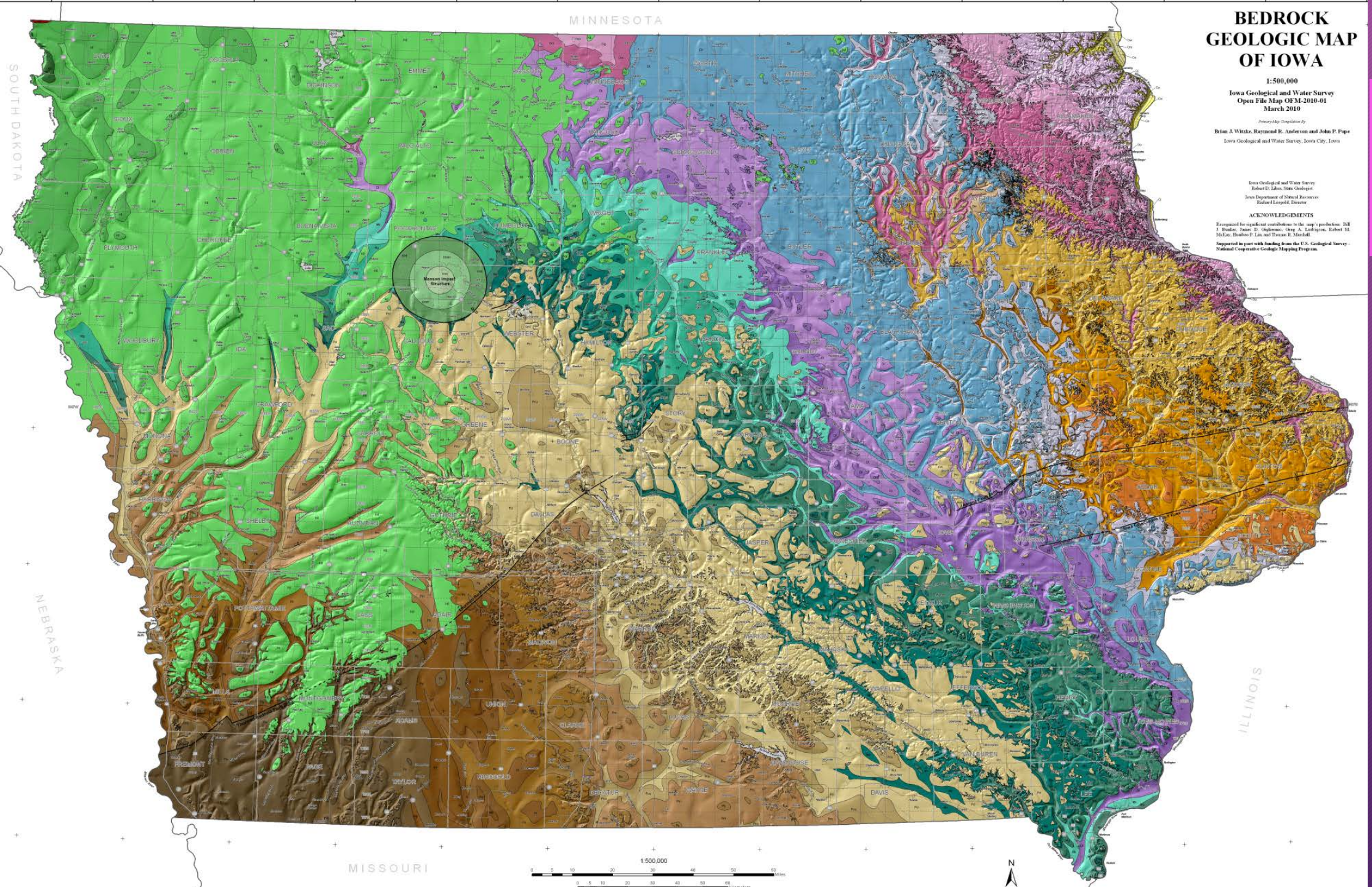
Iowa's Precambrian and Cambrian

University of Northern Iowa

Dr. Chad Heinzel



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

Recognized for significant contributions to the map's production: Bill J. Bunker, James D. Giglierano, Greg A. Ludvigson, Robert M. McKay, Huaibao P. Lin, and Thomas E. Marzolf.

Supported in part with funding from the U.S. Geological Survey – National Cooperative Geologic Mapping Program.

Concept of Geologic *Formations*

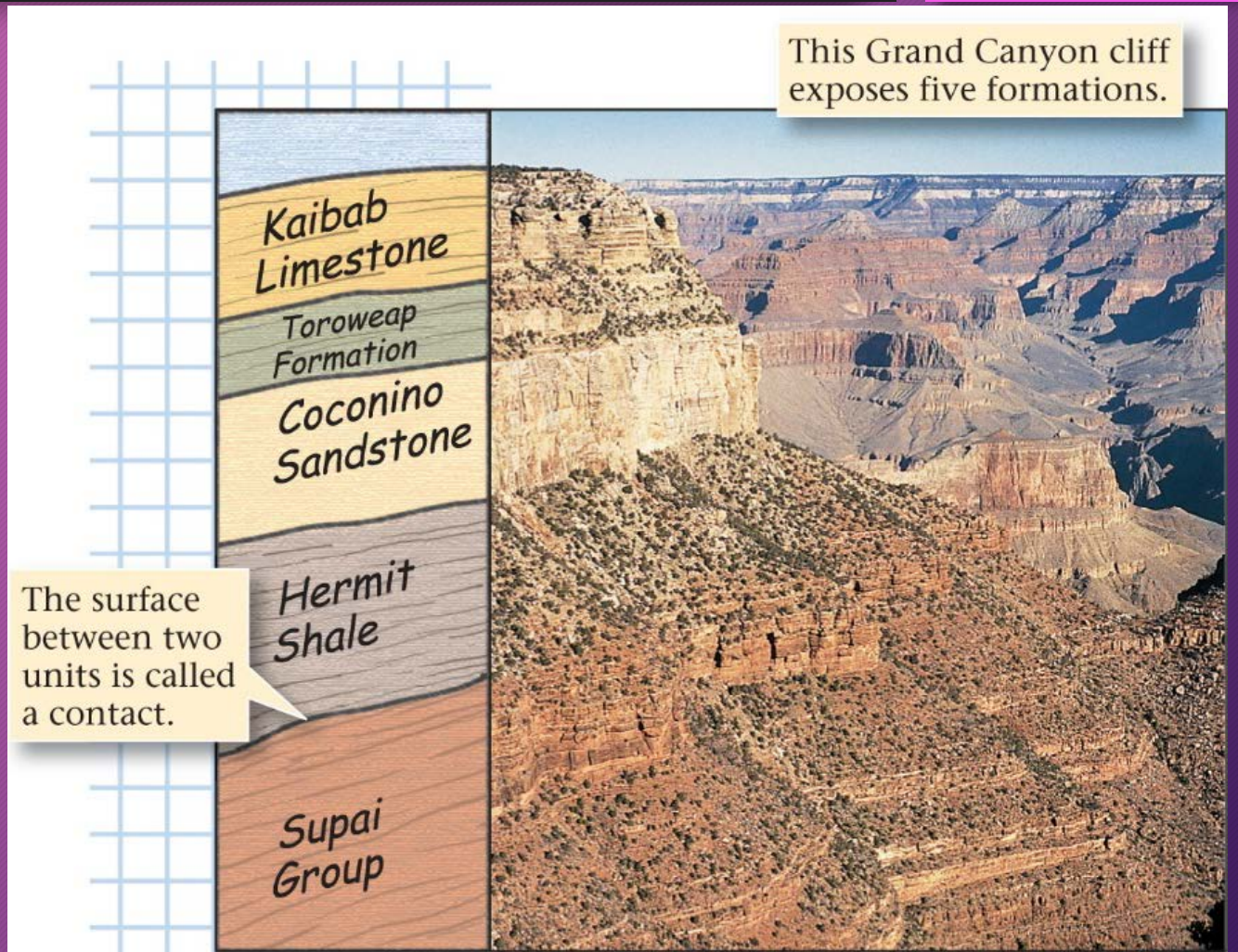
- A body/layer of rock that consists dominantly of a certain lithologic rock type
- Maybe combined into *Groups*
- Or maybe divided into *Members*

Origin of Geologic Time Names

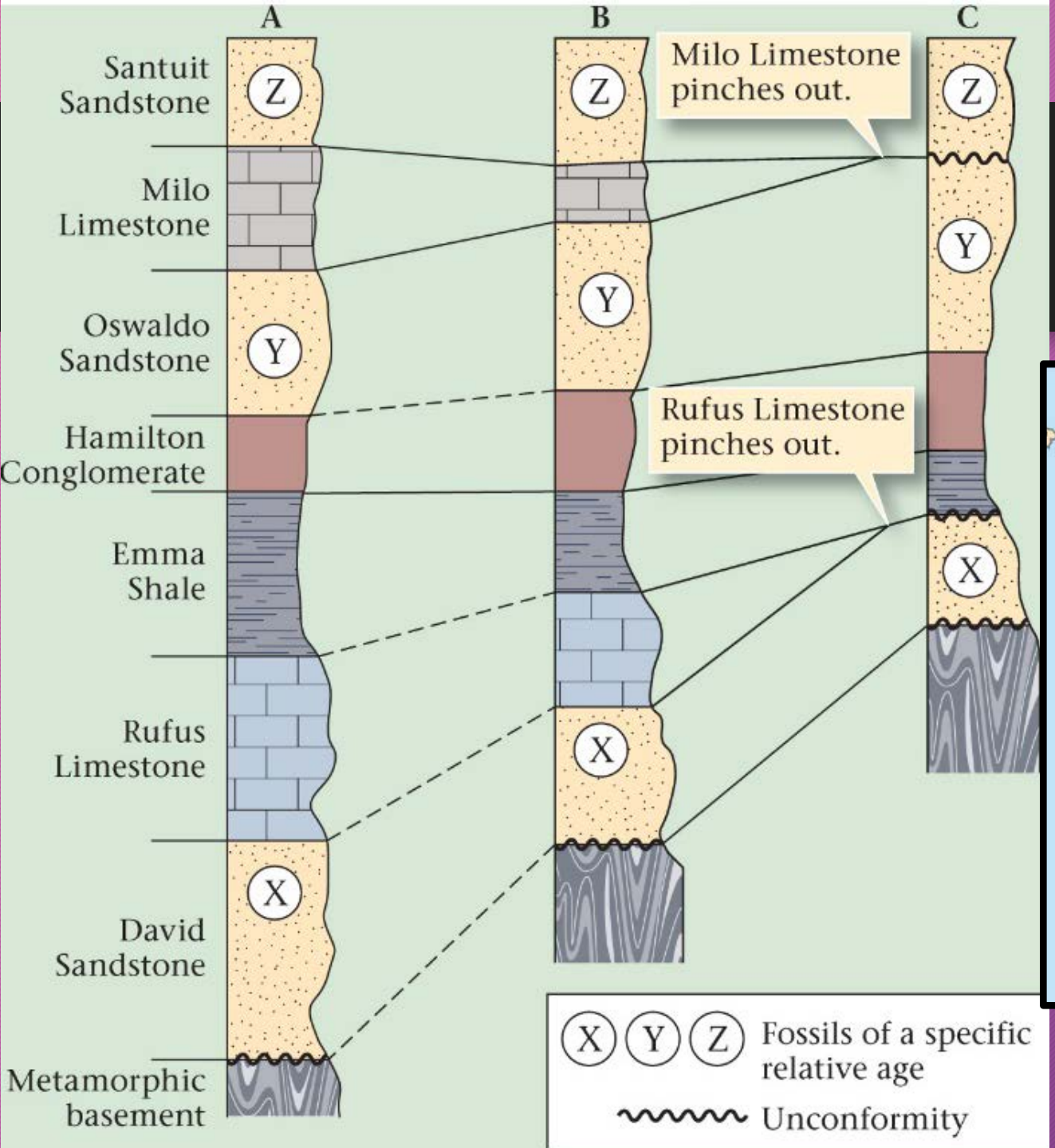
- Use of tribal names
  - Ordovician – Ordovices (historic Welsh tribe that was the last to submit to the Romans.
  - Silurian – Silures (ancient Wales tribe)
- Geographic localities
  - Cambrian – Cambria (Roman name for Wales)
  - Devonian – Region of Devonshire England

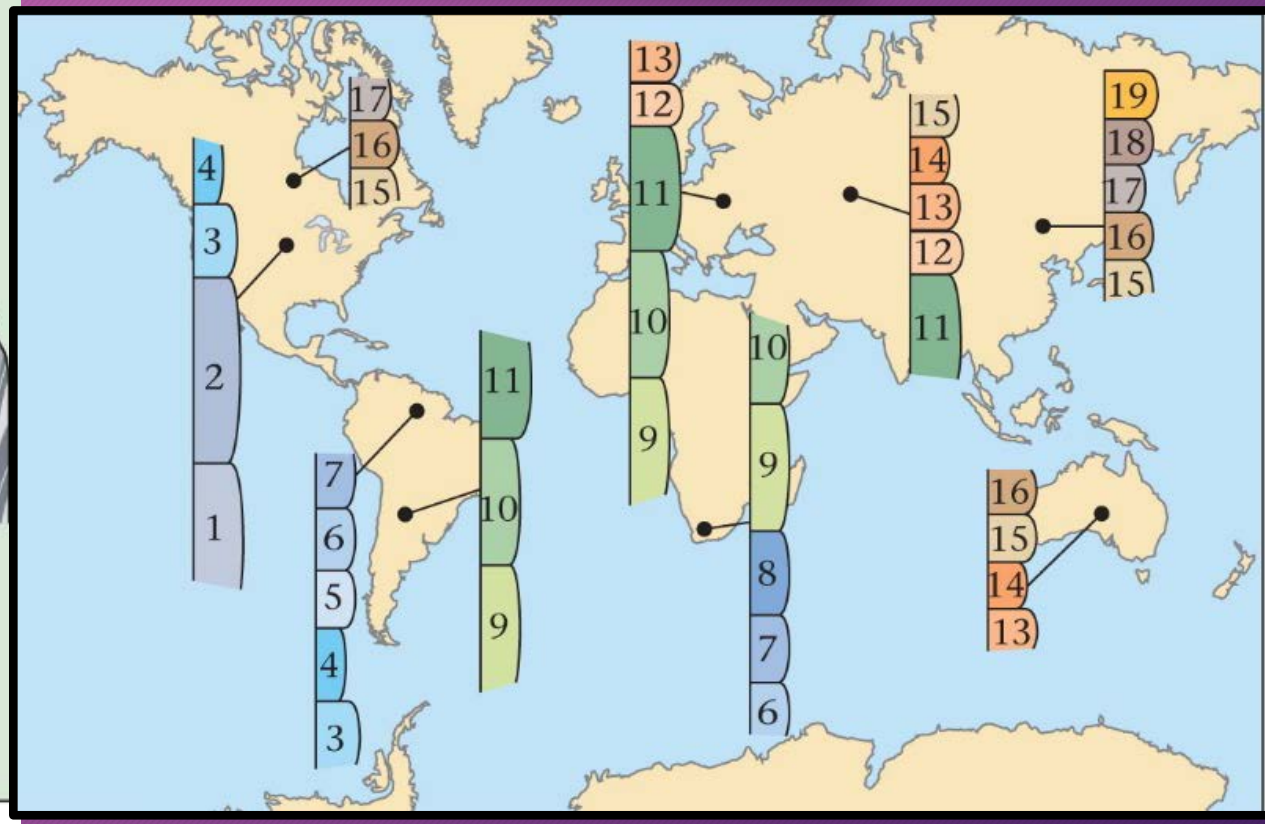
Stratigraphy – The science of rock layers

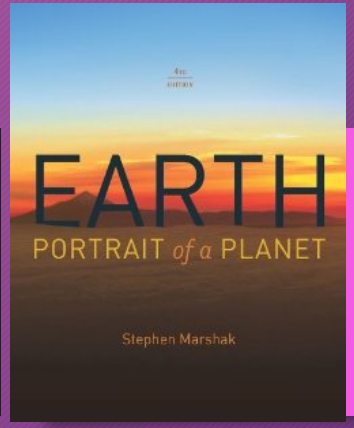
- Concerned with all characters and properties (physical, chemical and/or biological)
- Enables geologists to trace rock formations from one place to another
- Helps geologists to interpret modes of origin and history



Correlation







6 Major Unconformities in Iowa

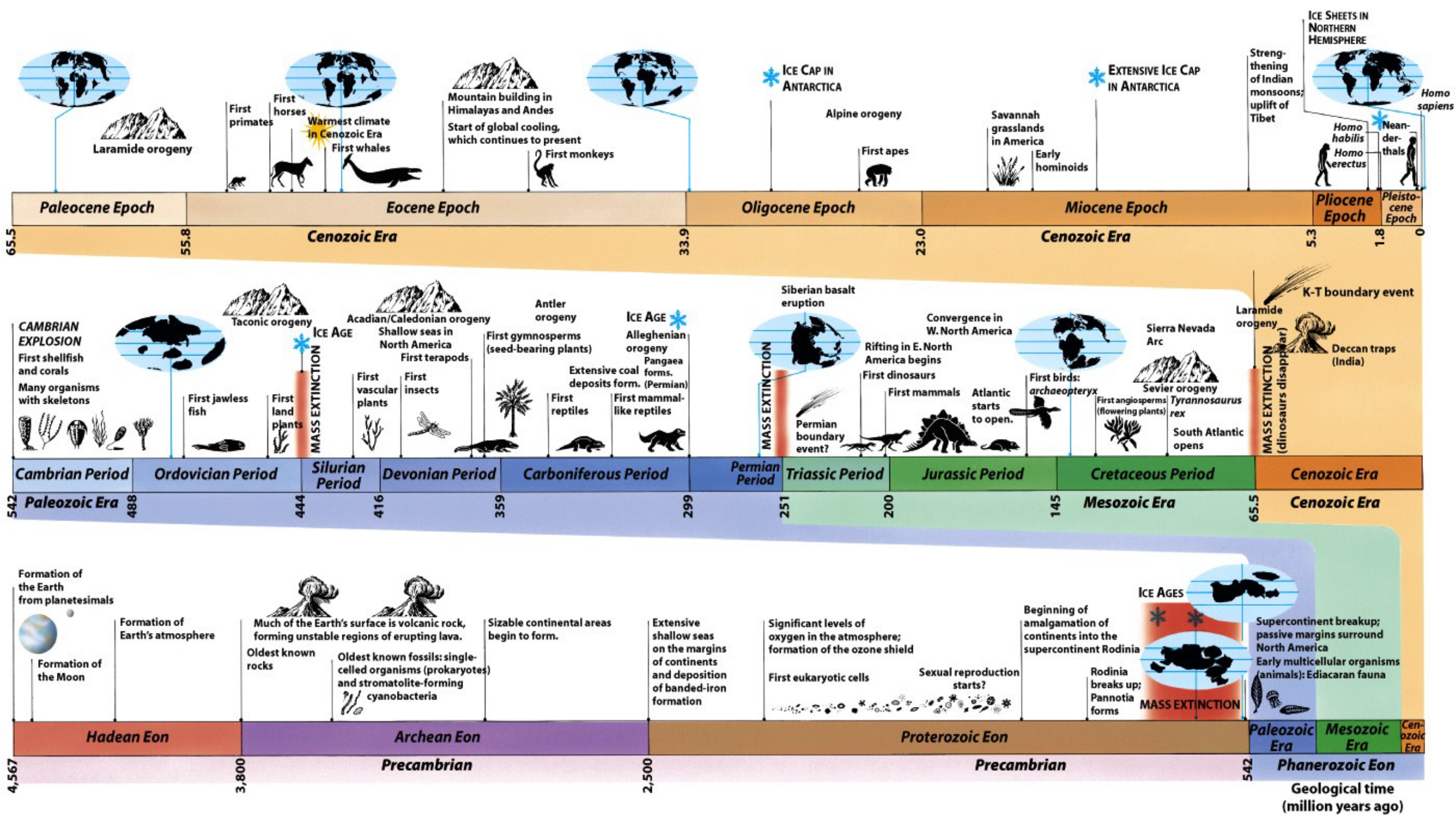
- Base of Cambrian
- Within Ordovician
- Base of Devonian
- Between the Mississippian and Pennsylvanian
- Between the Jurassic and Cretaceous
- Iowa does not have any exposed rocks dating to the Permian or Triassic

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


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
Taconic orogeny
Ice Age
Acadian/Caledonian orogeny
Shallow seas in North America
First terapods
Antler orogeny
First gymnosperms (seed-bearing plants)
Ice Age
Allegenian orogeny
Pangaea forms. (Permian)
Extensive coal deposits form.
First jawless fish
First land plants
MASS EXTINCTION
First vascular plants
First insects
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
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MASS EXTINCTION (dinosaurs disappear)
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Ordovician Period
Silurian Period
Devonian Period
Carboniferous Period
Permian Period
Triassic Period
Jurassic Period
Cretaceous Period
Cenozoic Era
542
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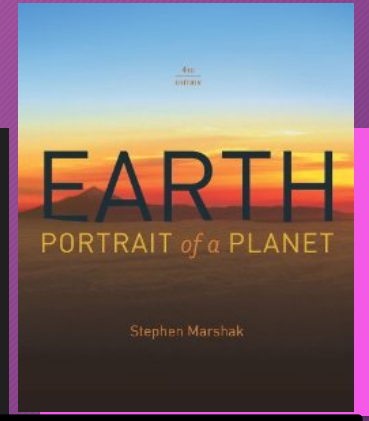
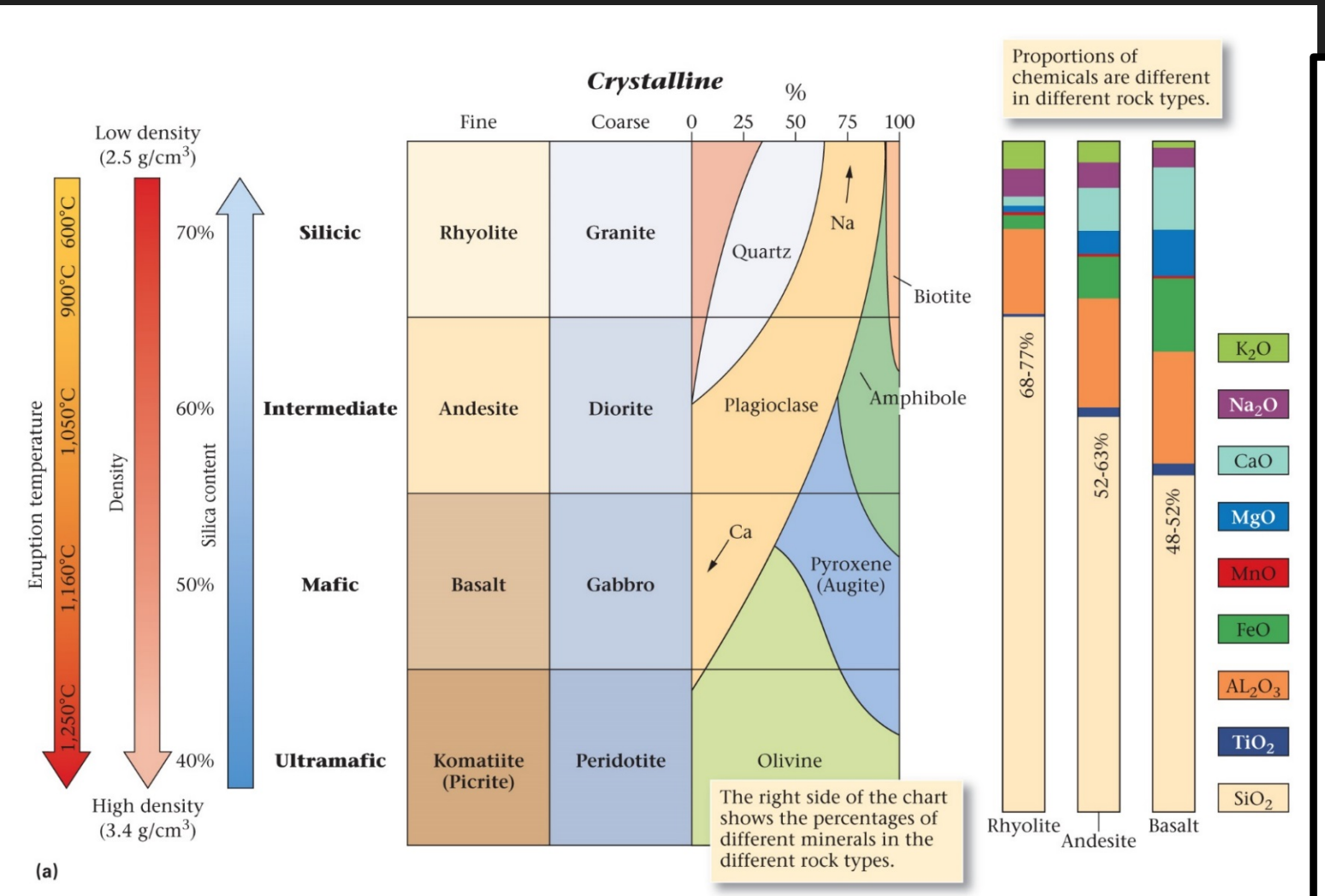
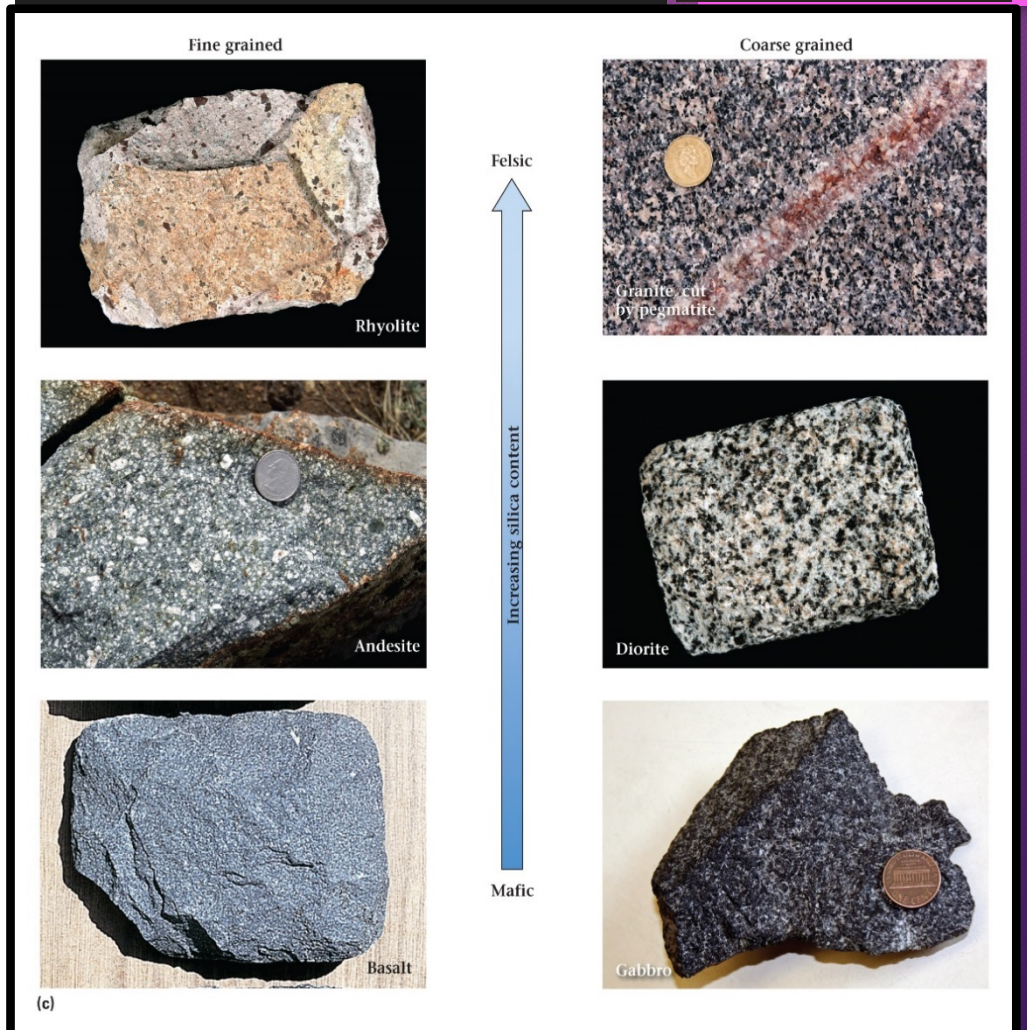
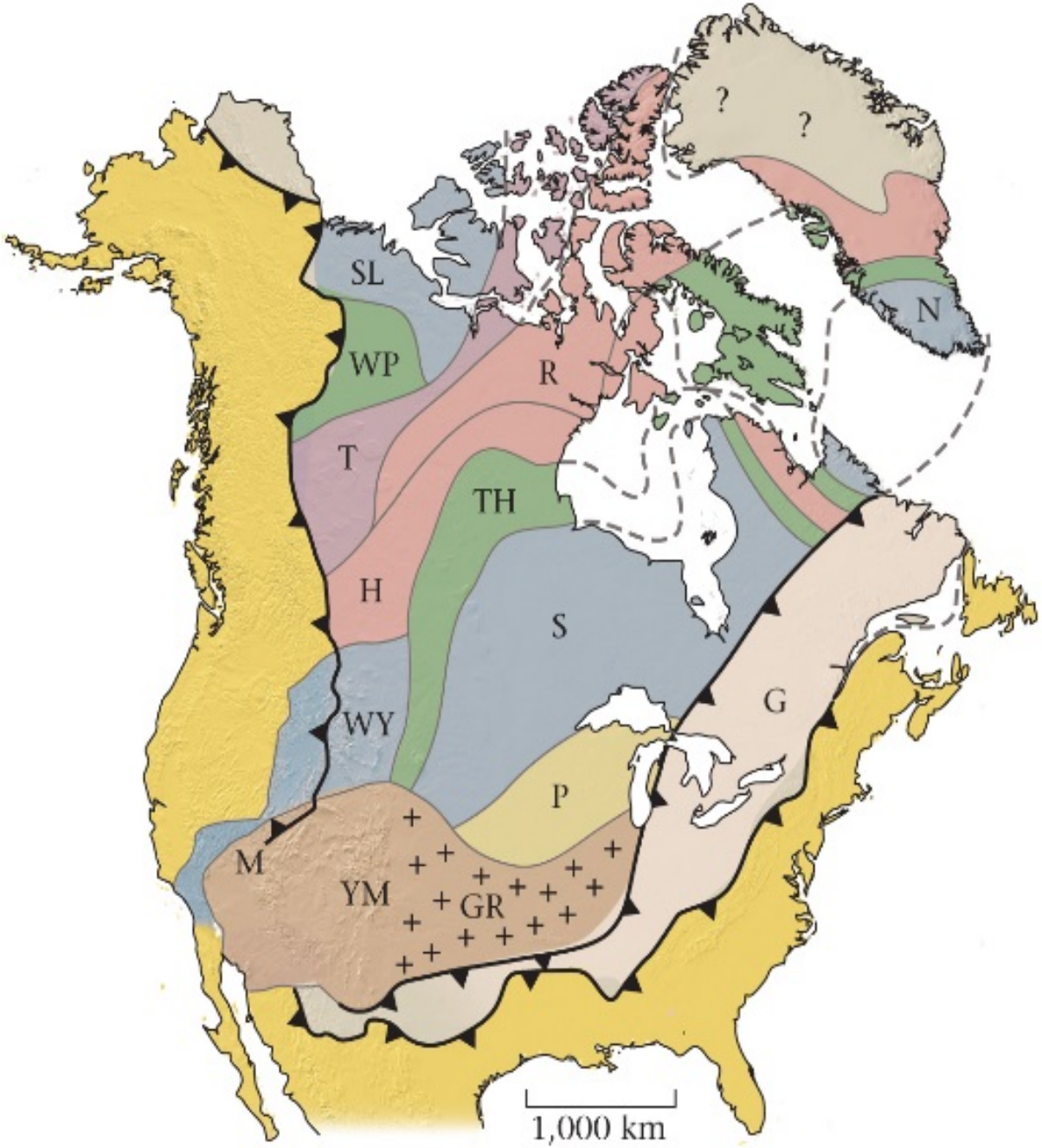
145
65.5
Paleozoic Era
Mesozoic Era
Cenozoic Era
Formation of the Earth from planetesimals
Formation of the Moon
Formation of Earth's atmosphere
Much of the Earth's surface is volcanic rock, forming unstable regions of erupting lava.
Oldest known rocks
Oldest known fossils: single-celled organisms (prokaryotes) 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
Ice Ages
Rodinia breaks up; Pannotia forms
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)

Extended concept (Igneous Intrusive vs Extrusive rocks)









Phanerozoic orogen

1.1- Ga collisional orogen (G = Grenville)

1.6- to 1.7- Ga accreted crust covered by granite and rhyolite, where patterned (GR = granite-rhyolite province)

1.6- to 1.7- Ga accreted crust (YM = Yavapai and Mazatzal)

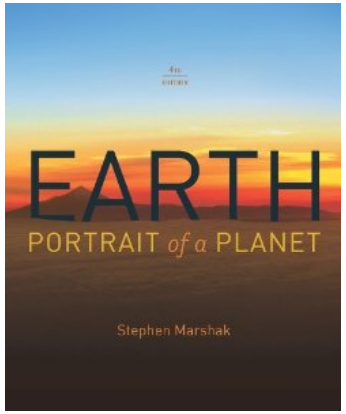
1.8- Ga accreted crust (P = Penokean)

1.8- Ga collisional orogen (TH = Trans-Hudson; WP = Wopmay)

1.9- Ga collisional orogen (T = Thelon)

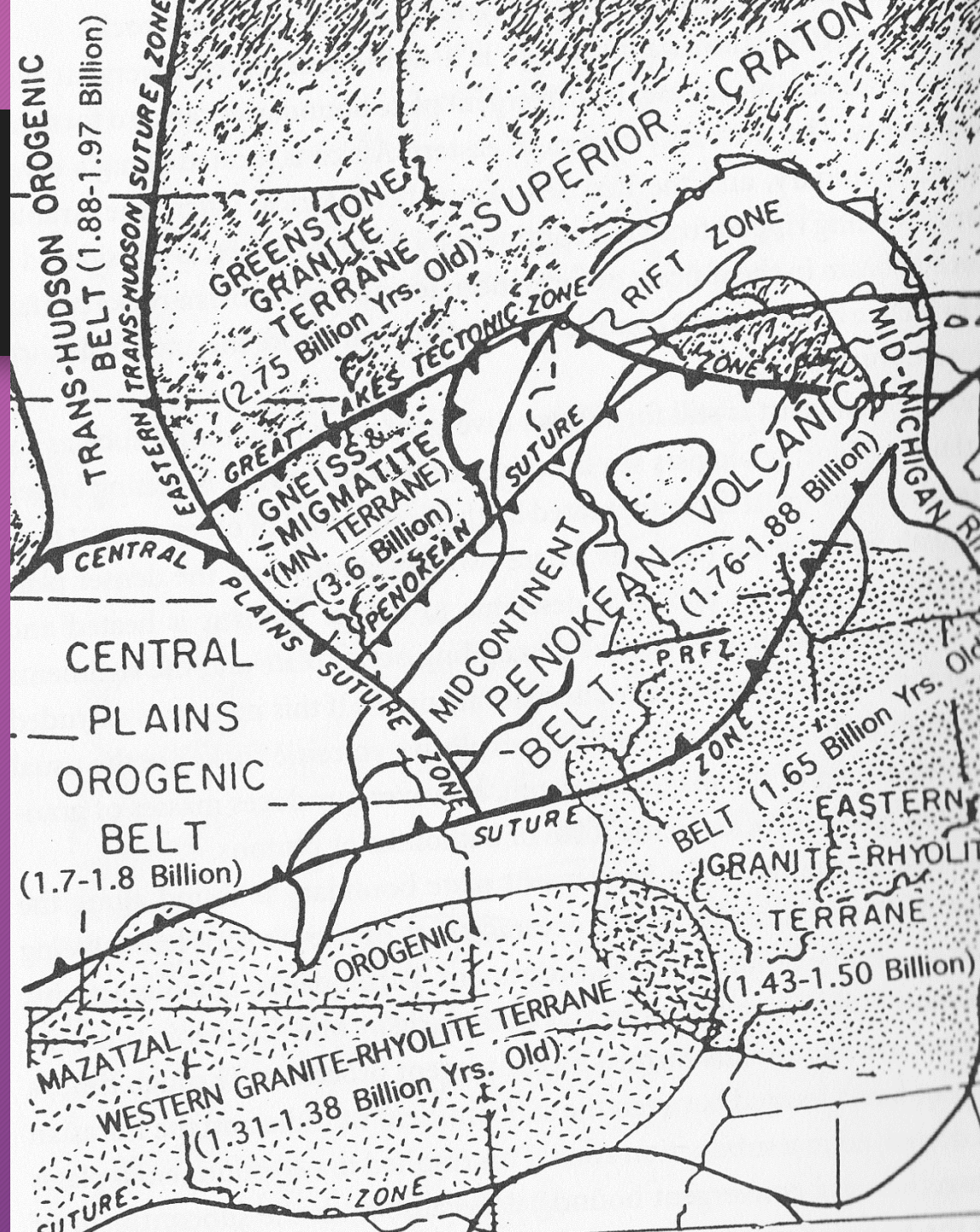
Archean rocks, later deformed and metamorphosed in the Proterozoic (H = Hearn; R = Rae)

Relicts of Archean crust (WY = Wyoming; M = Mojave; S = Superior; N = Nain; SL = Slave)



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

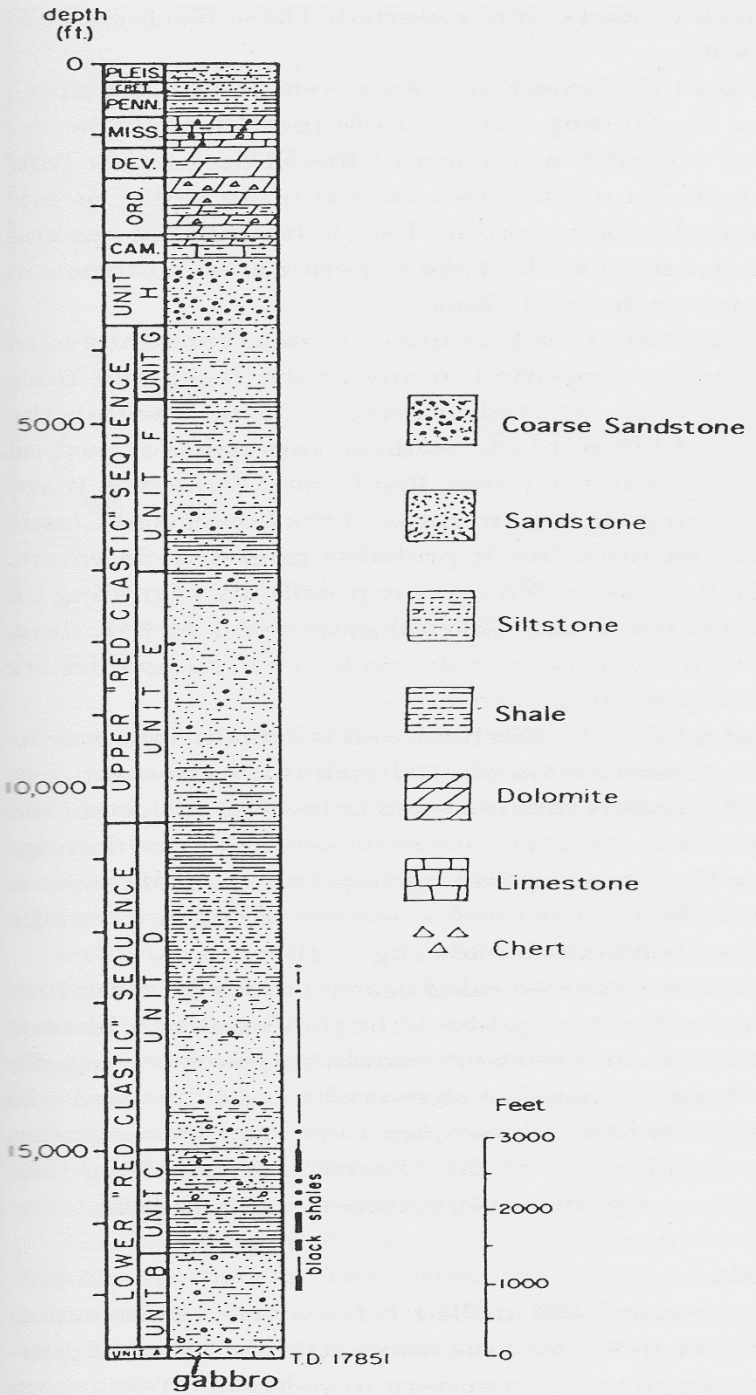


The Eischeid Well – Iowa's Deepest Drilled Well

- Oil likely formed in the Lower clastic unit, but has moved… Where?
- Basal Gabbro near 3 miles below
  - Dates to 1.28 Ga
  - Possibly correlates with Canada's Mackenzie Dike swarm…

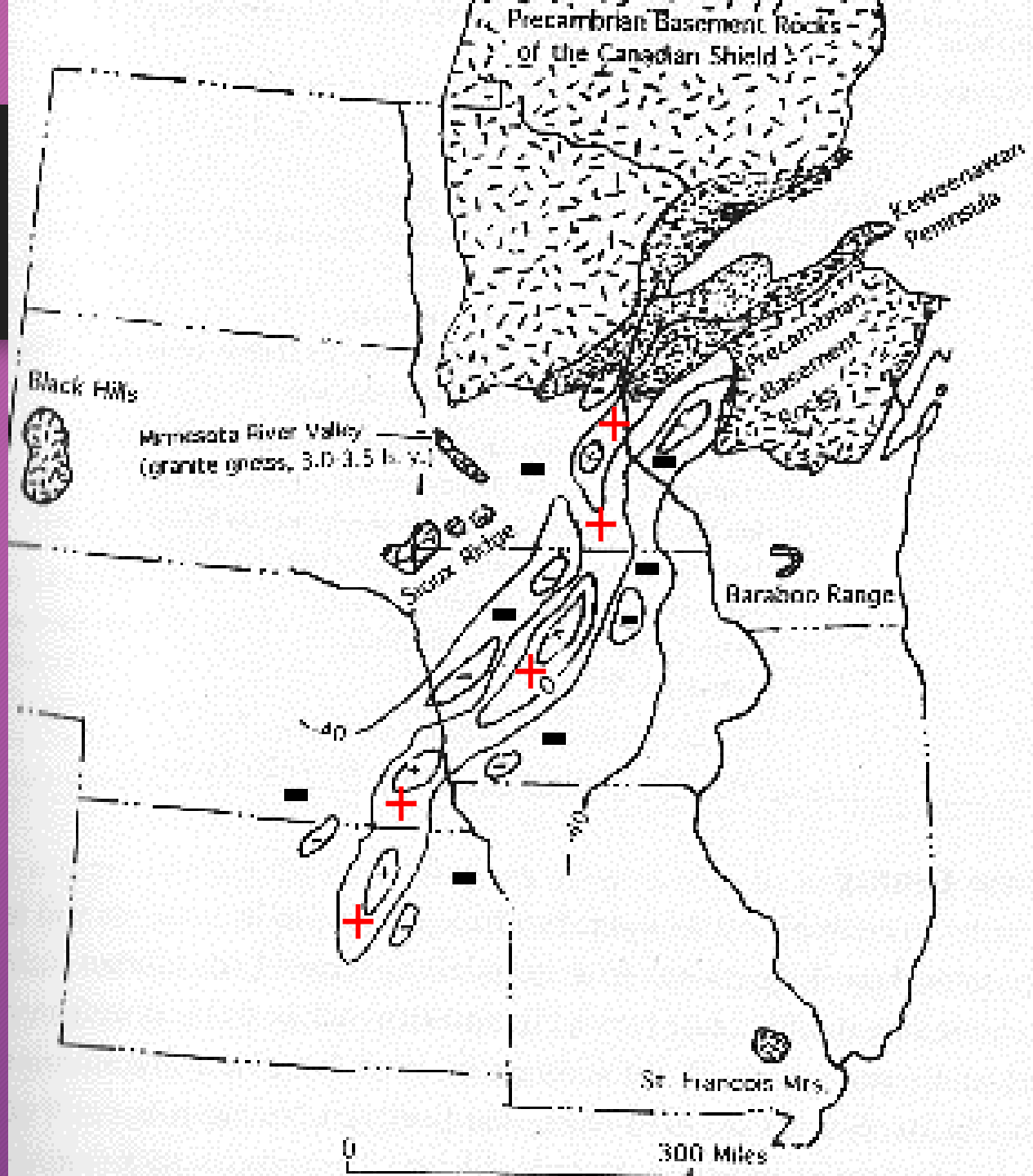
Lower 'Red-clastic'

Upper 'Red-Clastic'



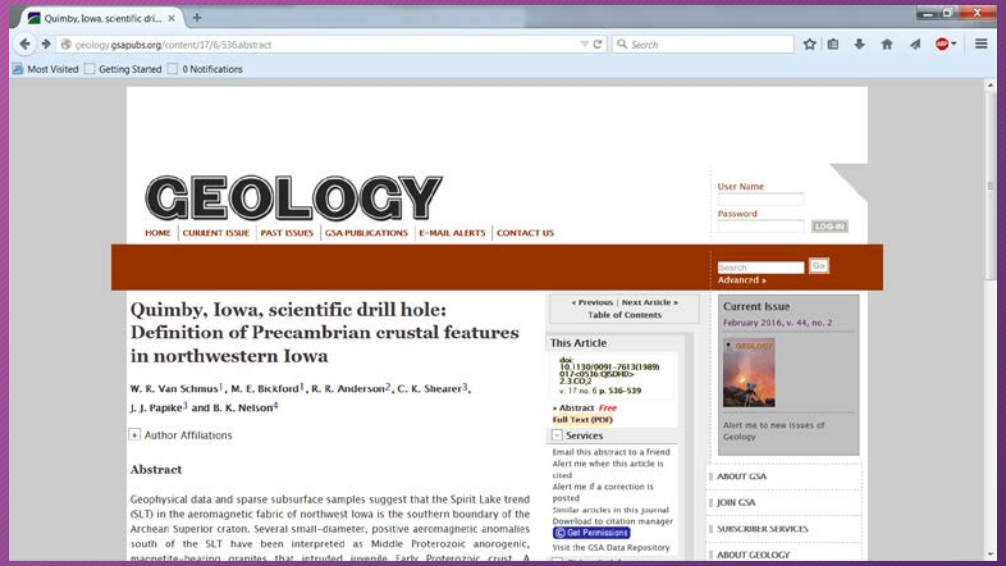
Iowa's Igneous & Metamorphic 'Basement'

- 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



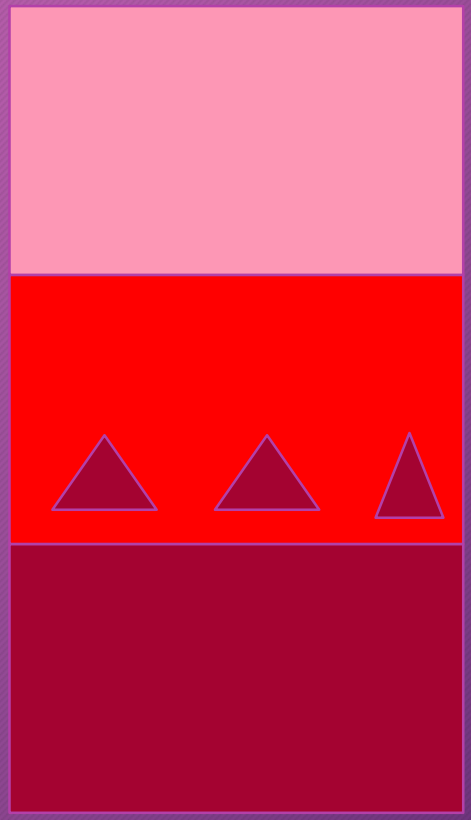
Quimby drill hole

- Cherokee County
- 2000’ deep core
  - 330’ of granite core
- Geochemistry suggests…
  - Reworked rock from the Penokean Orogeny



Matlock Cores, Lyon & Sioux Co.

- New Jersey Zinc Company
- Otter Creek mafic complex
  - 2.9 Ga, Iowa's Oldest known rock
  - 1.6 to 2.5 Ga, R. Anderson
- Matlock Keratophyre



Sioux Quartzite, 1.76 to 1.64 Ga

Matlock Keratophyre. 1.76Ga

Otter Creek, ~2.0Ga

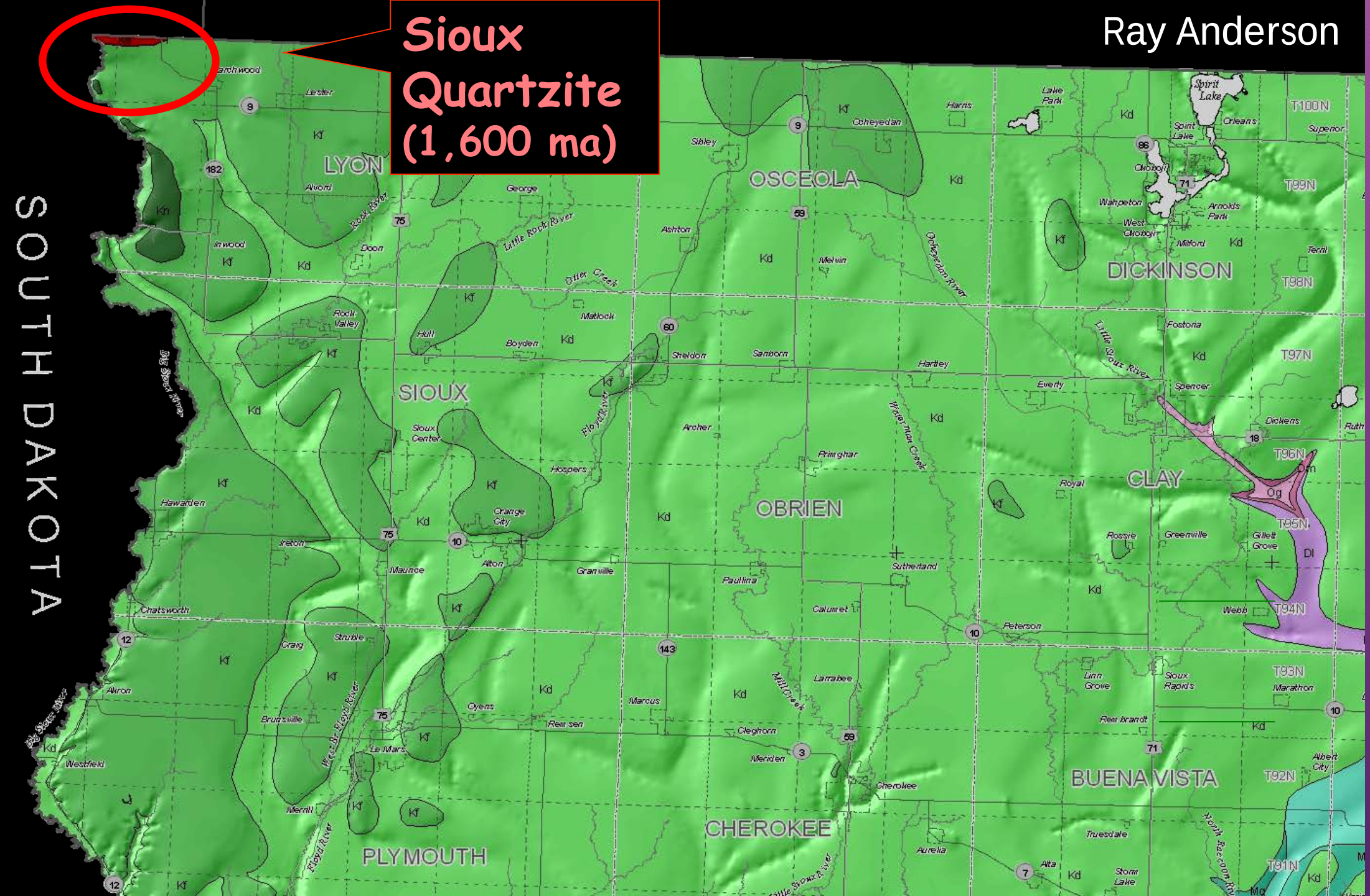
BIF

2.2 Ga

to

2.4 Ga

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

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
  - Occurs in eastern at great depths

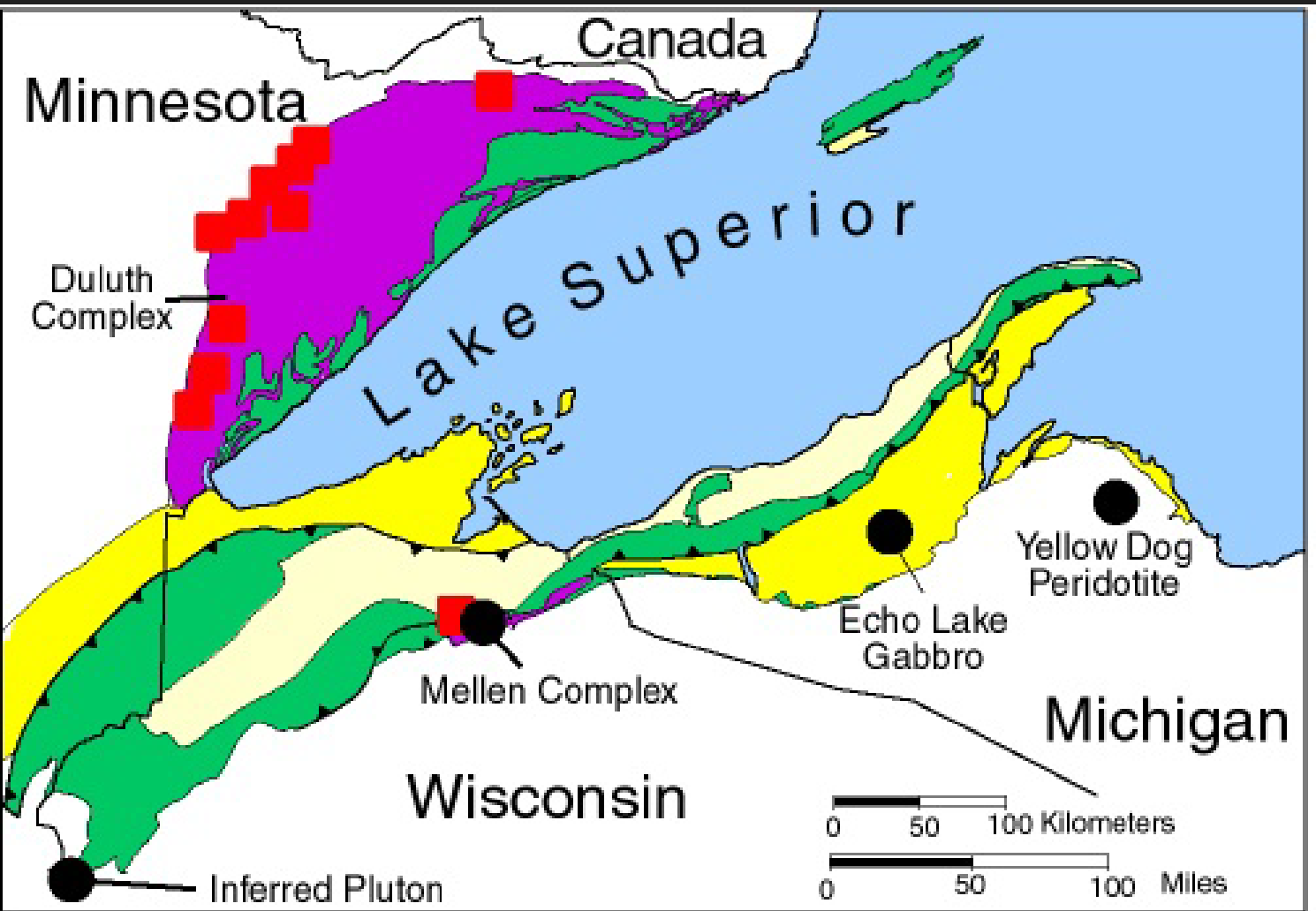
Federal building in Sioux Falls, SD

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

Manson impact structure

Duluth Complex & North shore Lake Superior

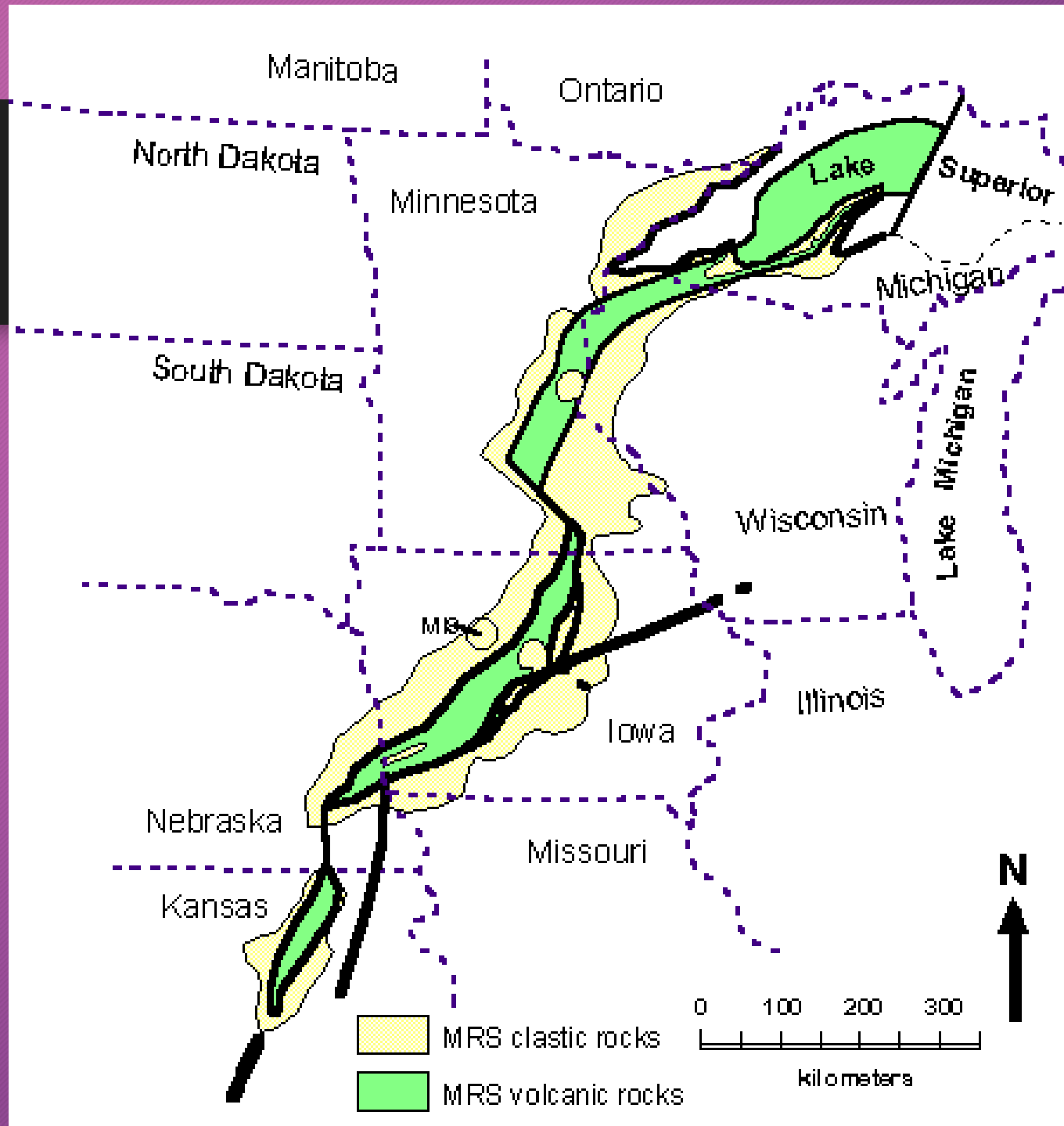


EXPLANATION

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

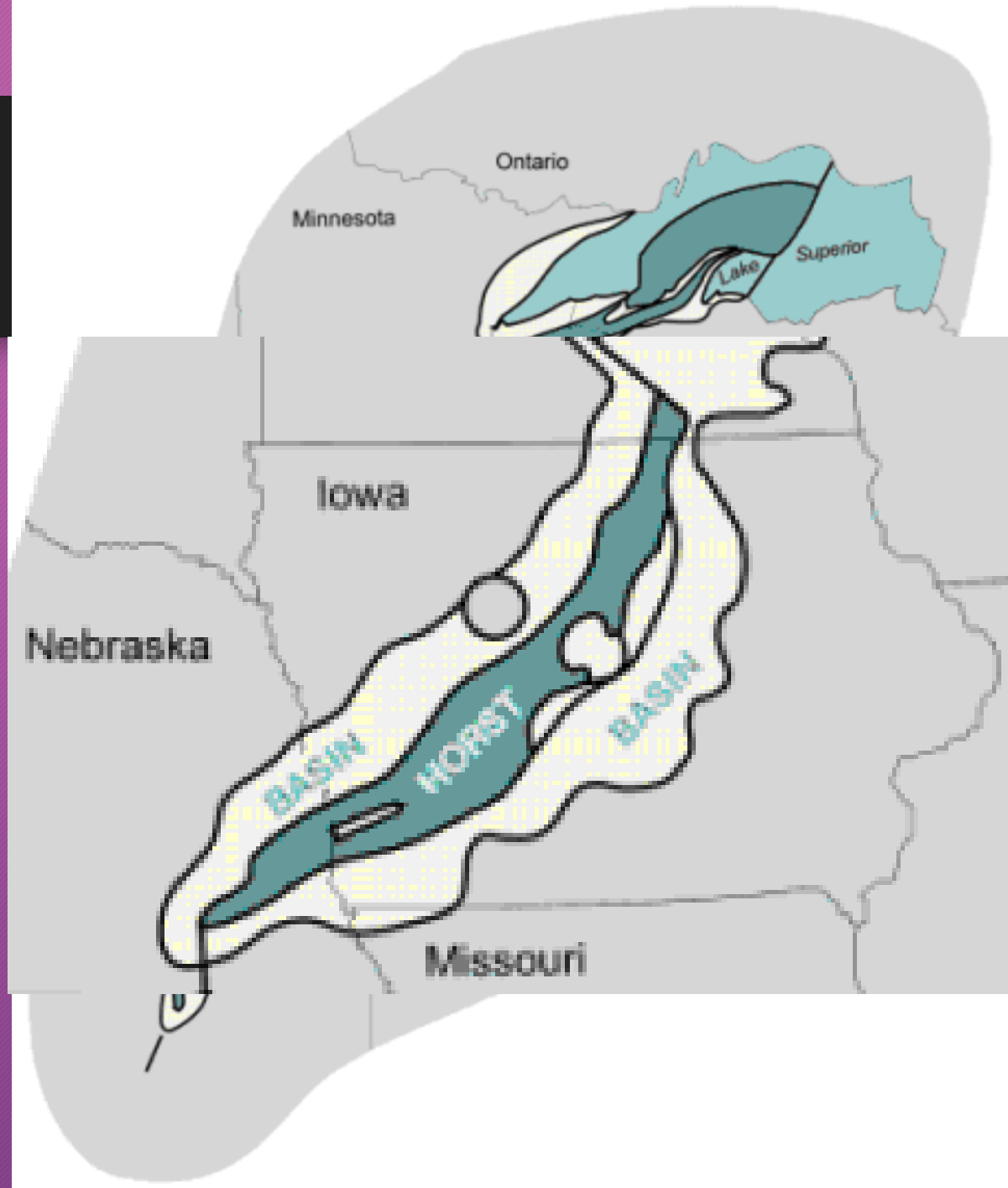
Midcontinent Rift System, 1.1 Ga

- In Iowa, under 1,200 to 5,500’ of Phanerozoic rock
- Formation of adjacent ‘*grabens*’, that infilled with sand and mud (lower red clastic sequence)
- At 1 Ga, areas are uplifted creating ‘*horsts*’, weathered-eroded to form (upper red clastic sequence)



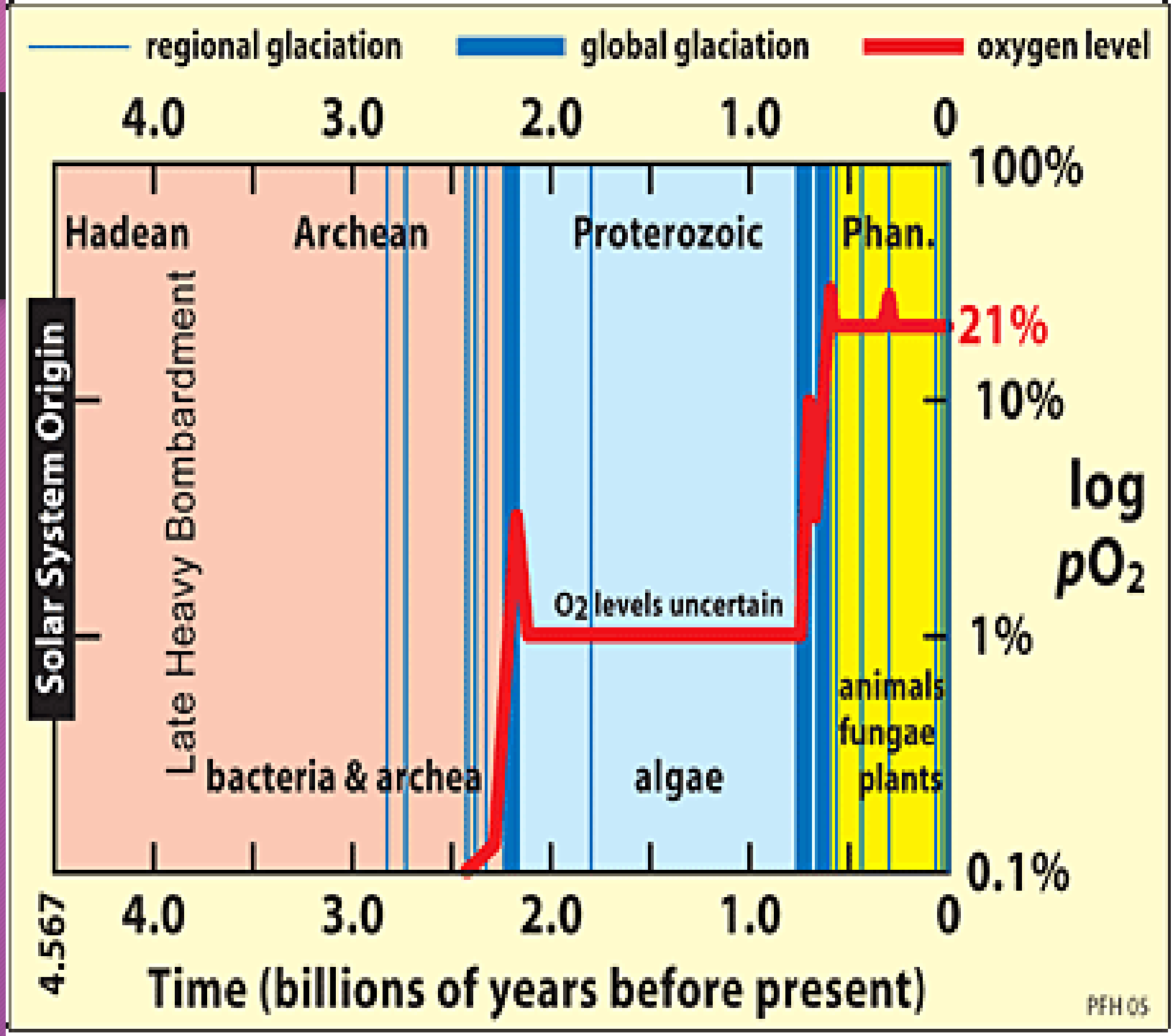
The Iowa Horst

- Uplifted, 30,000ft, area of basalt
- 20 to 40 miles wide, 350+ miles long
- Adjacent sedimentary basins, cover 150,000 sq miles & over 35,000 cubic miles of red clastic sandstone, siltstone, and shale.



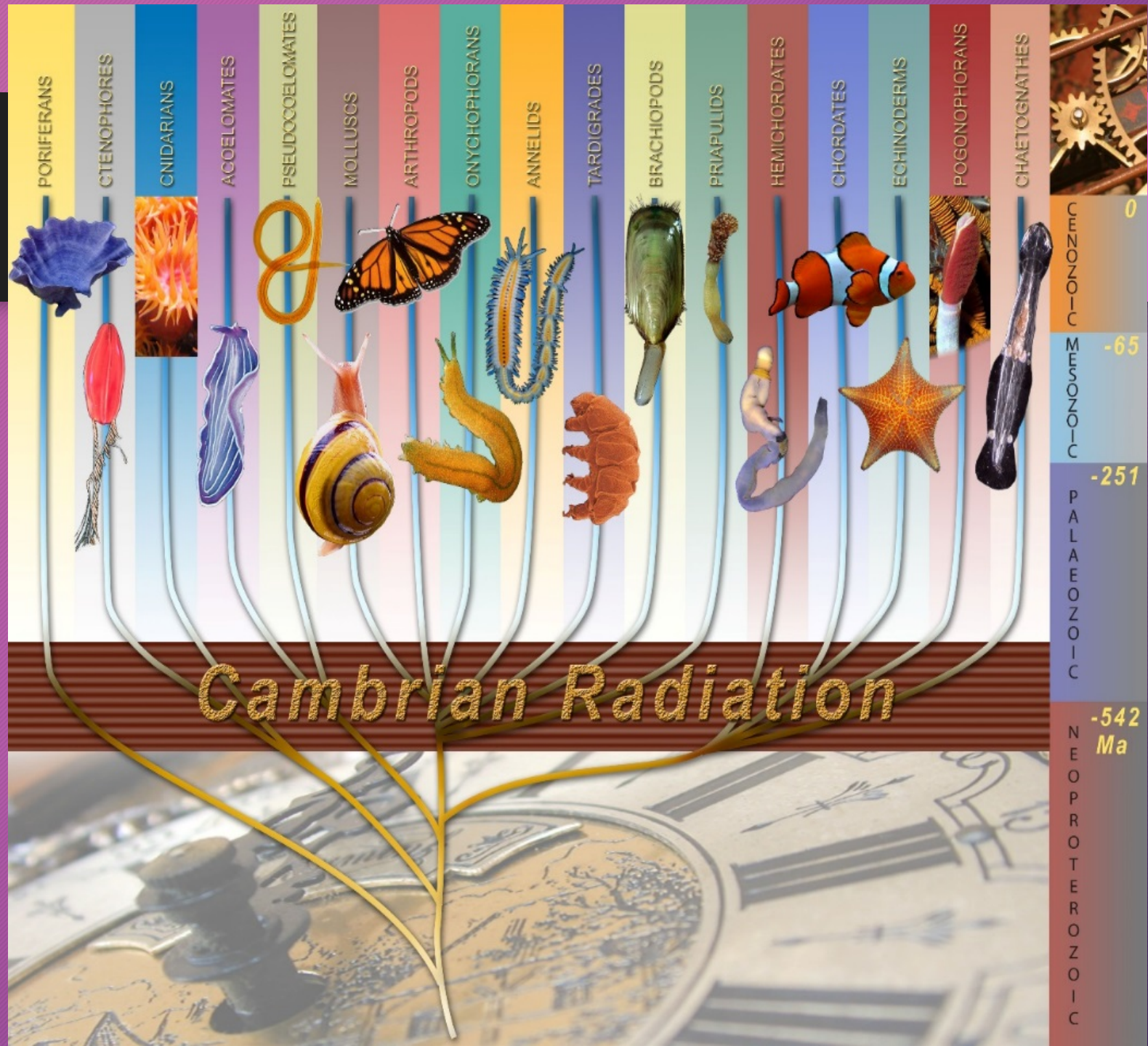
Precambrian – Cambrian Transition

- Snowball Earth
- Atmospheric composition
- Life



Cambrian Life

- The age of the Trilobites
- Trilobites and brachiopods are abundant in this period, but not in Iowa.
- Why???
- Iowa's Cambrian record is dominated by SANDY near shore transition environments.



Iowa's Paleozoic

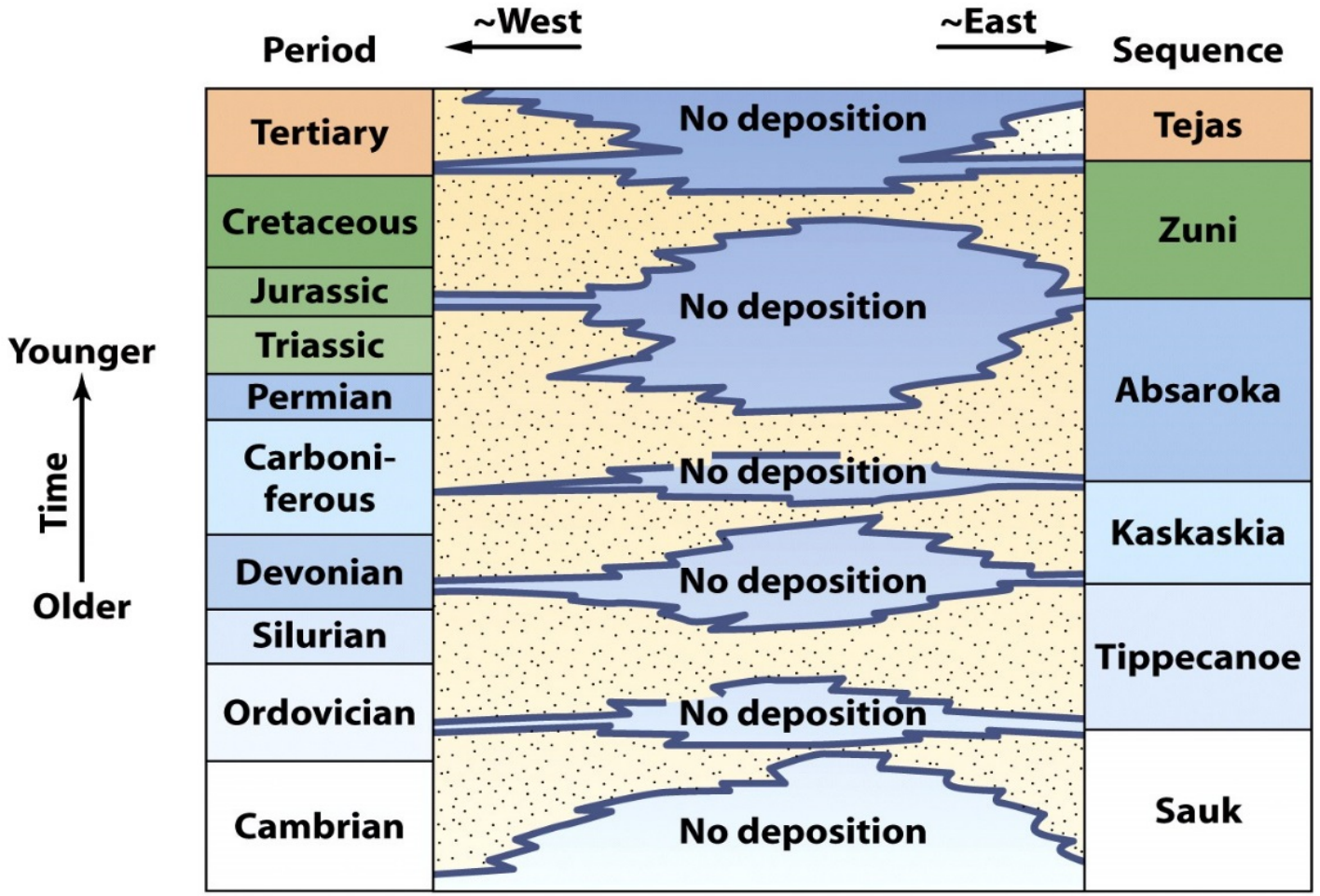
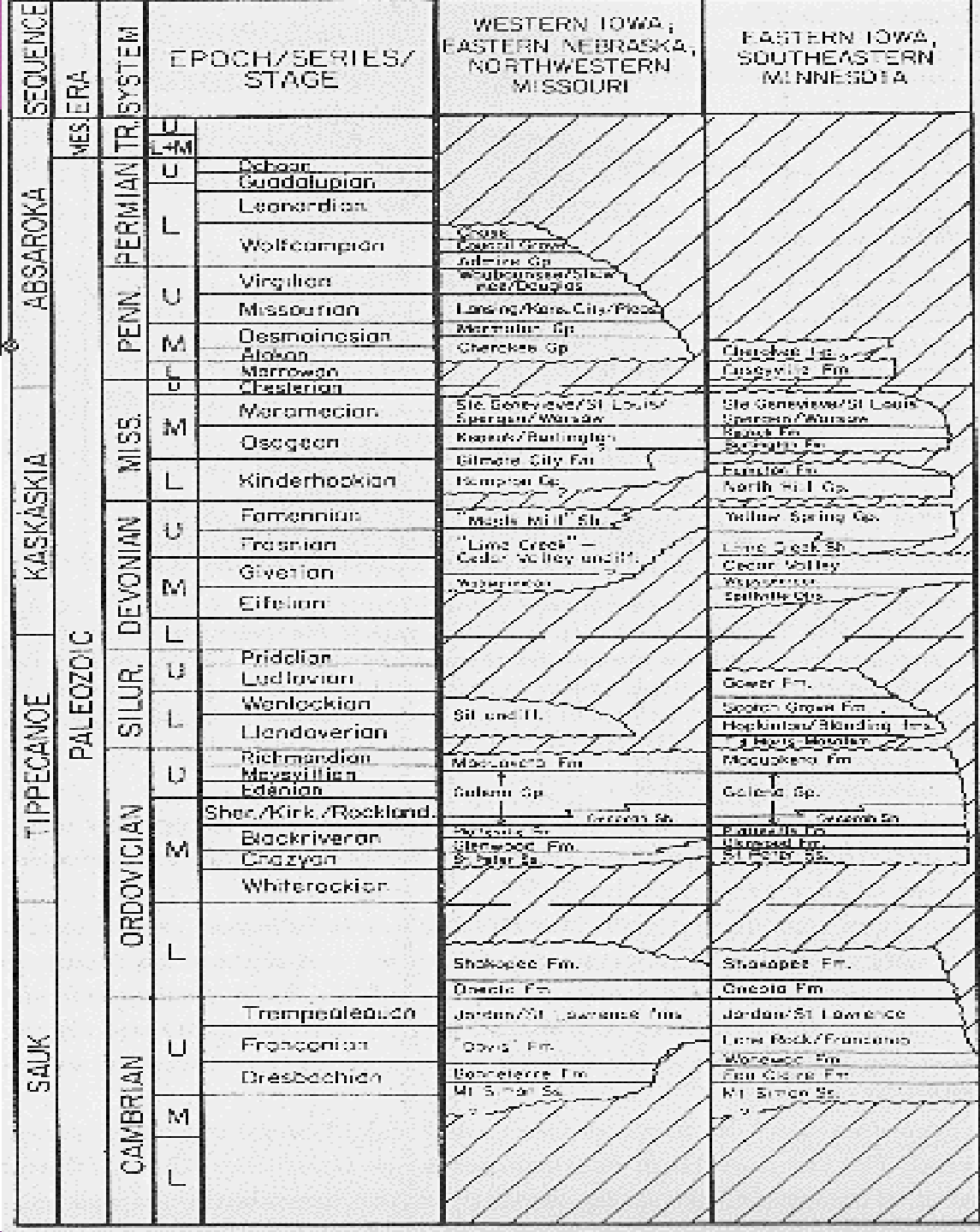
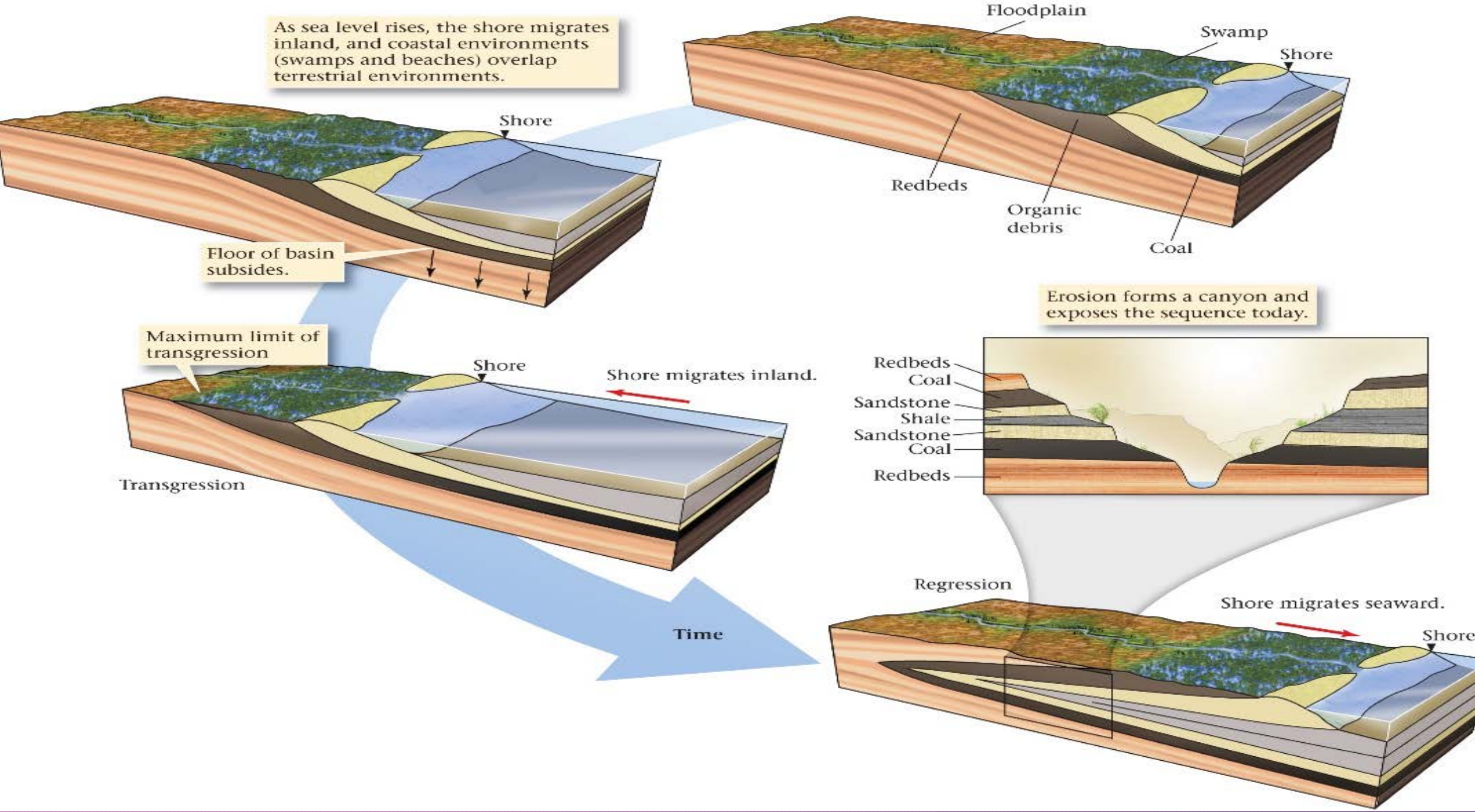


Figure 13-17b Earth: Portrait of a Planet 3/e

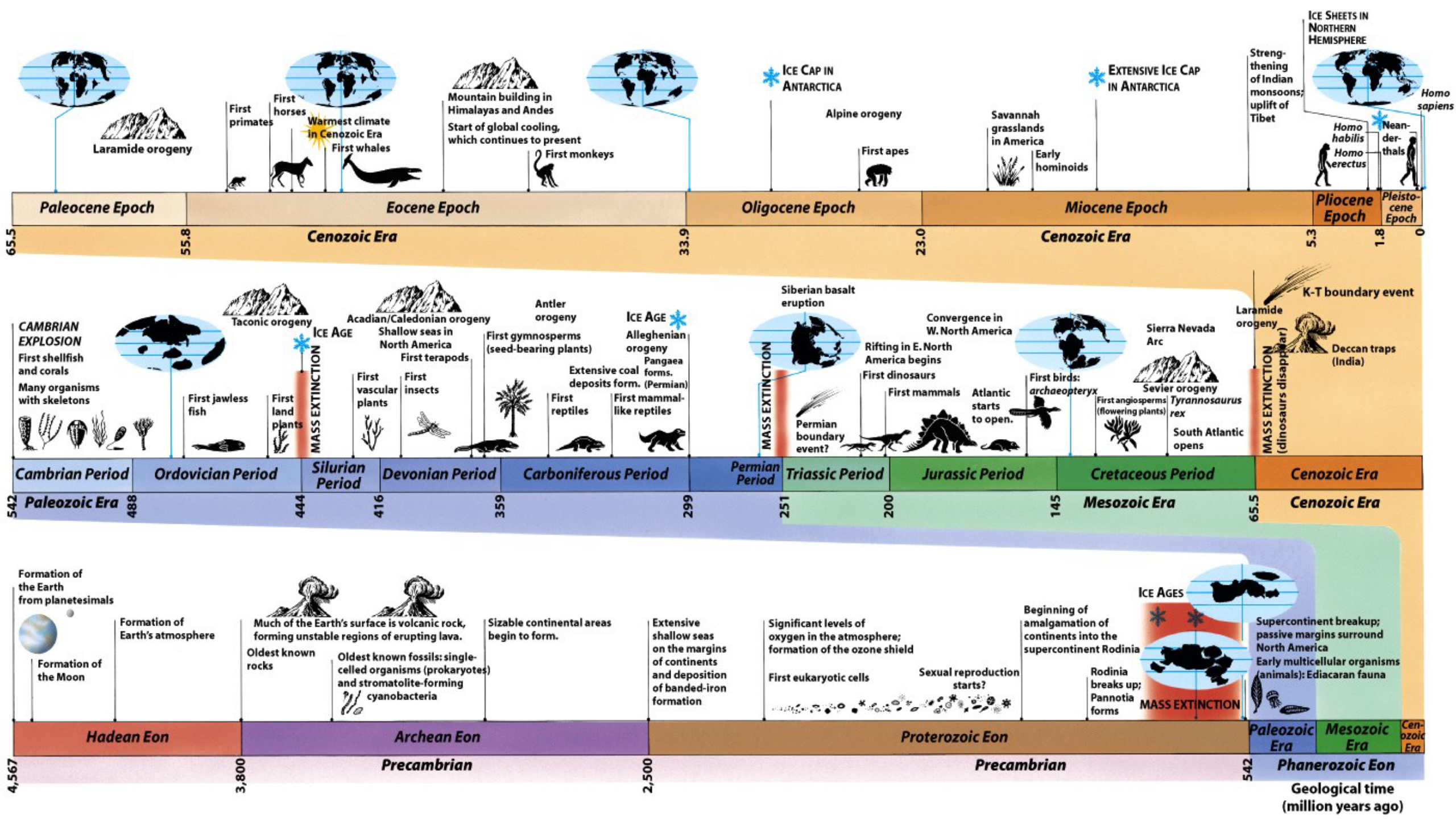



As sea level rises, the shore migrates inland, and coastal environments (swamps and beaches) overlap terrestrial environments.
Shore
Floor of basin subsides.
Floodplain
Swamp
Shore
Redbeds
Organic debris
Coal
Maximum limit of transgression
Shore
Shore migrates inland.
Transgression
Erosion forms a canyon and exposes the sequence today.
Redbeds
Coal
Sandstone
Shale
Sandstone
Coal
Redbeds
Time
Regression
Shore migrates seaward.
Shore

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 (Precambrian & Early Cambrian) sediments including resistant quartz, feldspar, clay minerals, and trace amounts of zircon, tourmaline and garnet.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First horses
Warmest climate in Cenozoic Era
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Start of global cooling, which continues to present
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Cenozoic Era
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Cenozoic Era
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3,800
2,500
542
Precambrian
Precambrian
Phanerozoic Eon
Geological time (million years ago)

Iowa's Cambrian Stratigraphy

Cambrian

Middle Upper

PC

Jordan

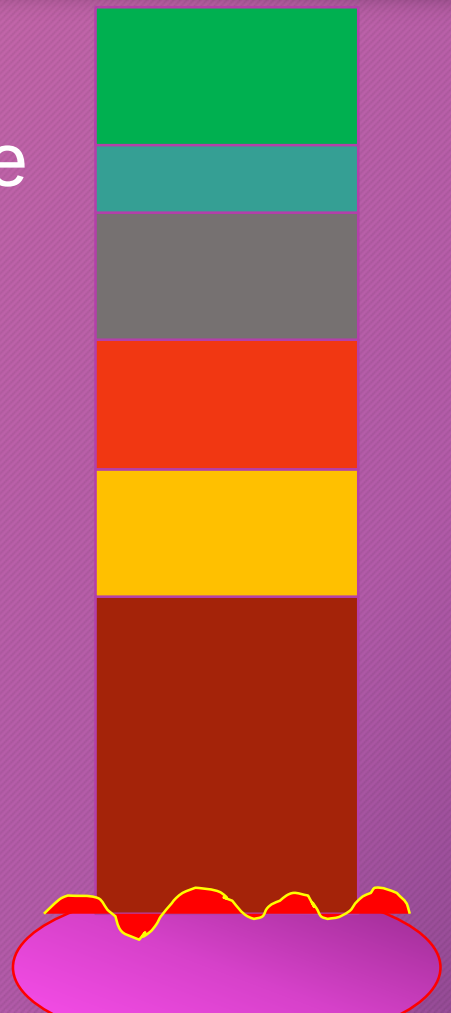
St. Lawrence

Lone Rock

Wonewoc

Eau Claire

Mt. Simon



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

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

Jordan Formation Isopachs

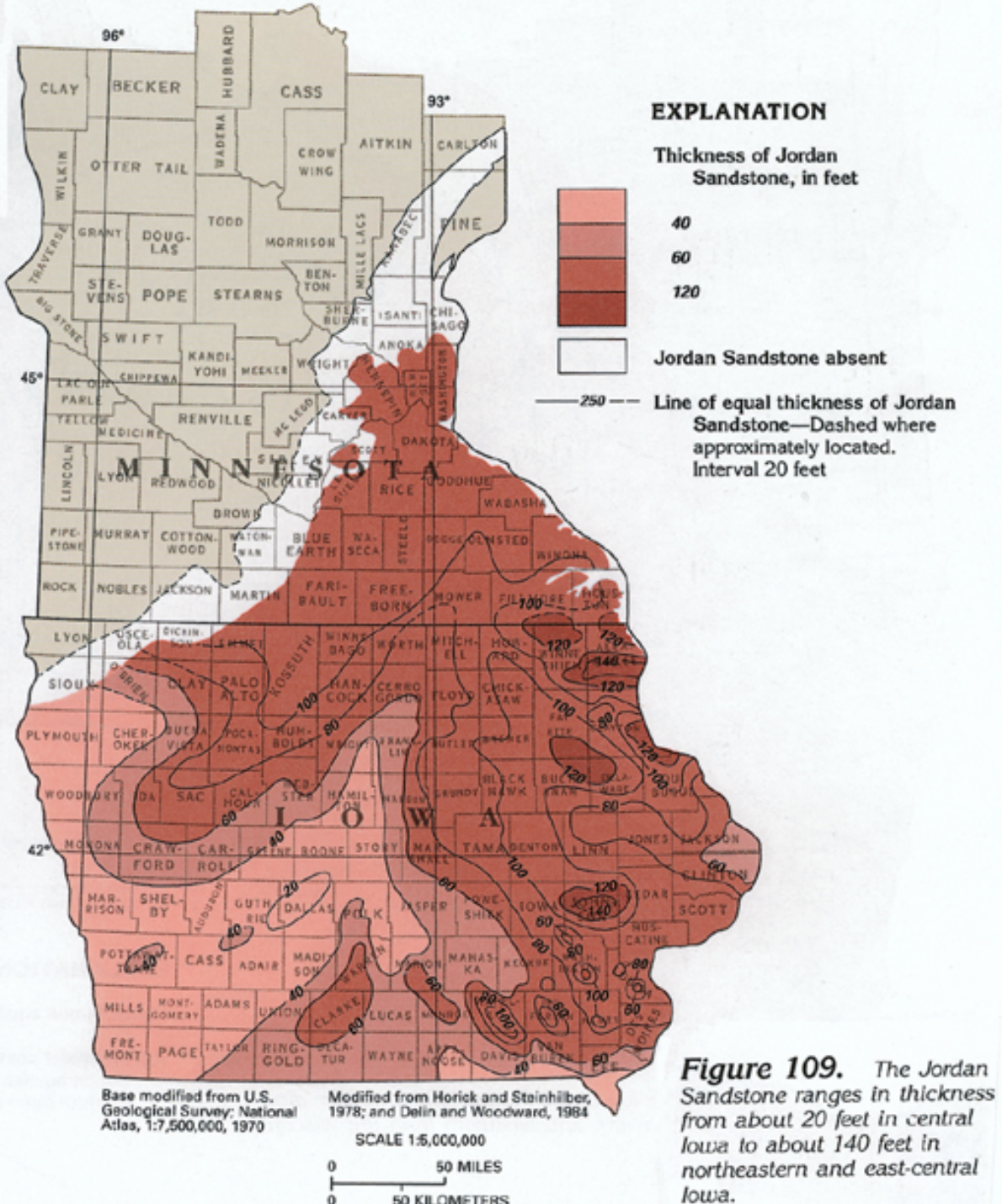
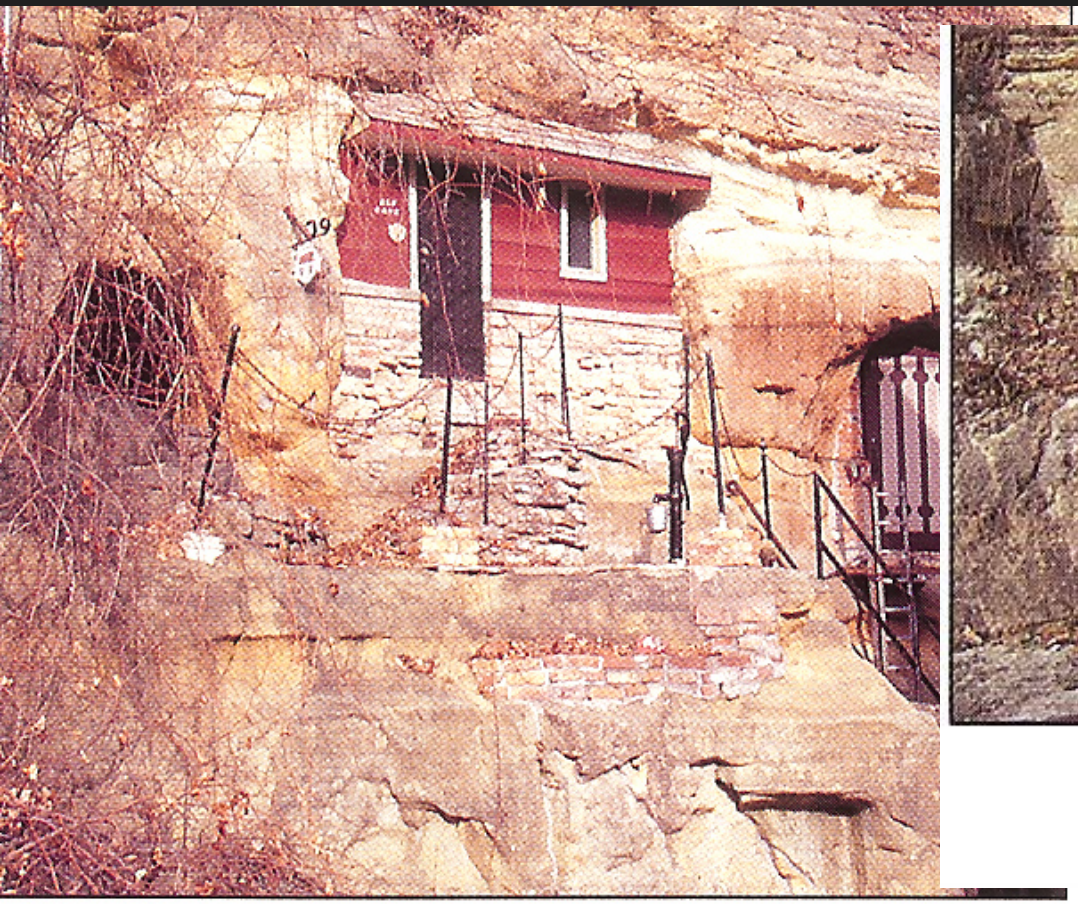
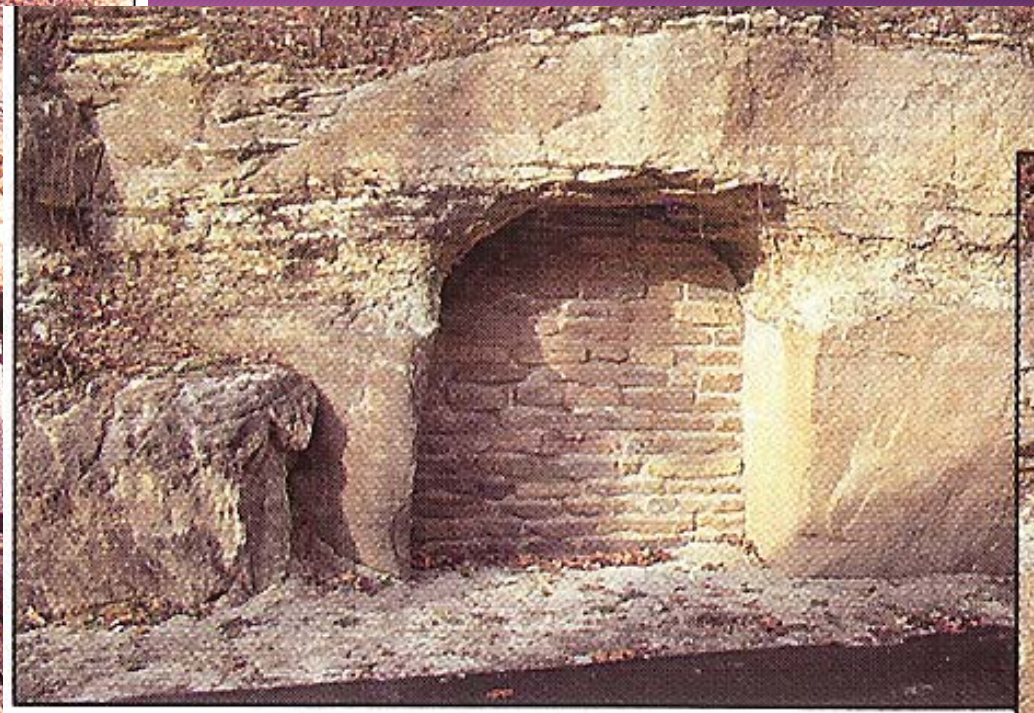


Figure 109. *The Jordan Sandstone ranges in thickness from about 20 feet in central Iowa to about 140 feet in northeastern and east-central Iowa.*

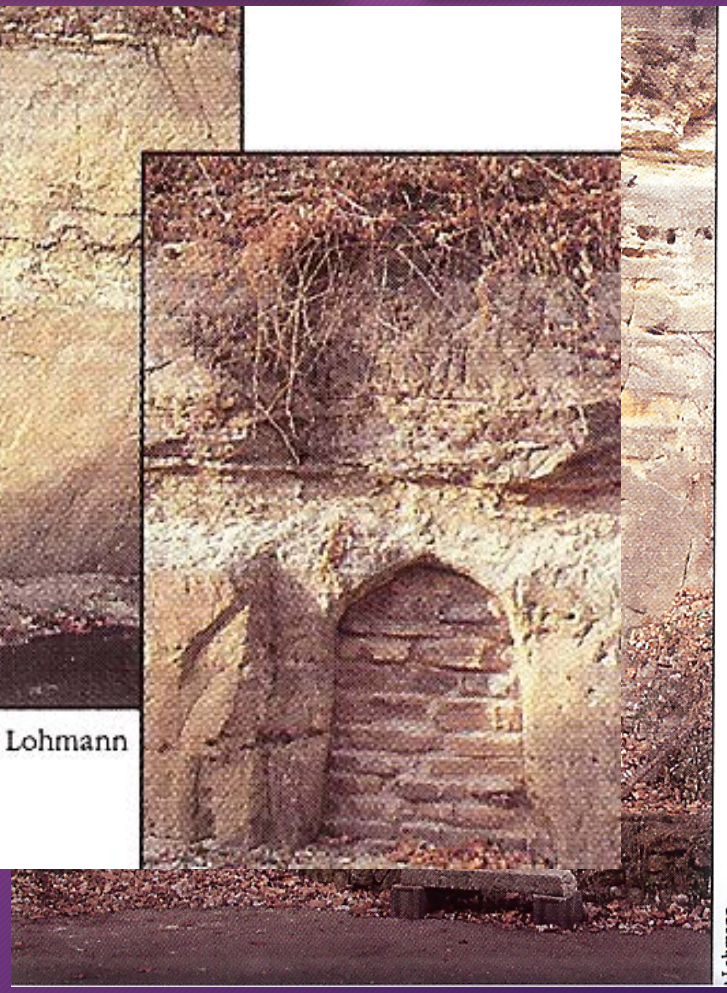
McGregor, Iowa 19th Century Refrigerators



Robert McKay



Pat Lohmann



On deck - The Ordovician