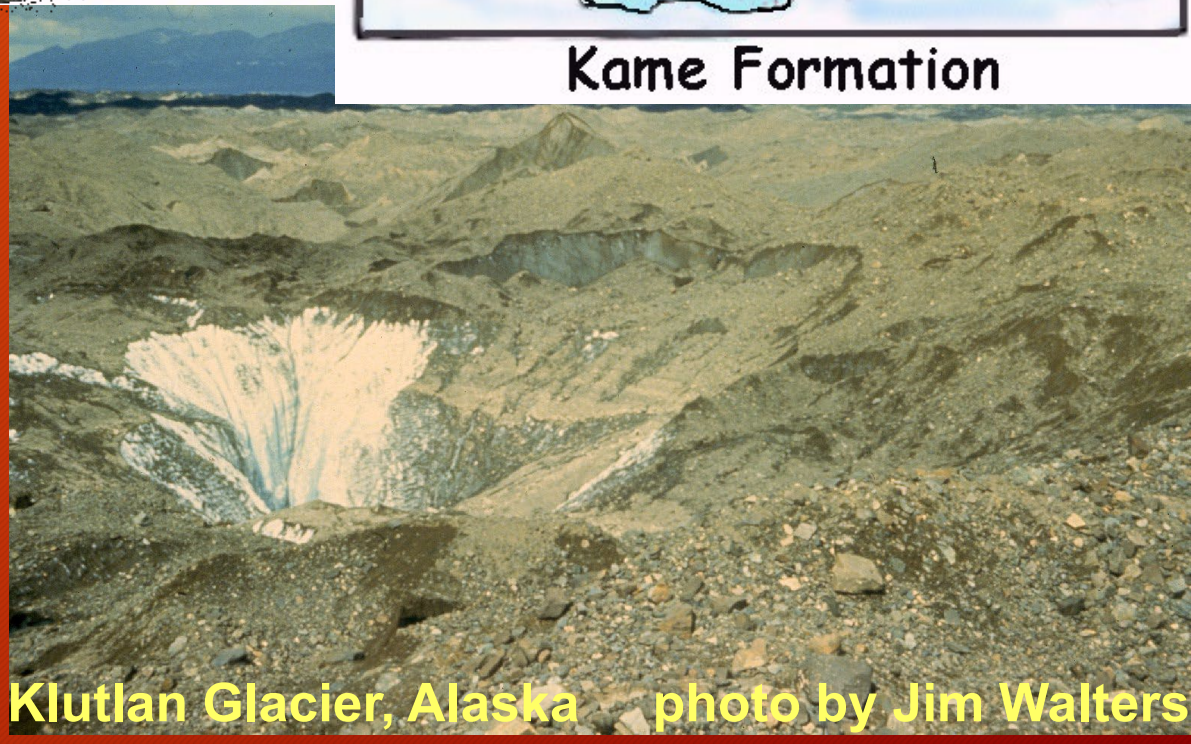


Kame Formation



Freda Haffner Kettlehole State Preserve

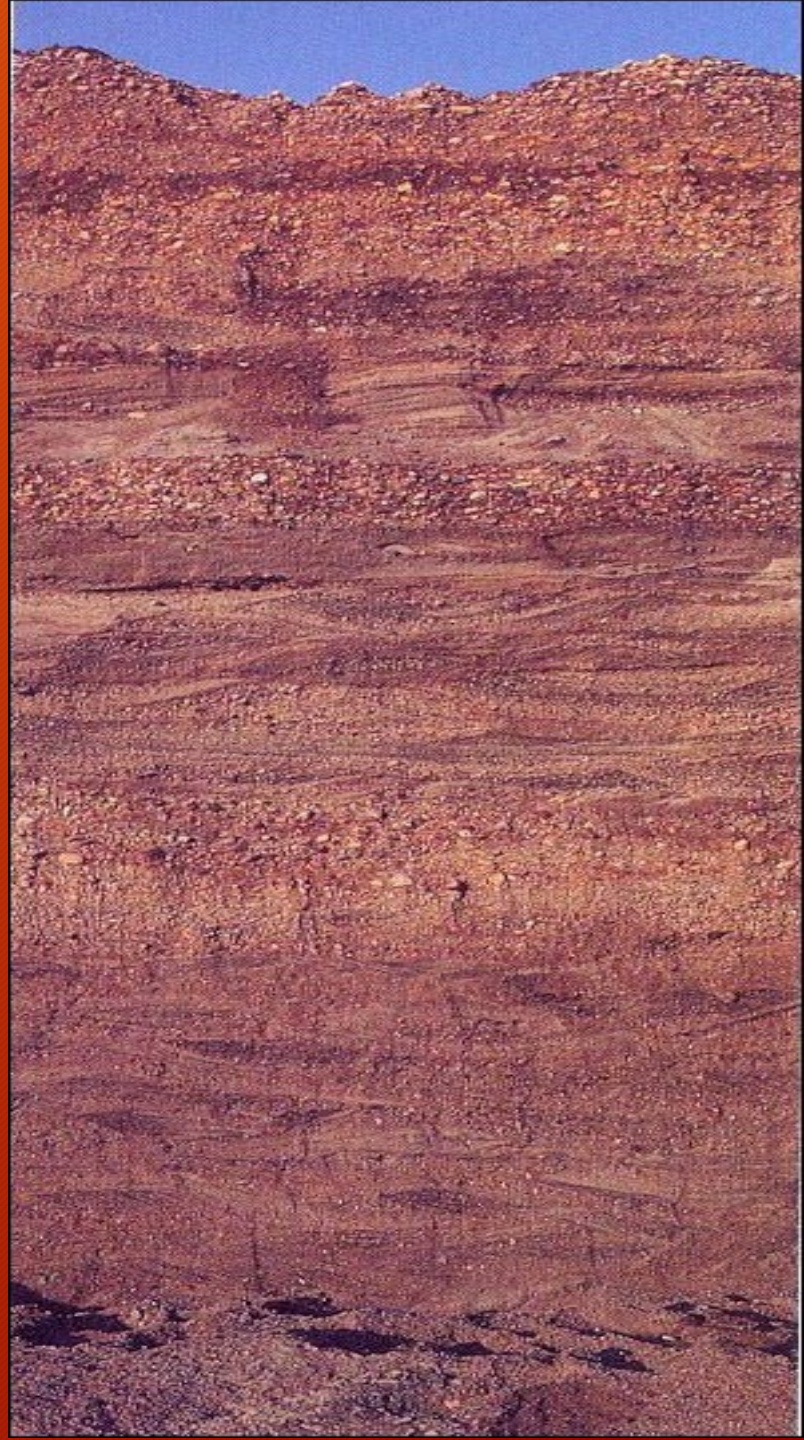
a large kettle in Dickinson Co



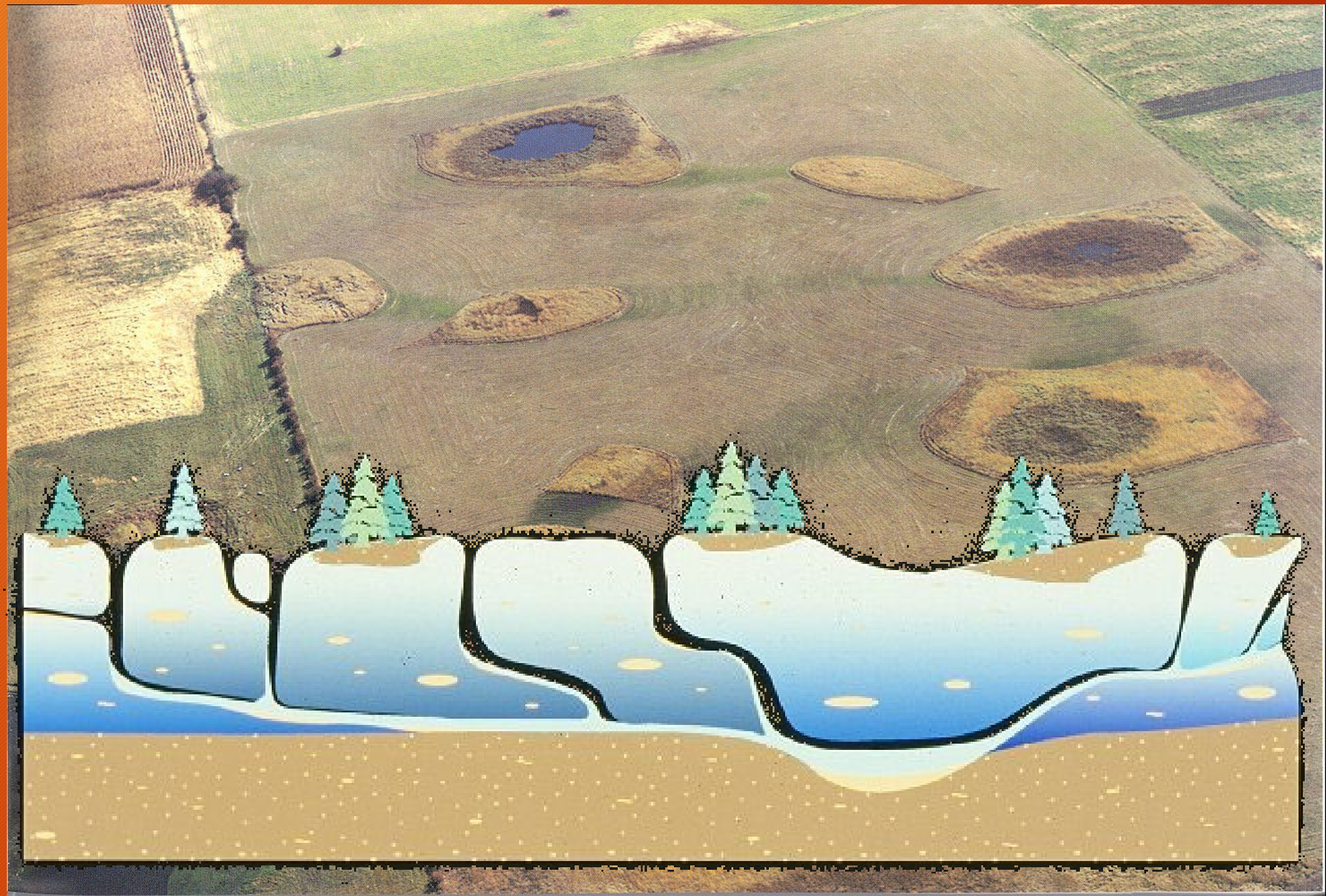
Klutlan Glacier, Alaska photo by Jim Walters

Upland sand and gravel deposits

Upland Sand and Gravel Deposit, Emmet County
photo by Tim Kemmis



linked depression systems



Doolittle Prairie, Story County *photo by Gary Hightshoe*

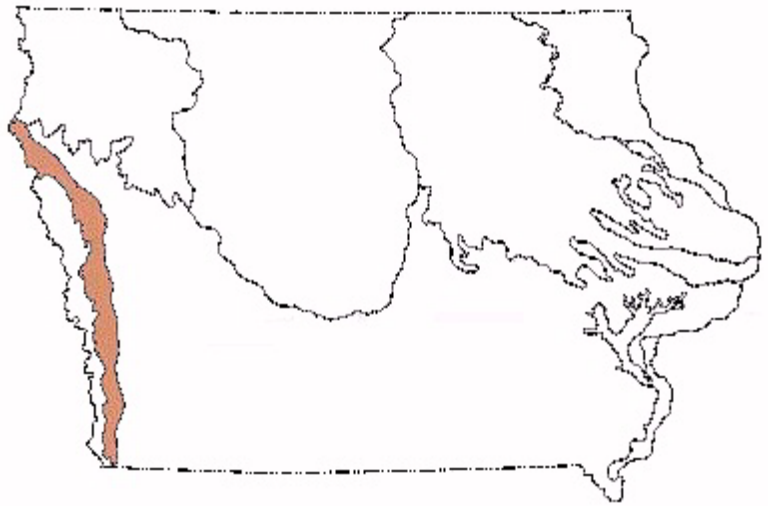
Spring Run State Wildlife Management Area, Dickinson County *photo by Douglas C. Harr*

poorly developed drainage

Natural lakes and wetlands

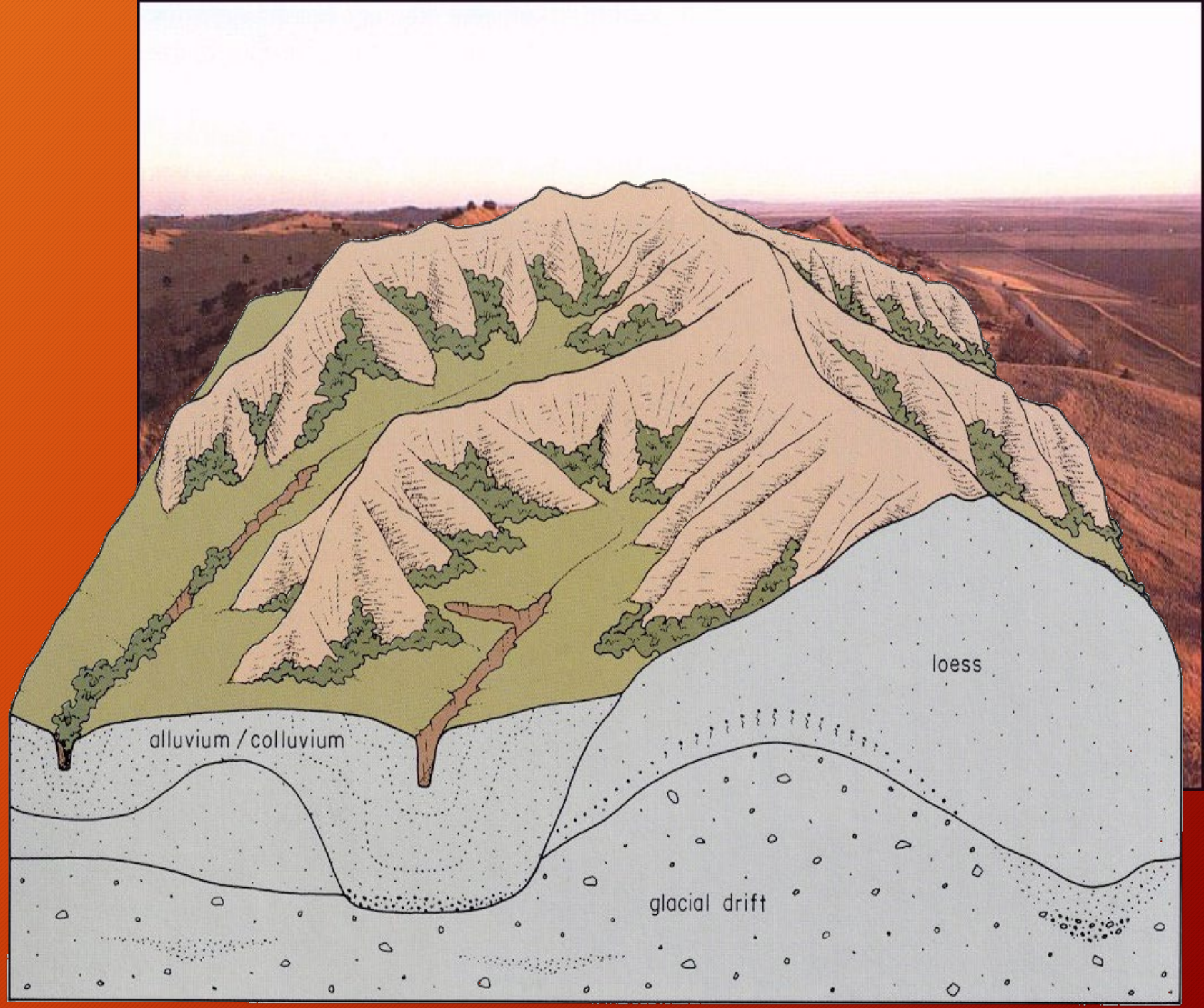
Three Corner Pond, Dickinson County *photo by Jean Prior*

Loess Hills

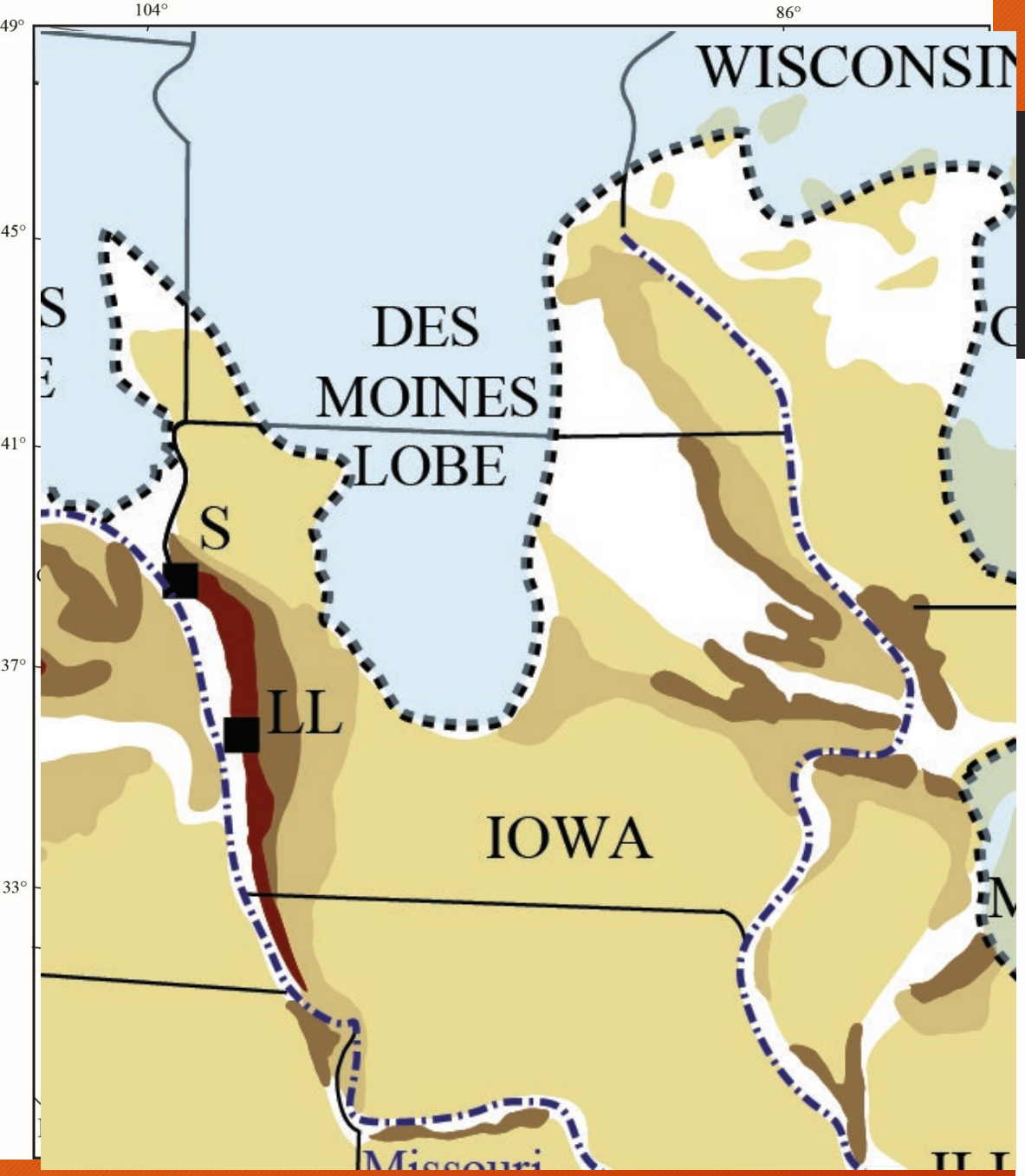


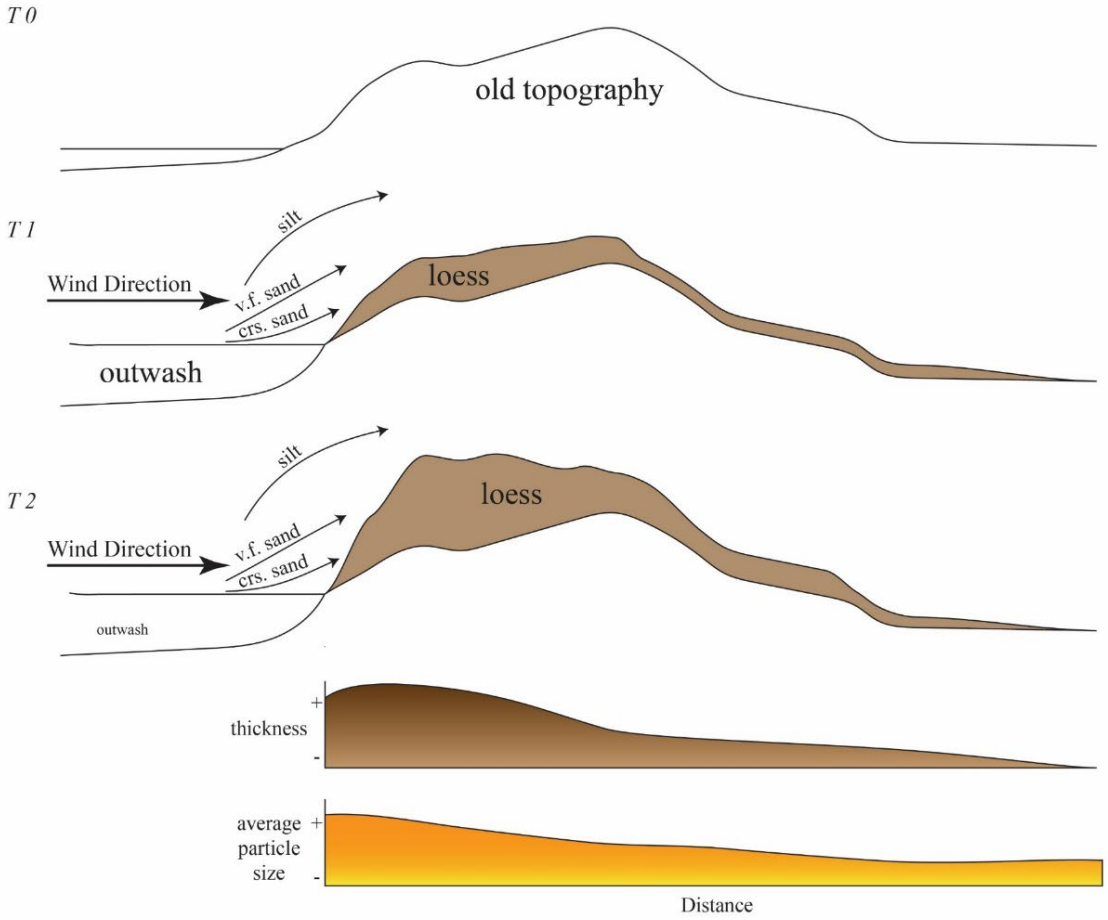
Terrain Characteristics

* thick loess cover
* sharply ridged terrain
* high drainage density
* rapid surface runoff
* gully development
* vertical road cuts

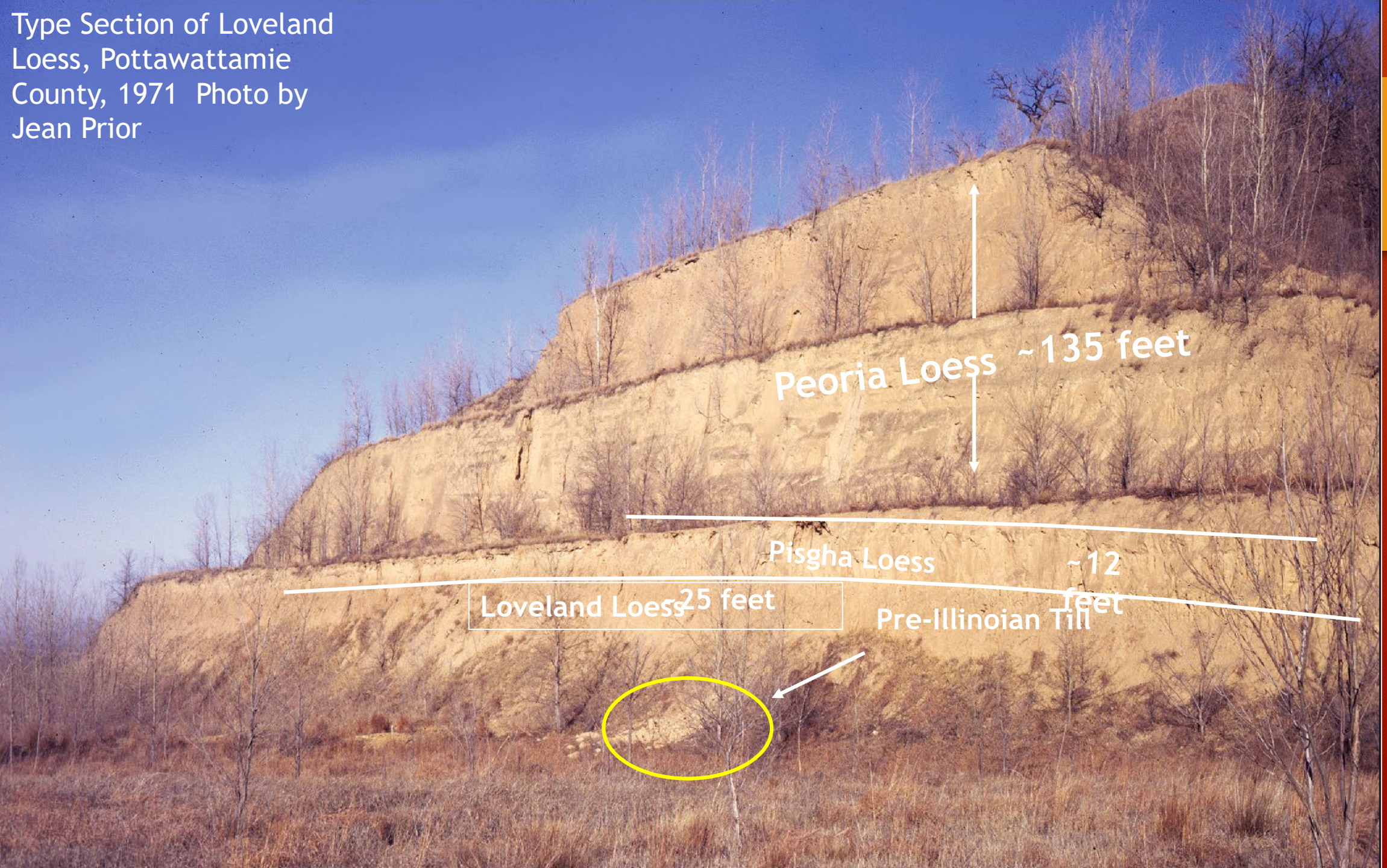


Loess?



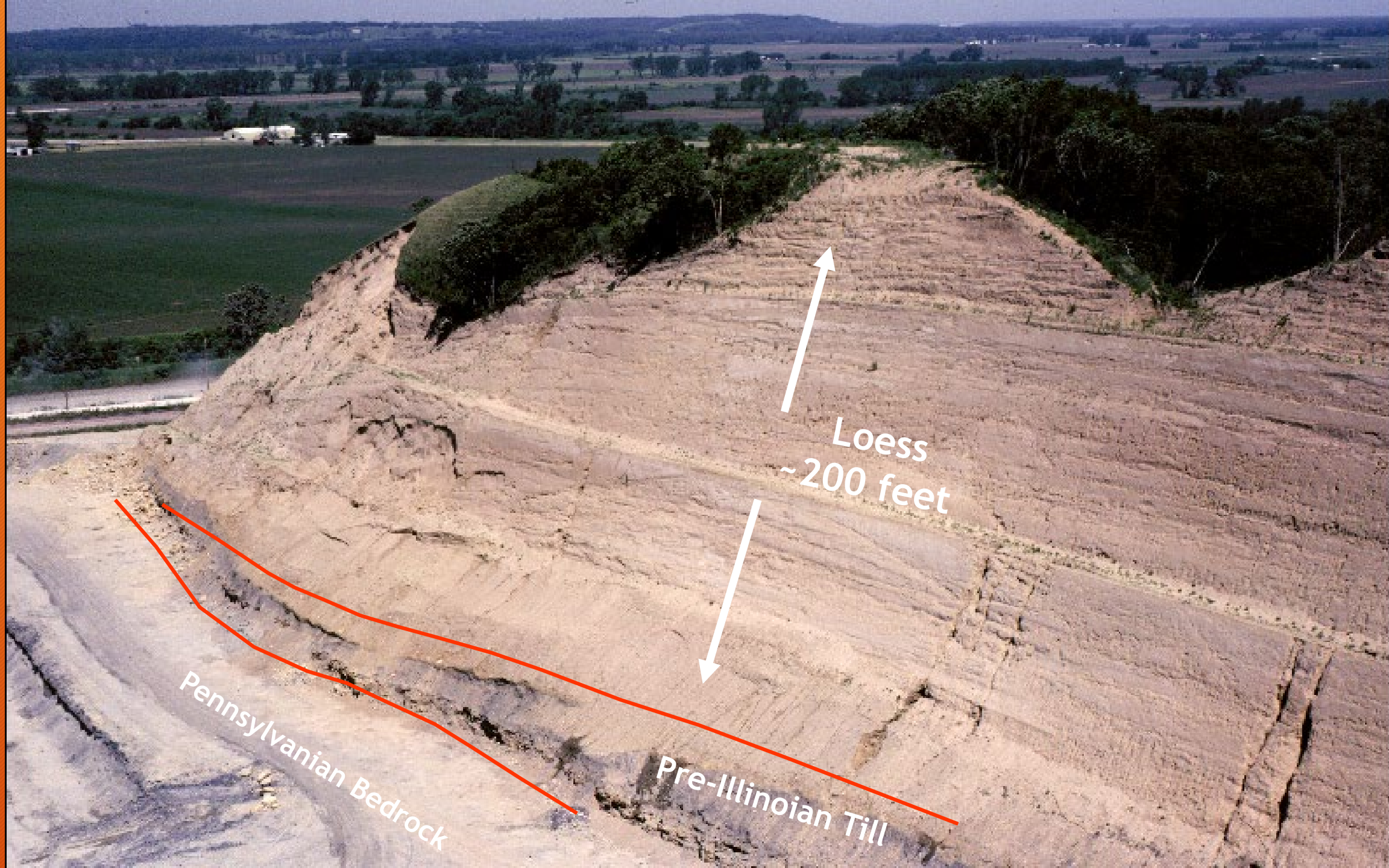


(Muhs et al., 2013)



Type Section of Loveland Loess, Pottawattamie County, 1971 Photo by Jean Prior

thick loess cover



Crescent Quarry, Pottawattamie County
photo by Ray Anderson

Sharply ridged terrain

Sharp ridge crests, Plymouth County
photo by Gary Hightshoe

Drainage development in thick loess, Monona County *photo by Gary Hightshoe*

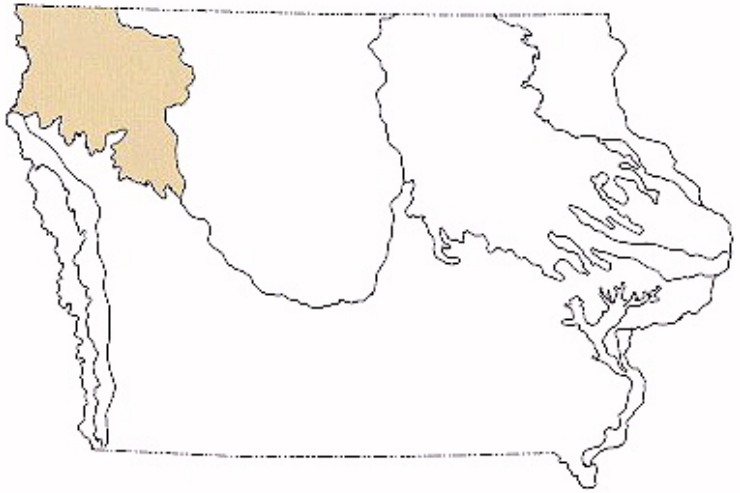
high drainage density

Gully development

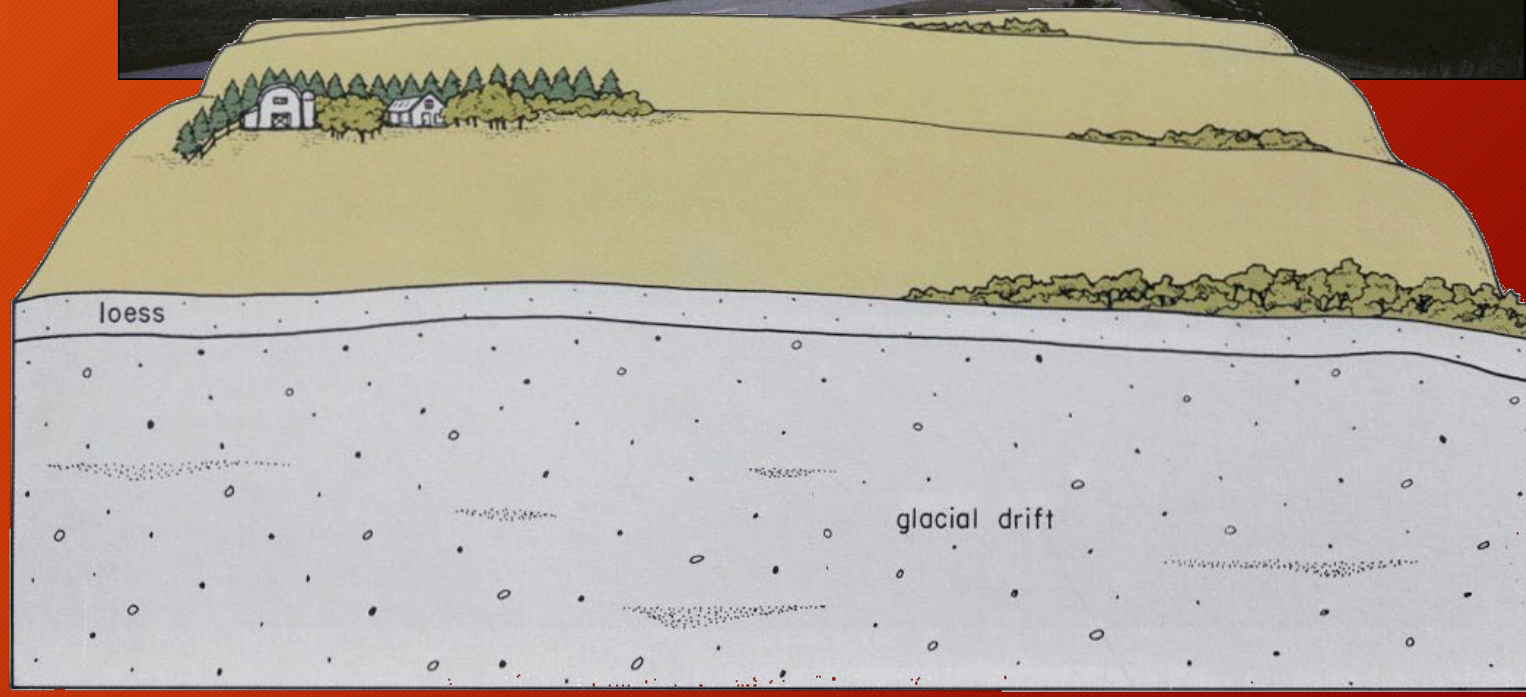
near Treynor, Pottawattamie County
photo by Tim Kemmis

Vertical loess cut, Durr Hill, Monona County
photo by Jean Prior

Northwest Iowa Plains



Northern Iowa Plains, Cherokee County *photo by Jean Prior*



Terrain Characteristics

* moderate to thick loess over glacial till
* gently rolling terrain
* integrated drainage network

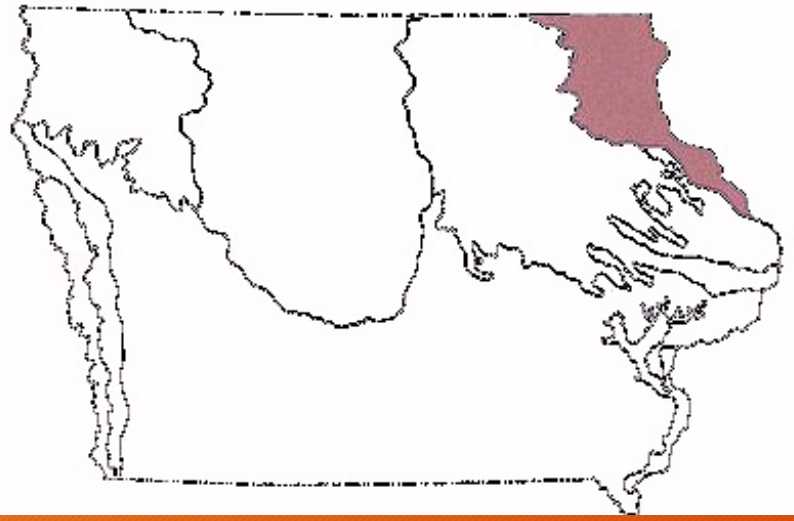
moderate to thick loess over glacial till

Loess-capped hills in Northern Iowa Plains, O'Brien County
photo by Andy Assell

Gently rolling terrain

Rolling hills of the Northwest Iowa Plains *photo by Jean C. Prior*

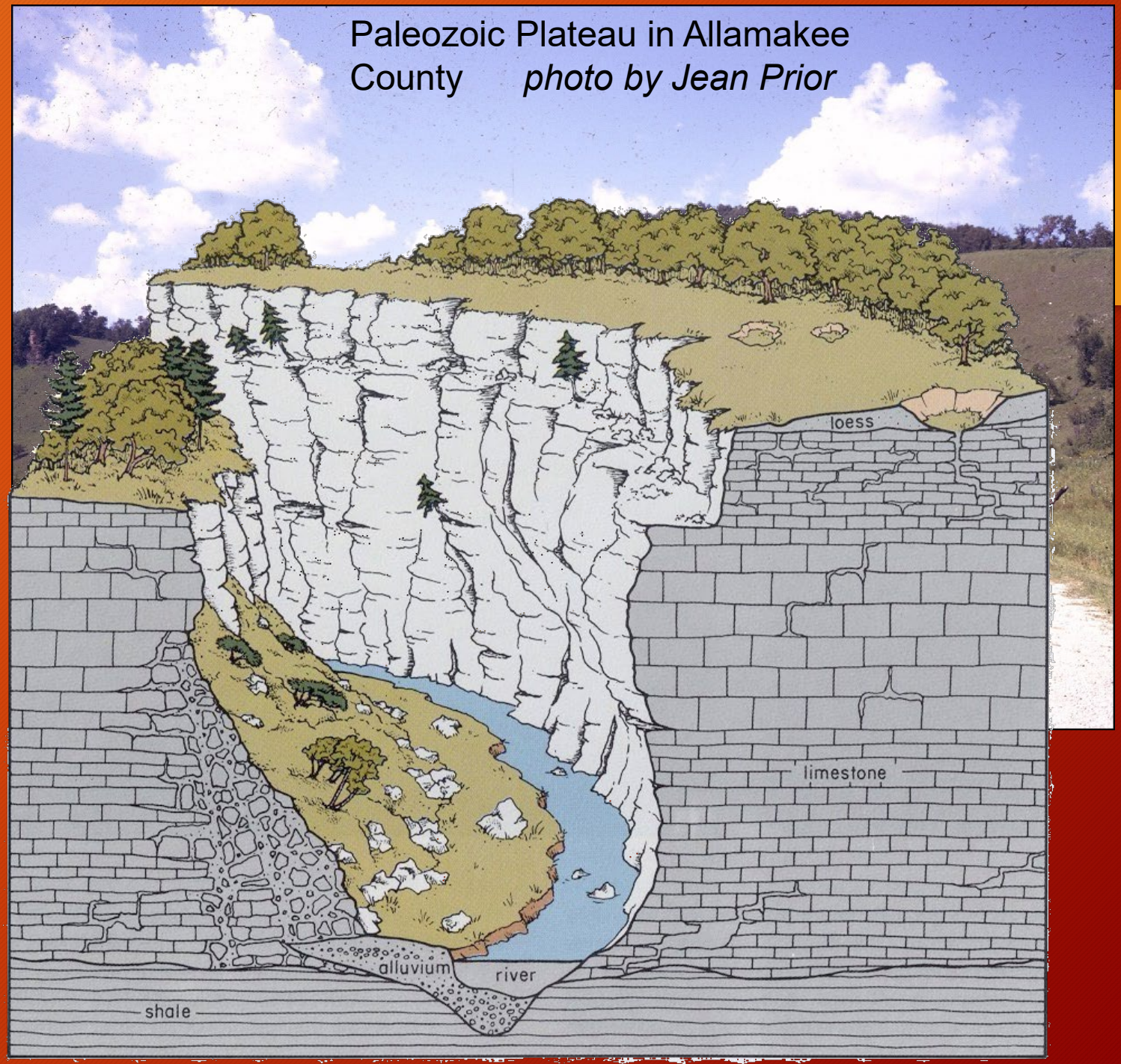
Paleozoic Plateau



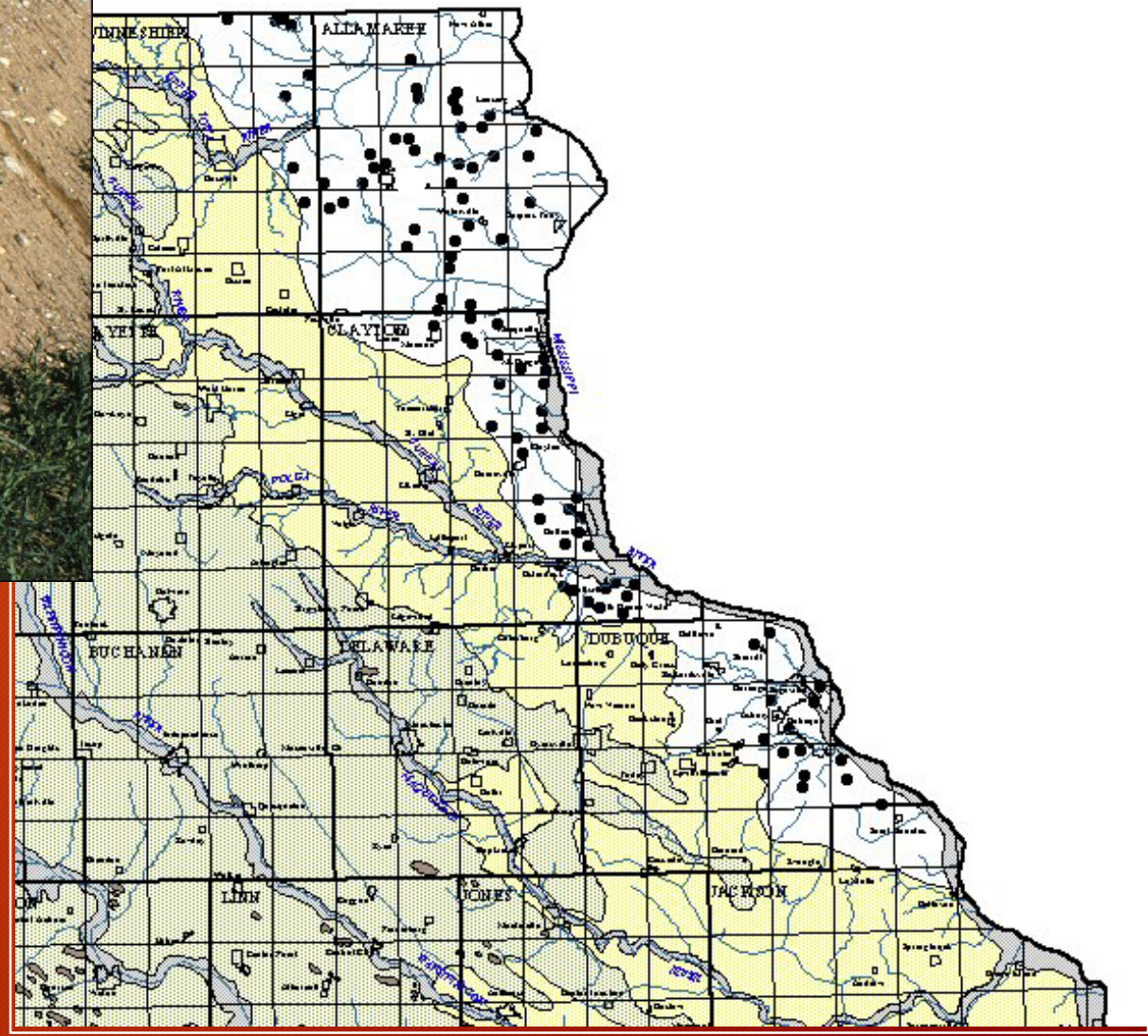
Terrain Characteristics

* thin loess cover
* Isolated patches of glacial drift
* bedrock-dominated terrain
* plateau-like uplands
* integrated drainage network
* deeply-entrenched valleys
* karst topography (sinkholes, caves, springs)

Paleozoic Plateau in Allamakee County *photo by Jean Prior*



thin loess cover
isolated patches of glacial drift



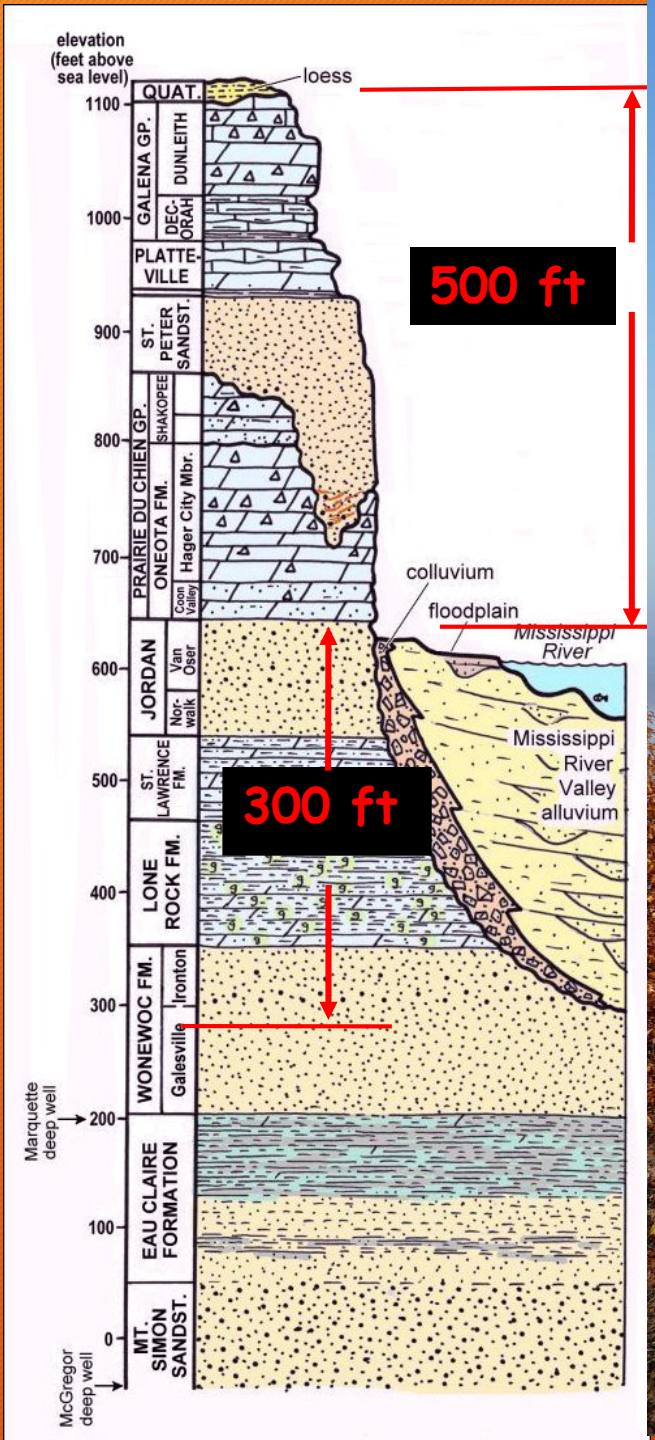
Glacial Geology of Iowa
unpublished map by Jean Prior

bedrock-dominated terrains

Ordovician Galena Group Limestone Cliffs,
Upper Iowa River, Allamakee County *photo by Ray Anderson*

plateau-like uplands

Mississippi River Valley, Allamakee County
photo by Jean Prior


elevation (feet above sea level)
1100
1000
900
800
700
600
500
400
300
200
100
0
QUAT.
loess
GALENA GP.
DUNLEITH
DEC-ORAH
PLATTE-VILLE
ST. PETER SANDST.
PRAIRIE DU CHIEN GP.
SHAKOPEE
ONEOTA FM.
Hager City Mbr.
Coon Valley
JORDAN
Van Oser
Nor-walk
ST. LAWRENCE FM.
LONE ROCK FM.
WONEWOC FM.
Ironton
Galesville
EAU CLAIRE FORMATION
MT. SIMON SANDST.
Marquette deep well
McGregor deep well
500 ft
300 ft
colluvium
floodplain
Mississippi River
Mississippi River Valley alluvium

Meandering rivers

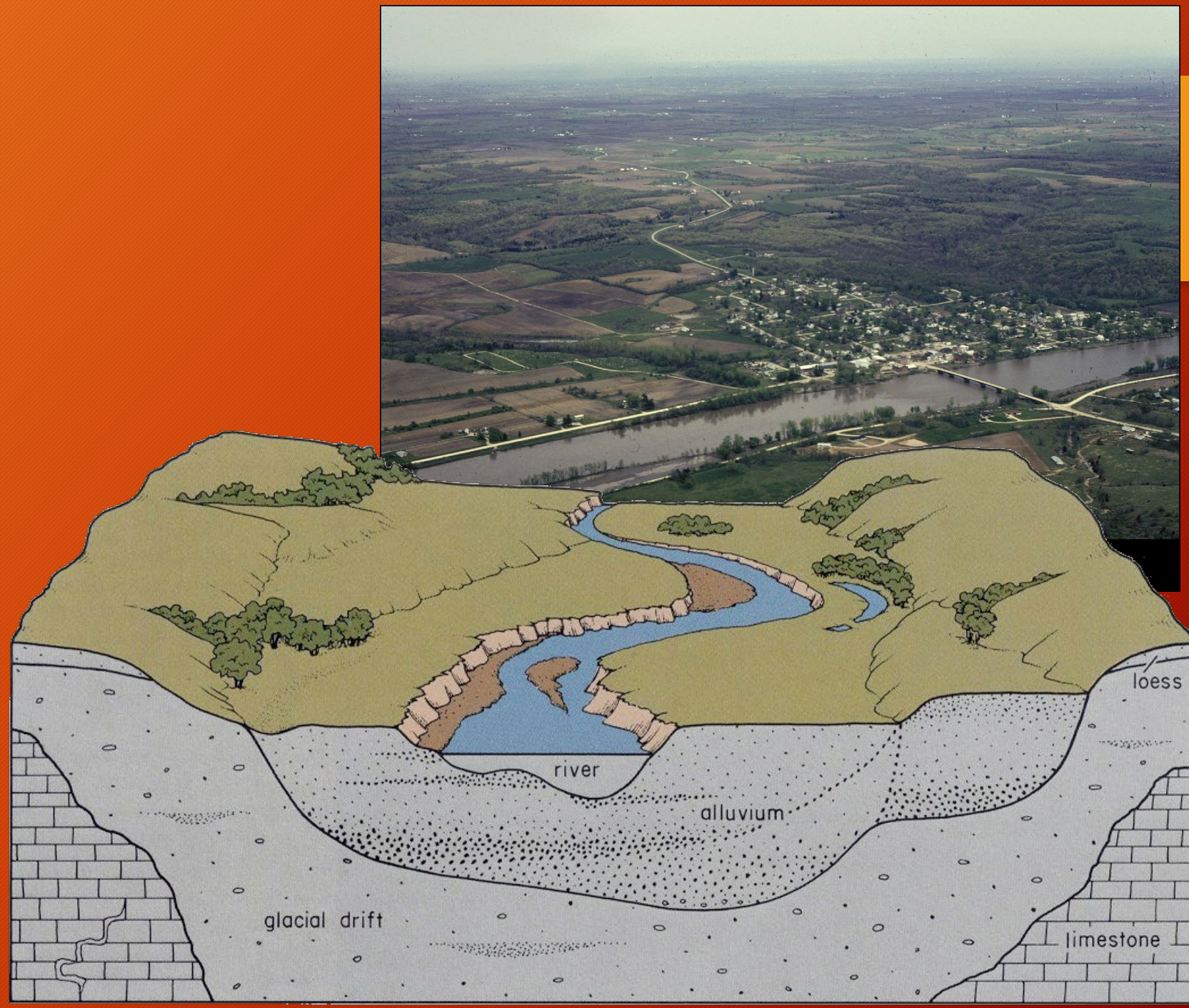
Turkey River, Clayton County
photo by Gary Hightshoe

Fish Farm Mounds State Preserve, Allmakee County
photo by Jean Prior

karst topography

Sinkhole country, Clayton County
photo by Gary Hightshoe

Alluvial Plains



Terrain Characteristics

* thick alluvium
* level terrain along valleys
  includes stream channels, floodplains, oxbow lakes, terraces, alluvial fans, sand dunes