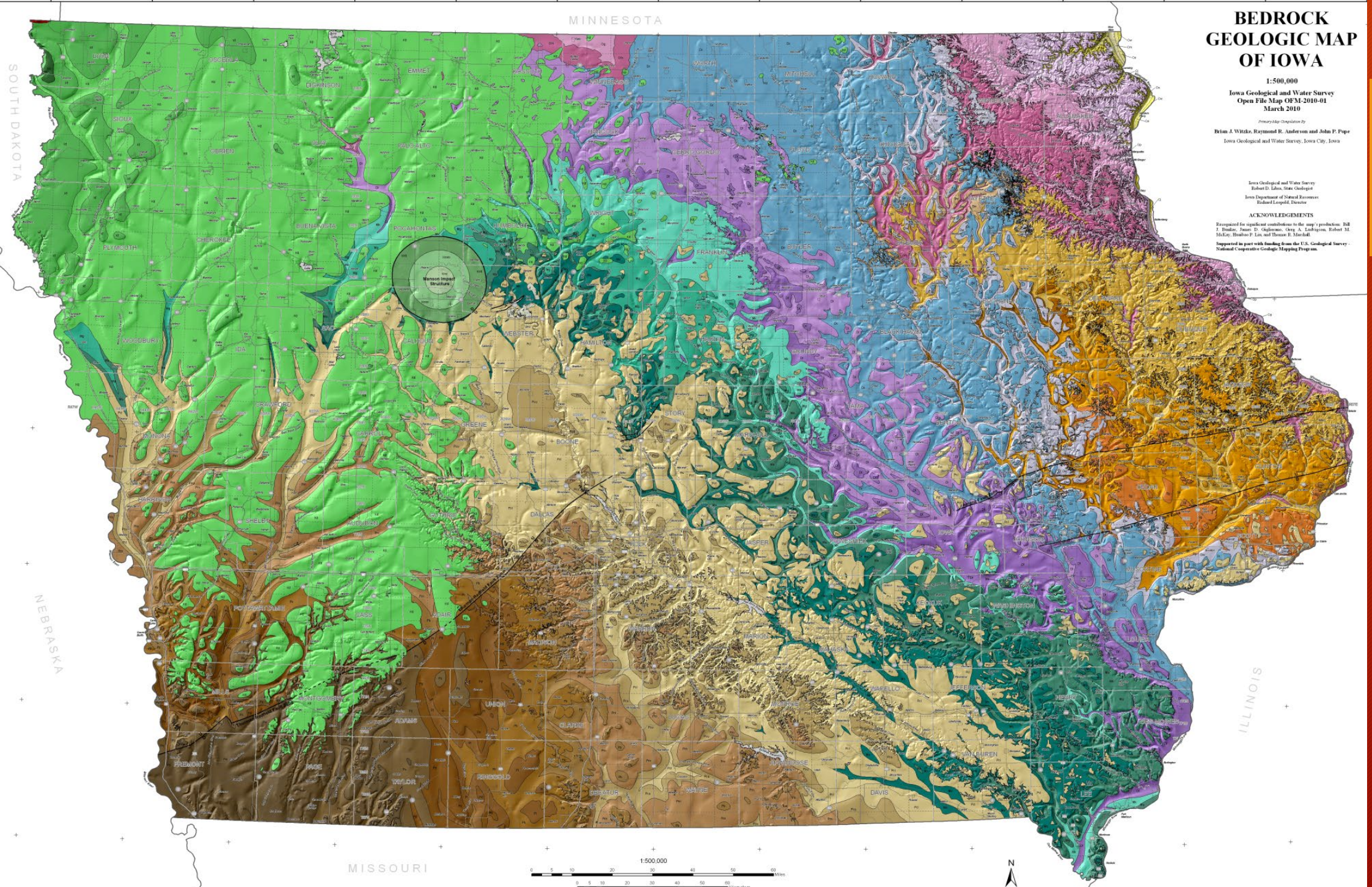
Iowa's Bedrock

Geological Resources of Iowa

University of Northern Iowa &

The Iowa Limestone Producers Association



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

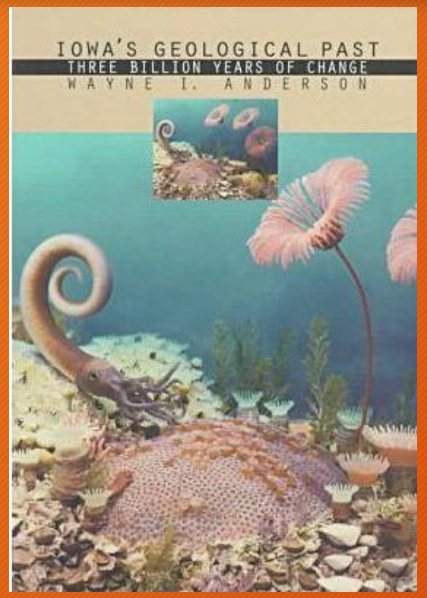
Iowa Department of Natural Resources
Richard Leopold, Director

ACKNOWLEDGEMENTS

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

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

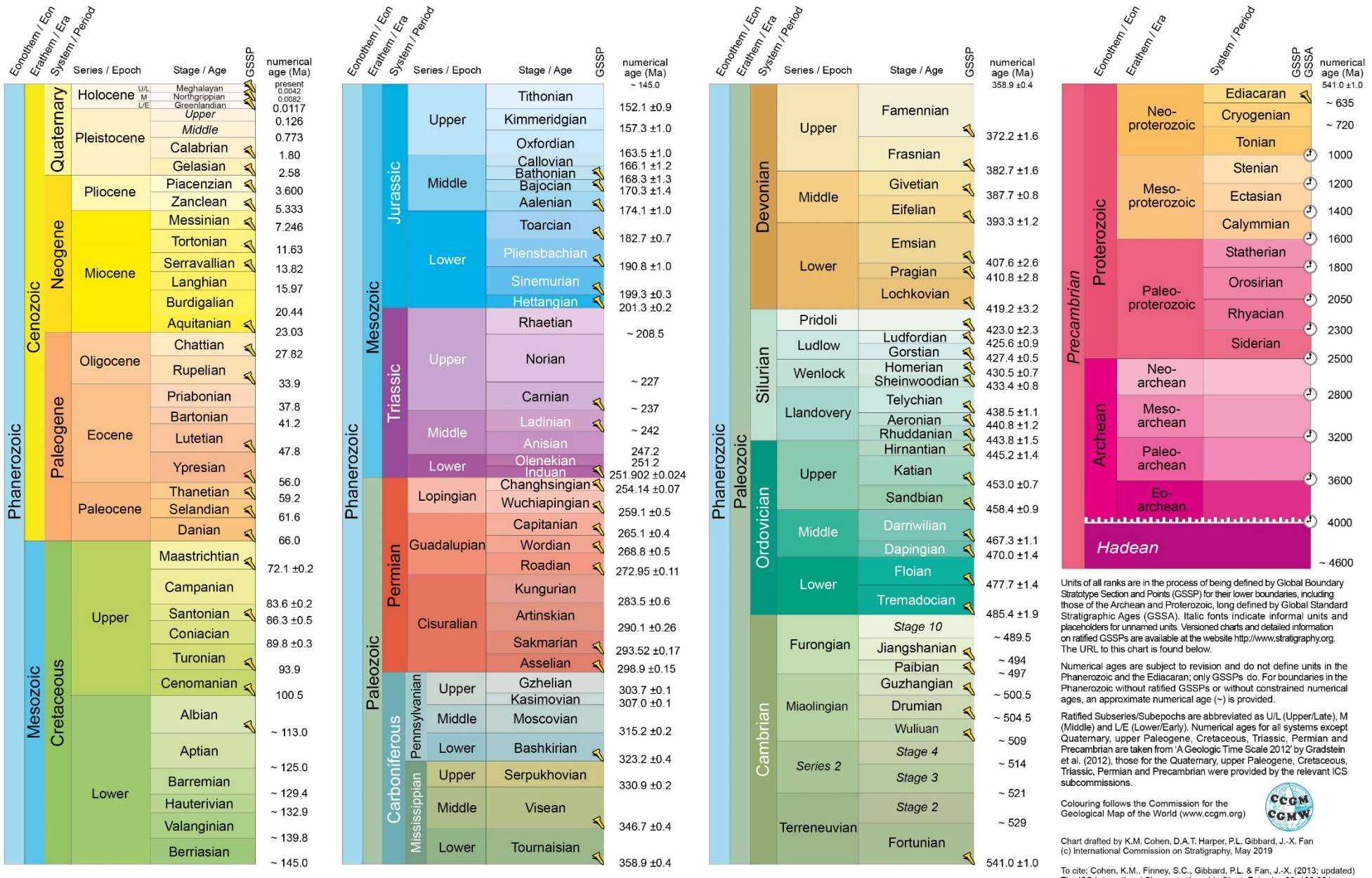
Geologic Time



Wayne Anderson
Jim Walters
Ray Anderson
Brian Glenister

INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

IUGS www.stratigraphy.org International Commission on Stratigraphy v 2019/05



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, Triassic, Permian and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012), those for the Quaternary, upper Paleogene, Cretaceous, Triassic, Permian 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, J.-X. Fan
(c) International Commission on Stratigraphy, May 2019

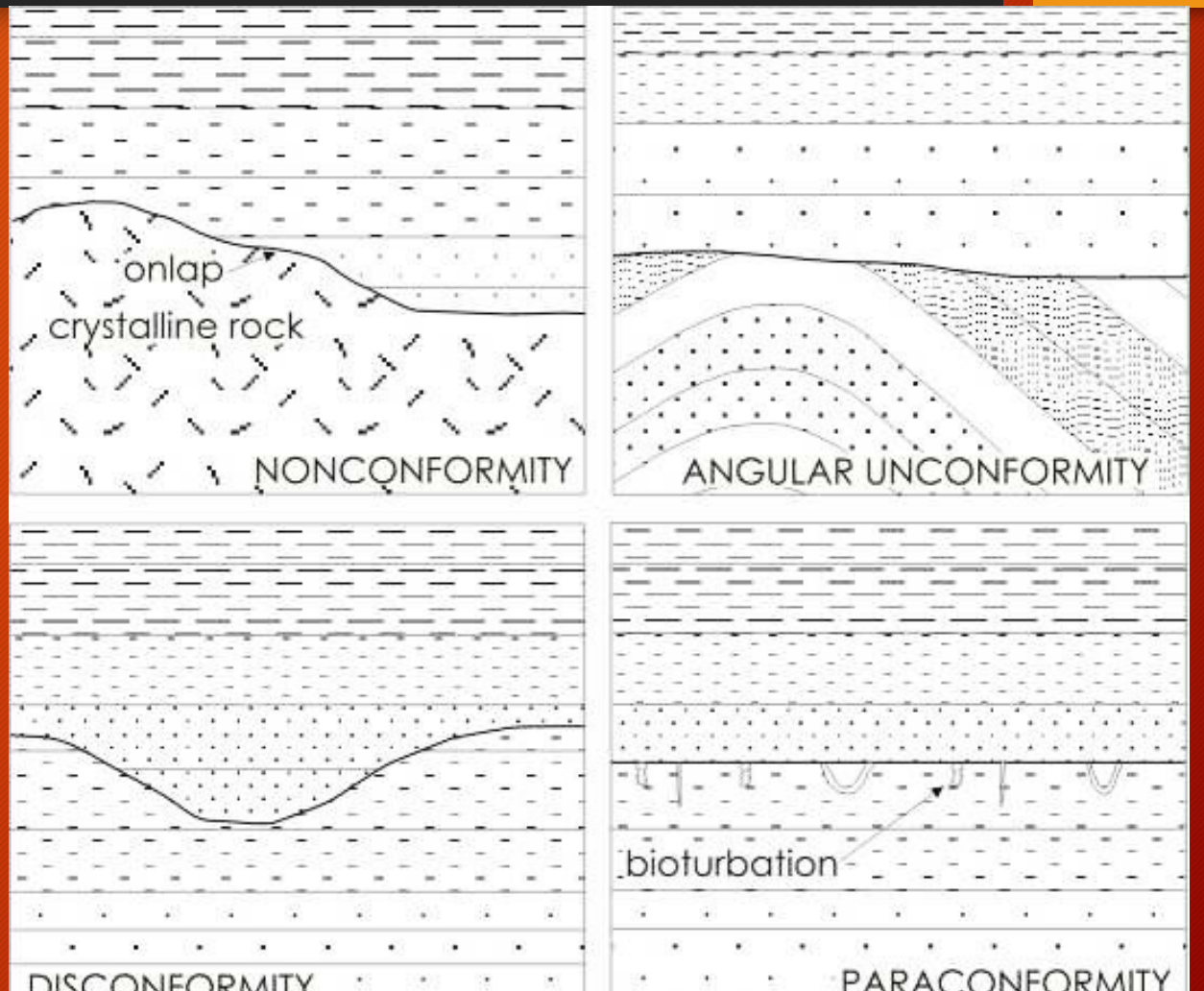
To cite: Cohen, K.M., Finney, S.C., Gibbard, P.L. & Fan, J.-X. (2013; updated) The ICS International Chronostratigraphic Chart. Episodes 36: 199-204.

URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2019-05.pdf

Unconformities (Gaps in time, ‘missing pages’)

A. Geologic strata never formed OR deposited

B. Geologic strata were formed and/or deposited, but were partially or completed eroded



Major Unconformities in Iowa

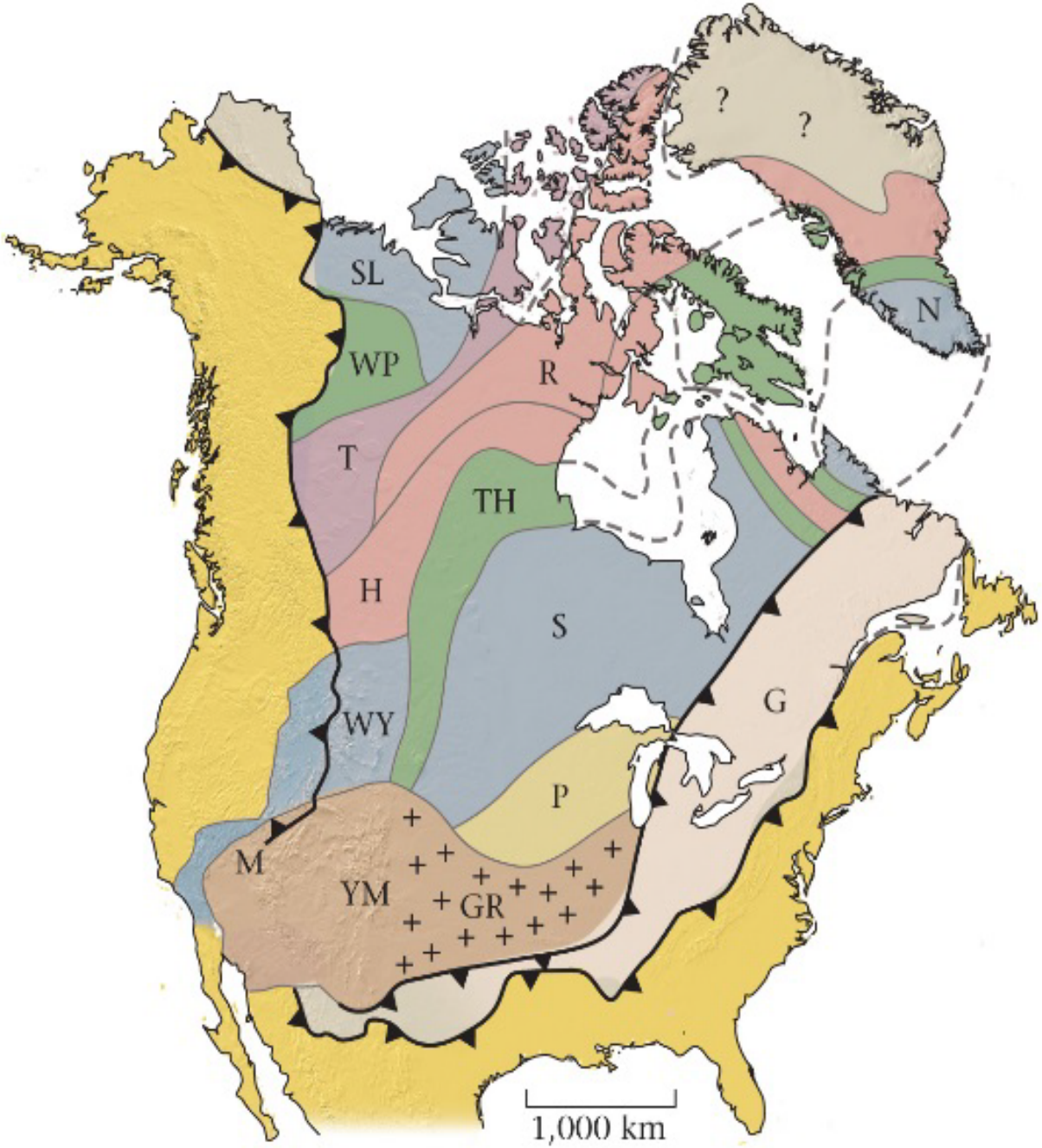
- Base of Cambrian
- Within Ordovician
- Base of Devonian
- Between the Mississippian and Pennsylvanian
- Between the Jurassic and Cretaceous
- Iowa does not have any exposed rocks dating to the Permian or Triassic

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



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)

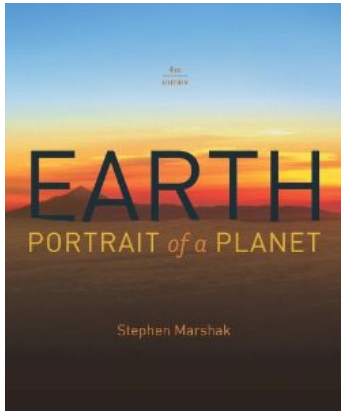
1.8- Ga accreted crust (P = Penokean)

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

1.9- Ga collisional orogen (T = Thelon)

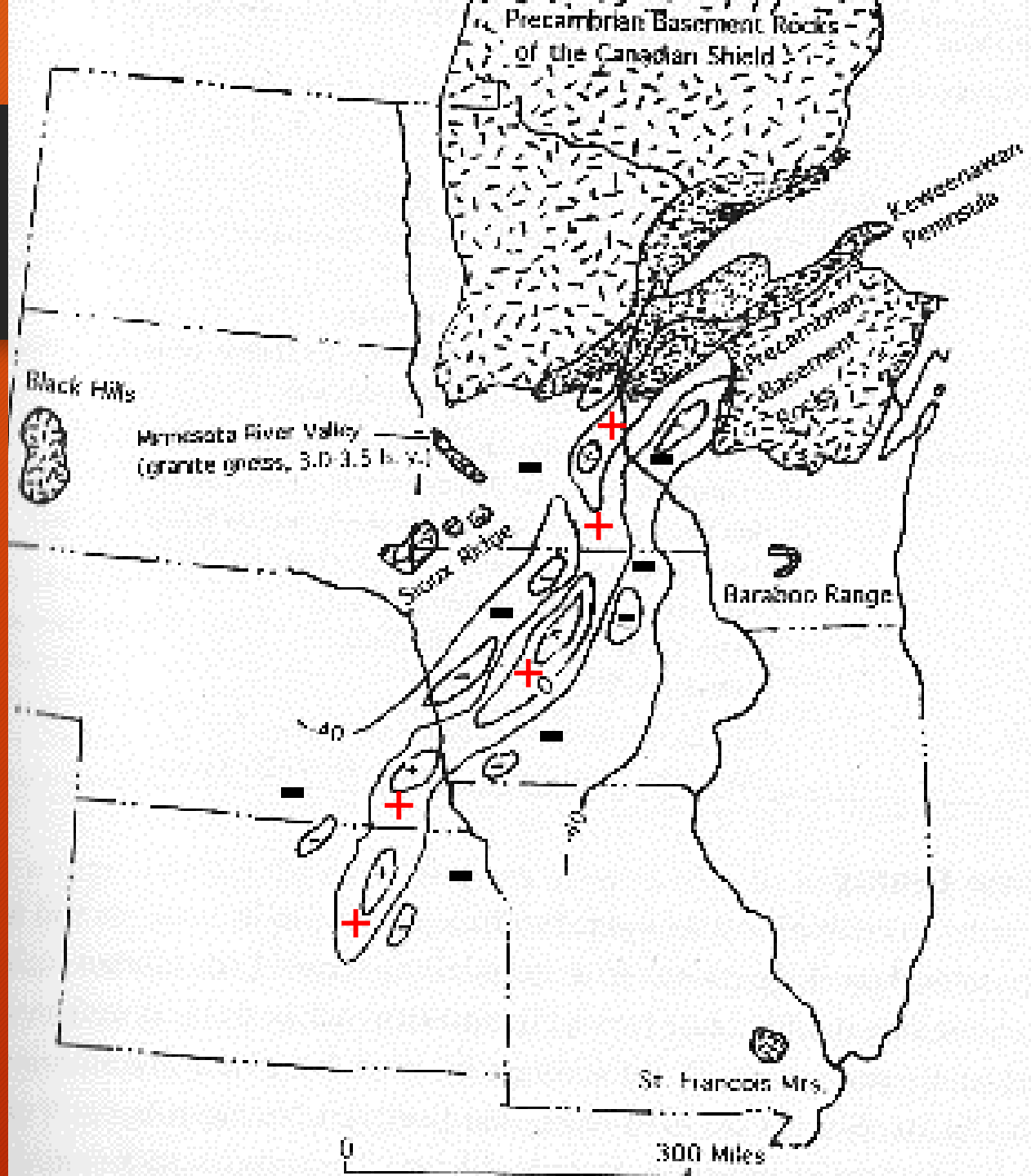
Archean rocks, later deformed and metamorphosed in the Proterozoic (H = Hearn; R = Rae)

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



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



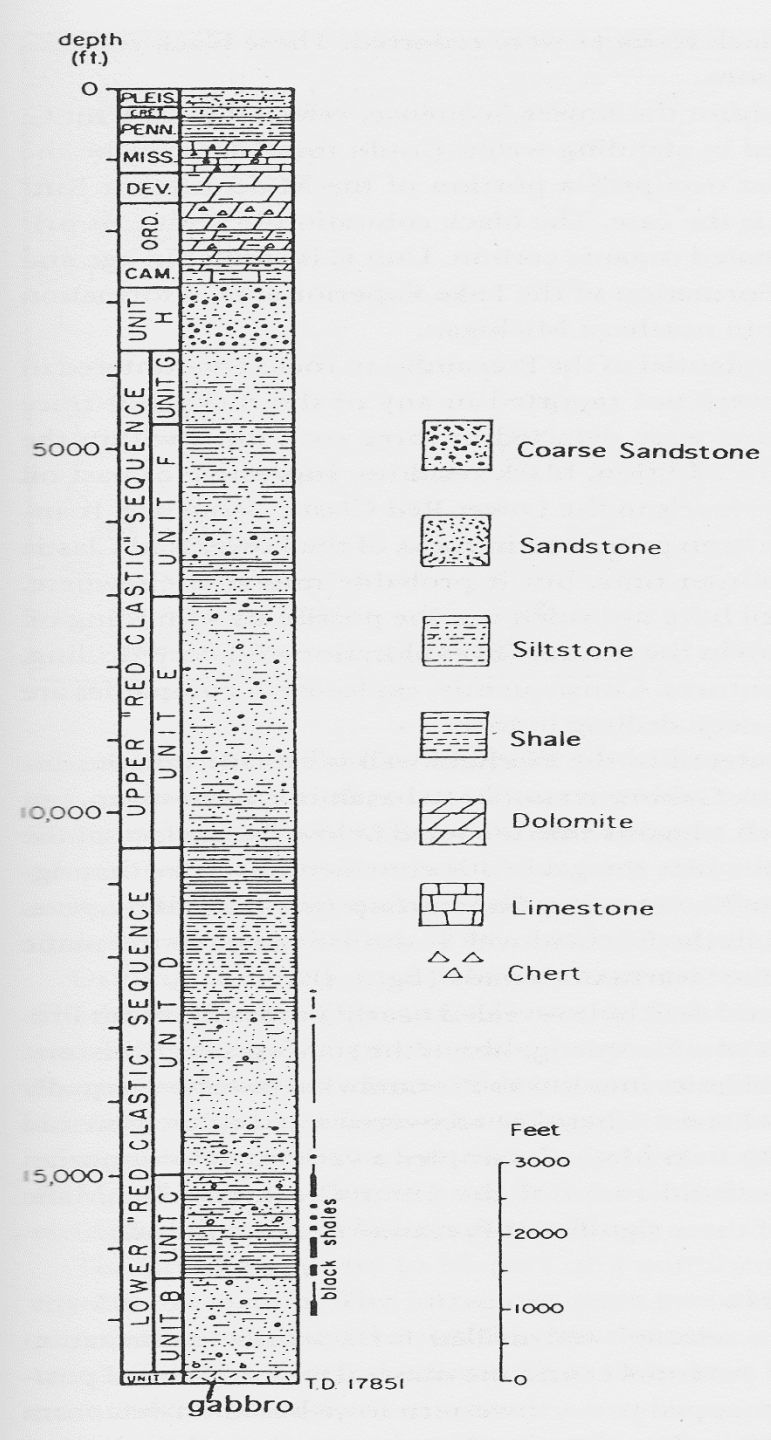
Start Here April 13, 2020

The Eischeid Well – Iowa's Deepest Drilled Well

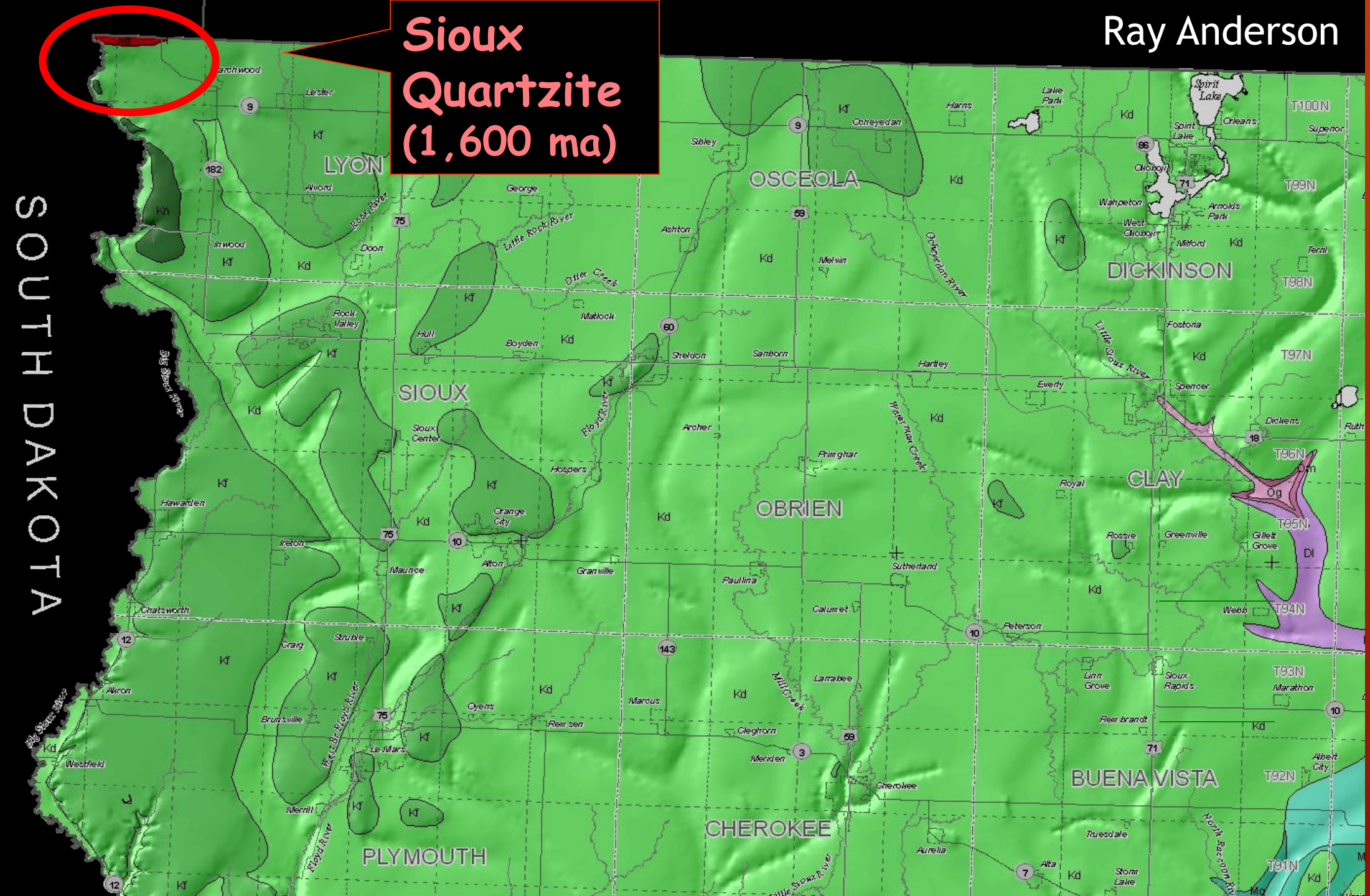
- Carroll County
- Amaco Production Company
- **208** days of drilling to reach a depth of **17,851**ft (one of the deepest in the Midwest!)
- $20,000,000.00

Upper 'Red-Clastic'

Lower 'Red-clastic'



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

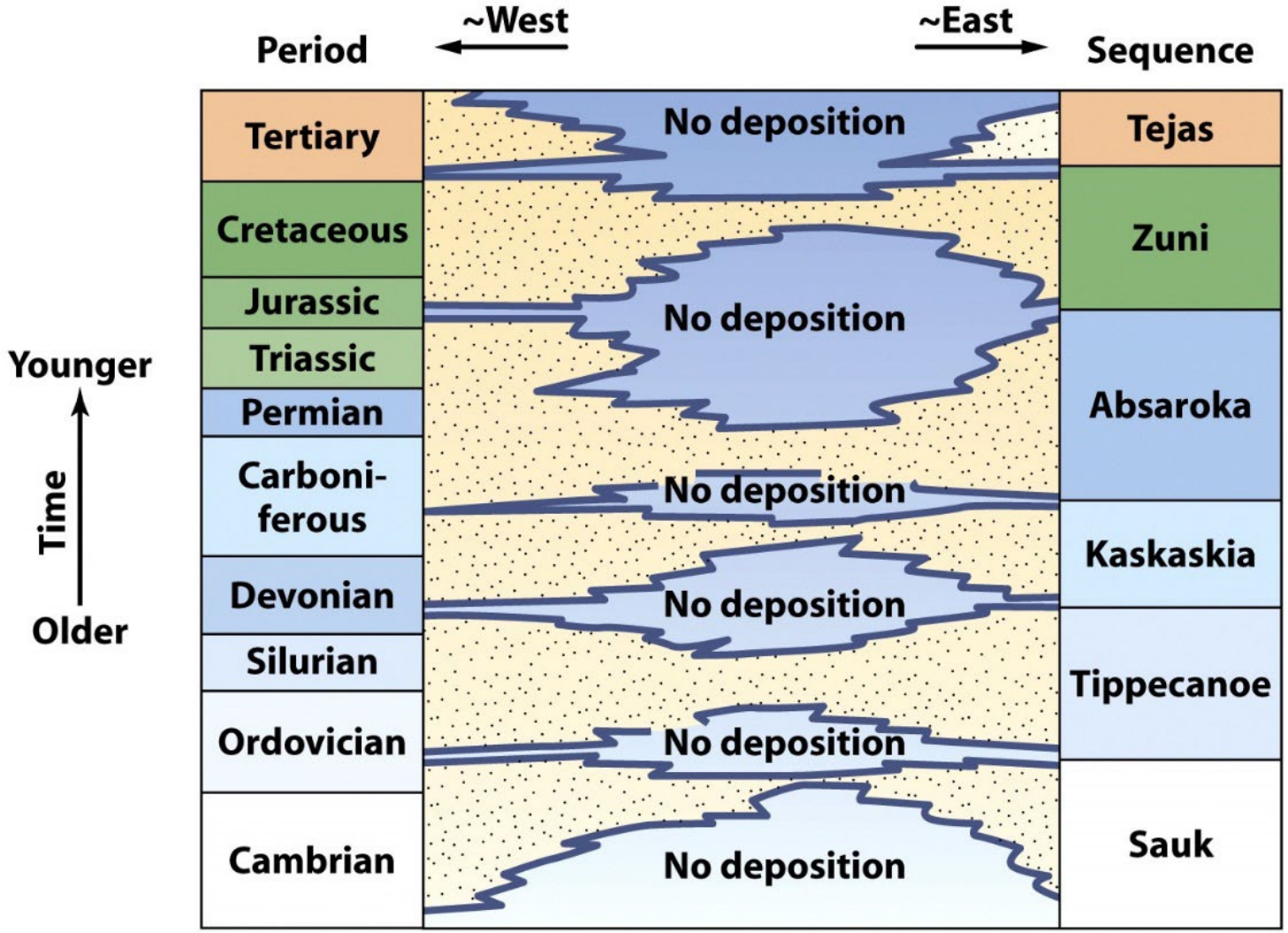
- Environment of Deposition?
  - Upper portion = tidal/shallow marine
  - Lower portion = fluvial/river
- The formation is up to 7,800ft thick
- Correlated with the Baraboo Quartzite
  - Occurs in eastern at great depths

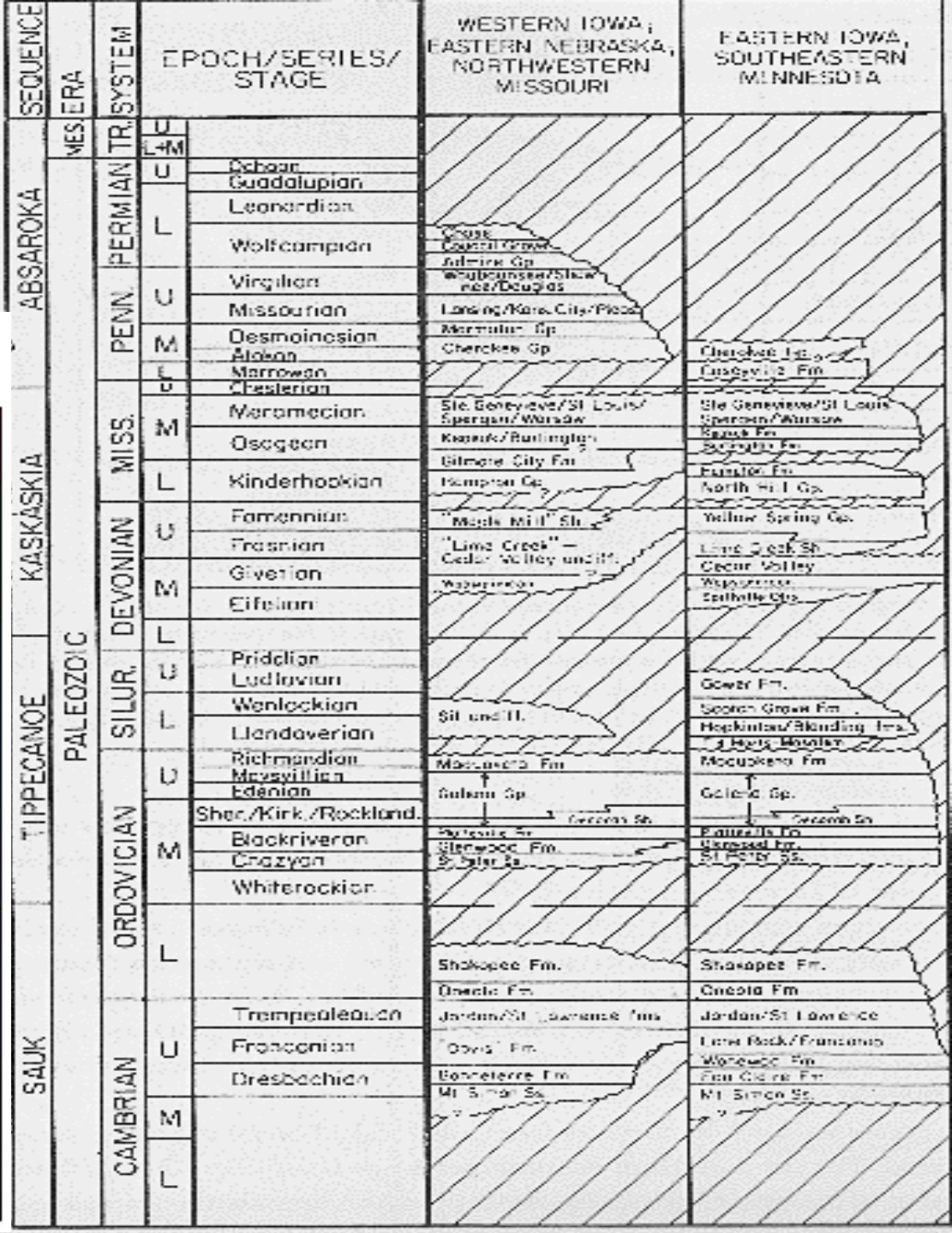
Federal building in Sioux Falls, SD

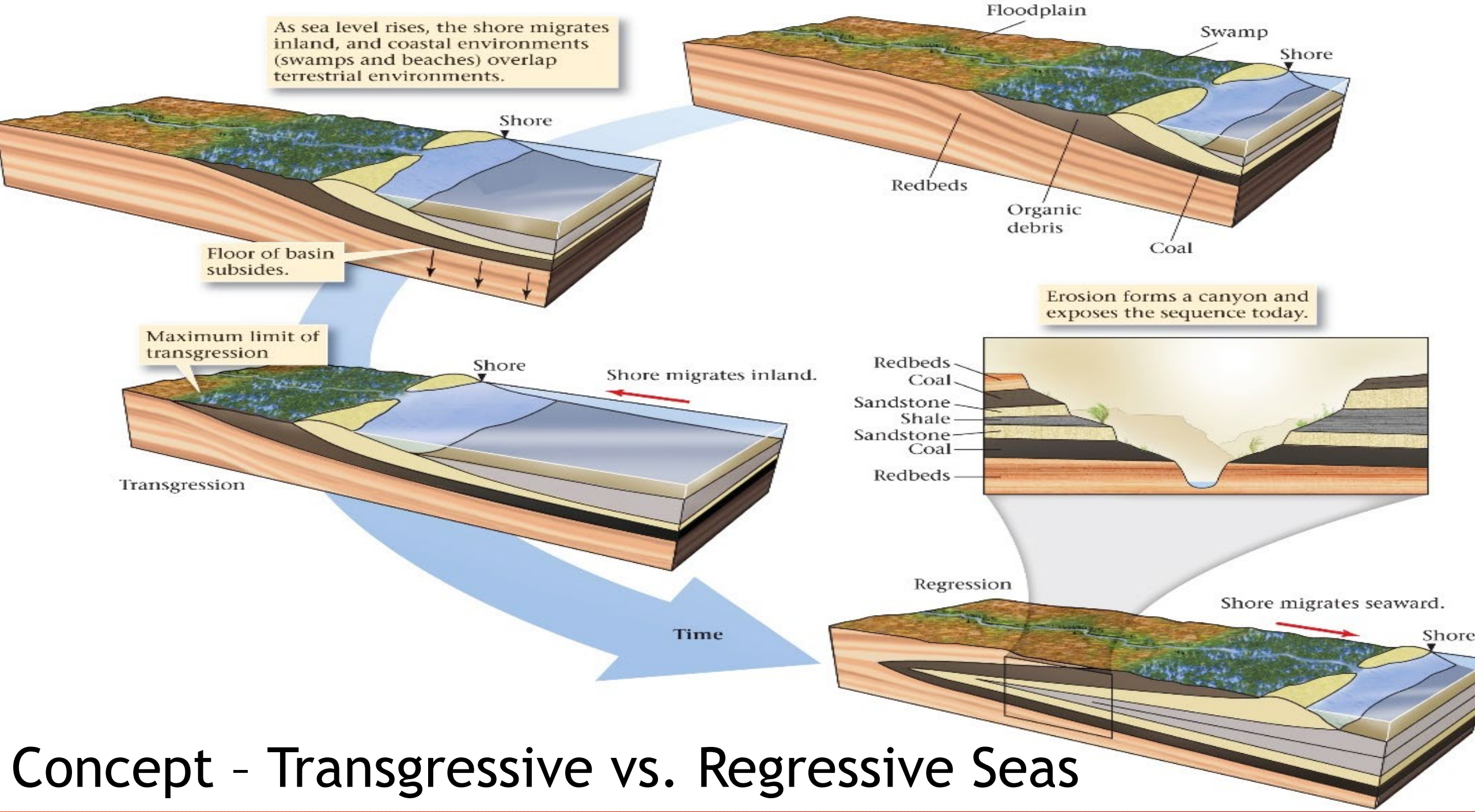
Pipestone

- 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

Iowa's Paleozoic





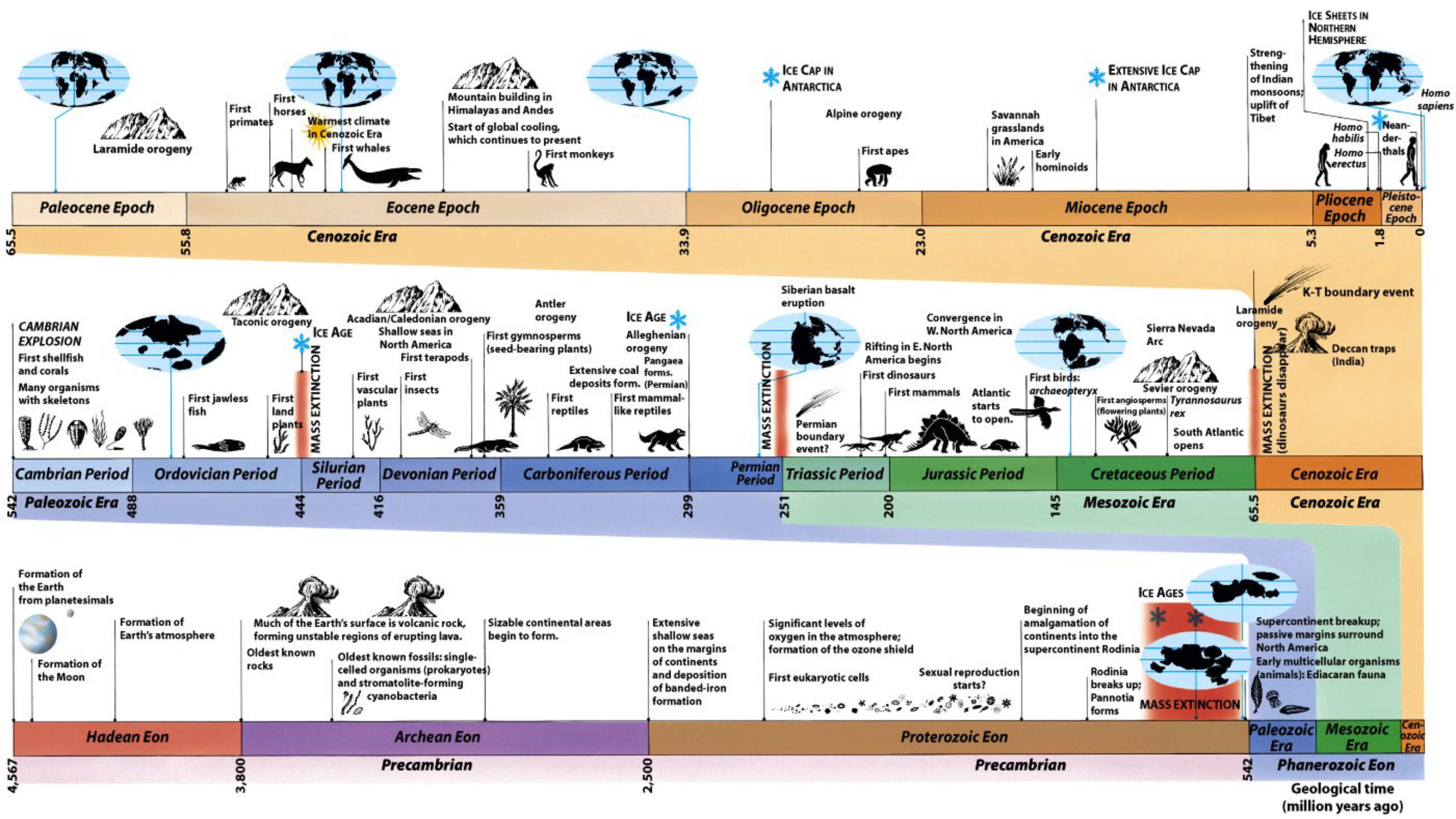


Concept – Transgressive vs. Regressive Seas

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.


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)

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

Location

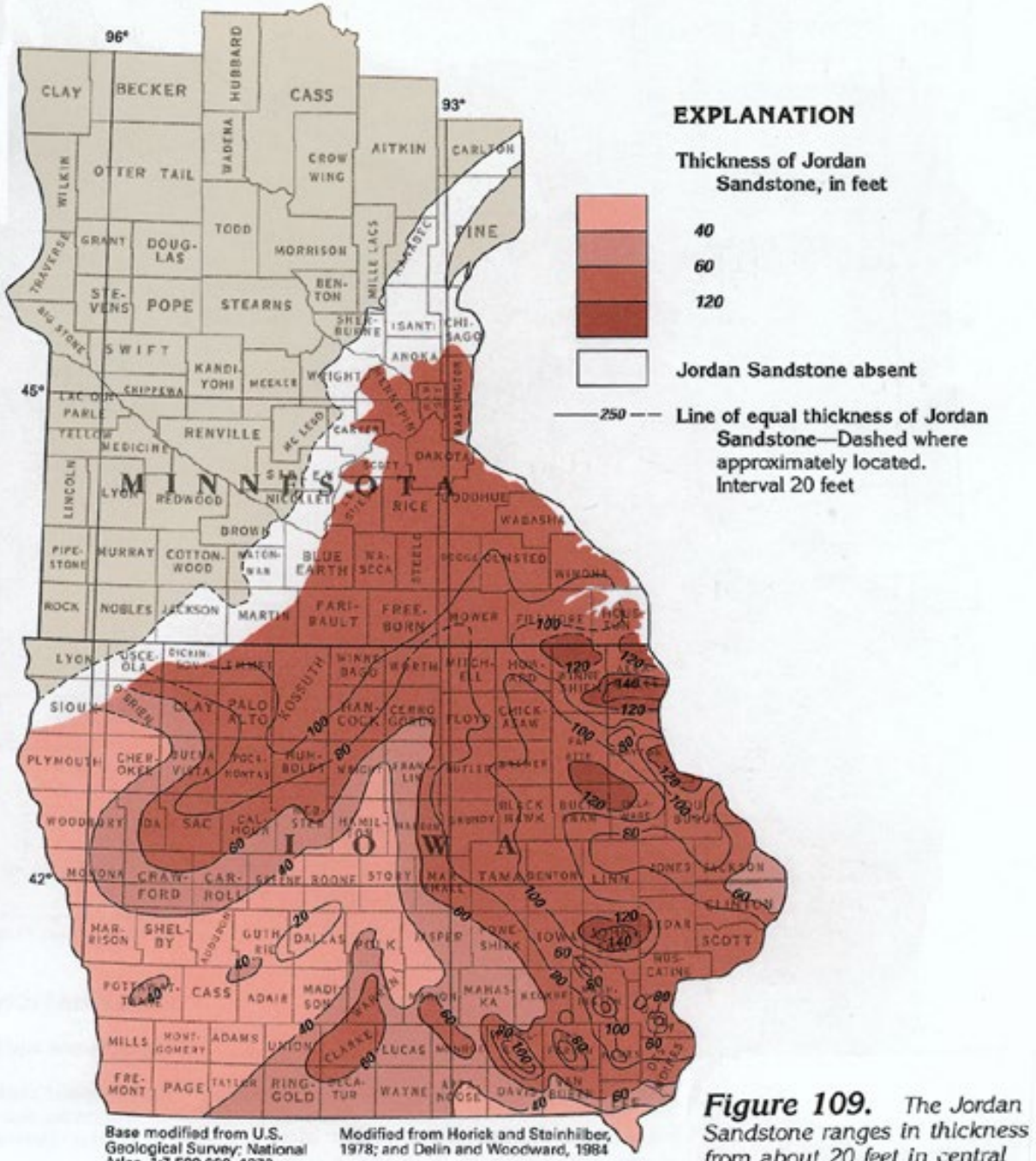


Figure 109. *The Jordan Sandstone ranges in thickness from about 20 feet in central Iowa to about 140 feet in northeastern and east-central Iowa.*

Cambrian Life

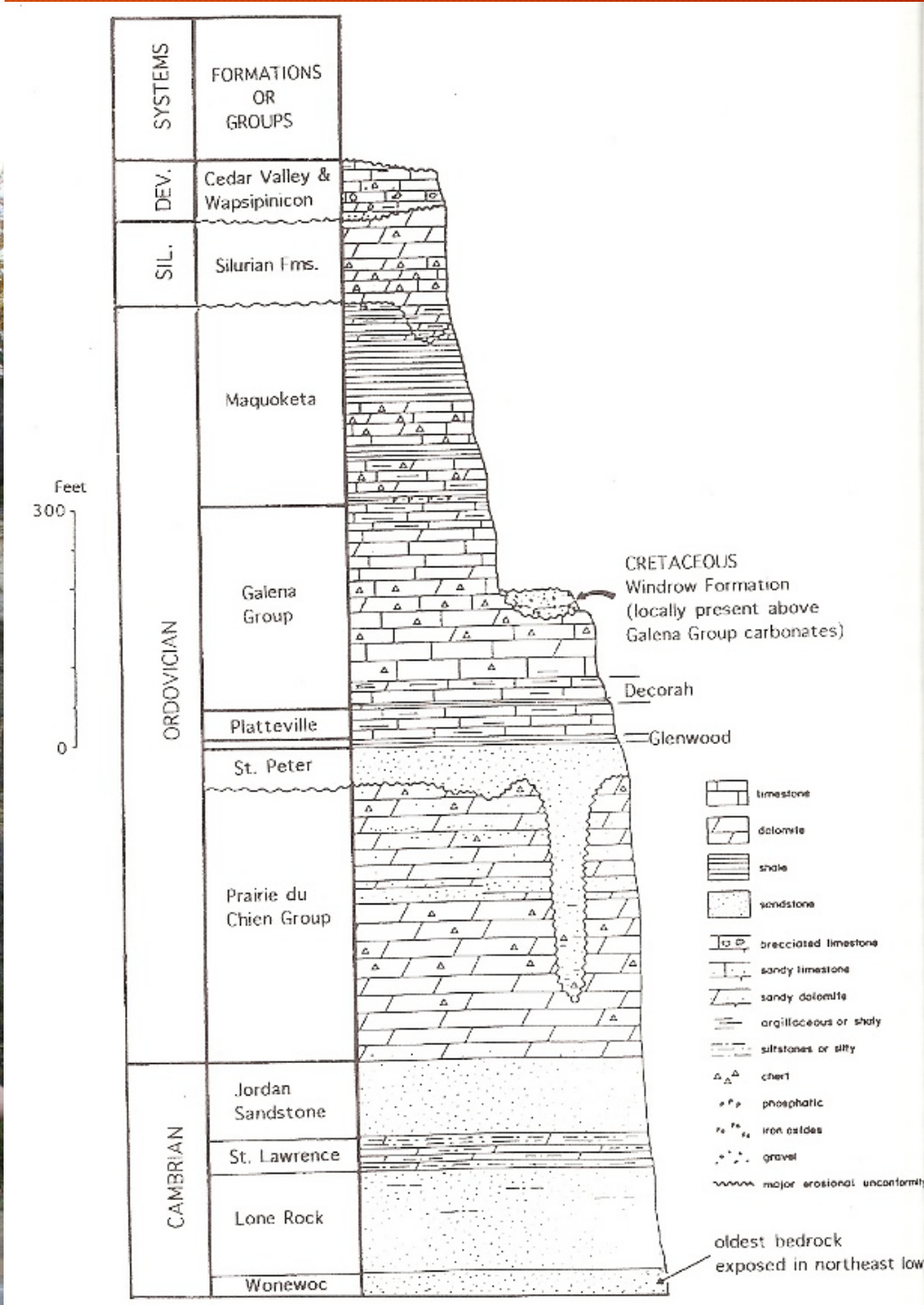
- The age of the Trilobites
- Trilobites and brachiopods are abundant in this period, but not in Iowa.
- Why???
- Iowa's Cambrian record is dominated by SANDY near shore transition environments.

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 ???

Ordovician Stratigraphy

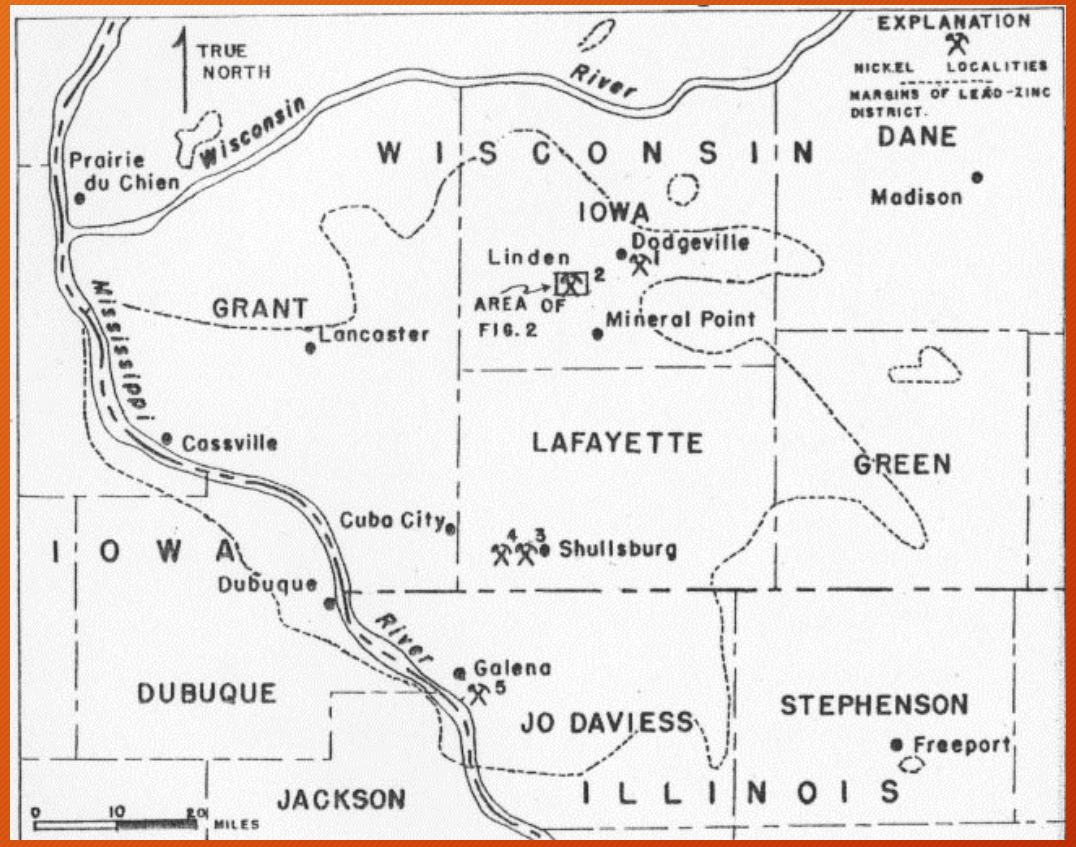


St. Peter Formation

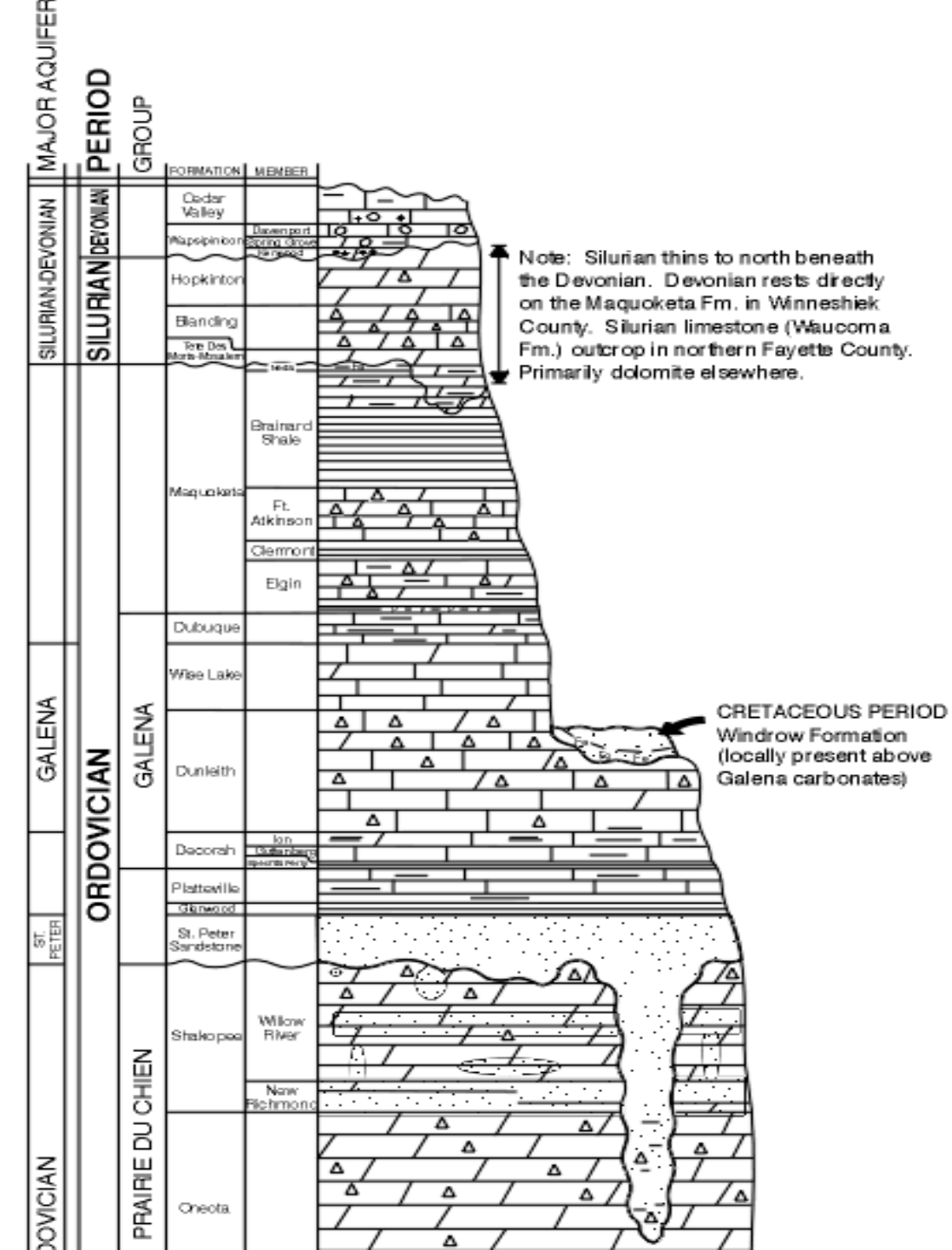
- Quartz Sandstone (super mature)
  - But, In NW Iowa the St. Peter contains a lot of shale from the then exposed Transcontintal Arch
- Well exposed in Pikes Peak St. Park
- An important economic resources for glass and fracking
- 1960's served as a fall out shelter with supplies to meet the needs of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

Galena Group

- Dunleith, Wise Lake, and Dubuque Formations

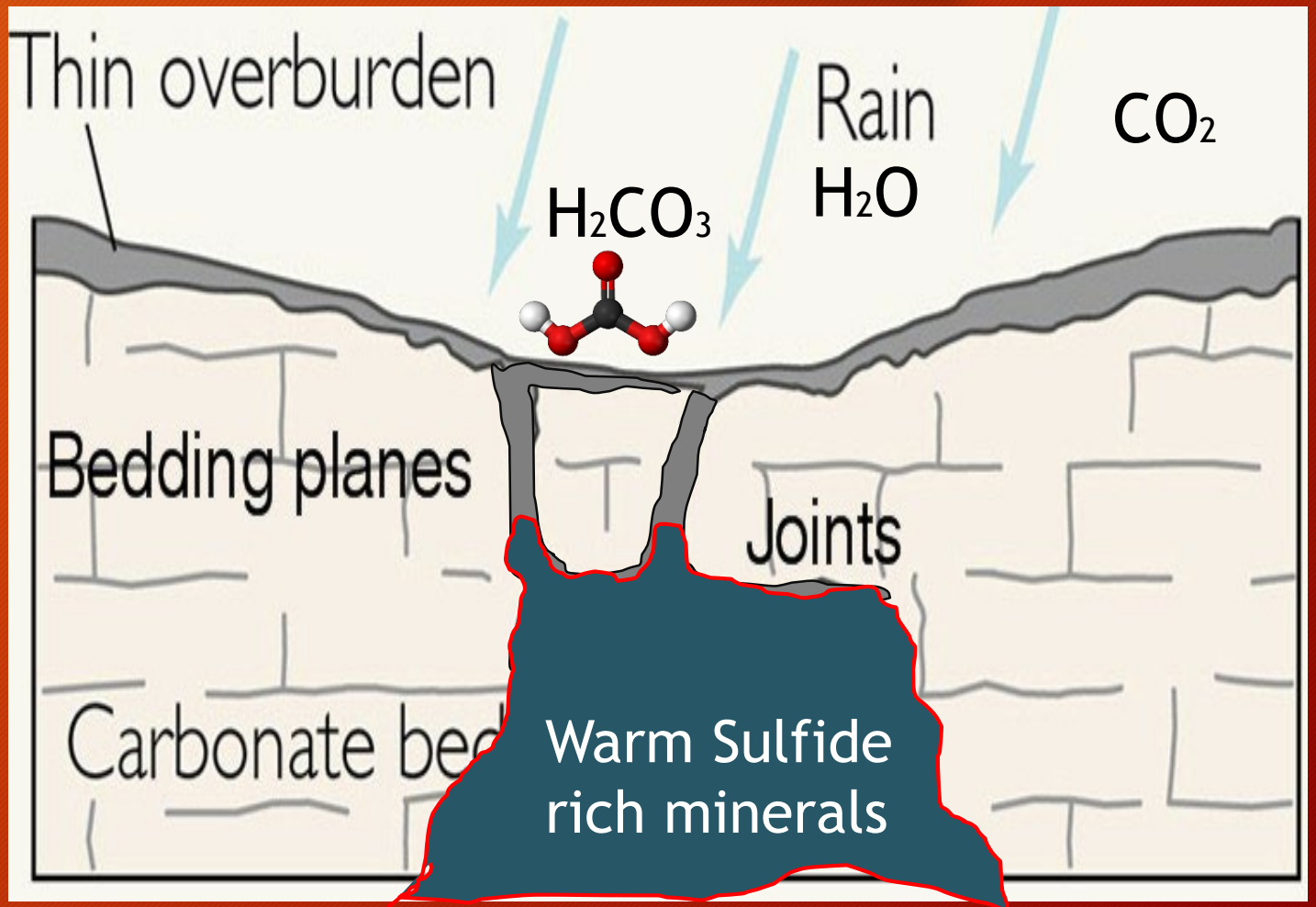


Upper Mississippi Valley Zinc and Lead District



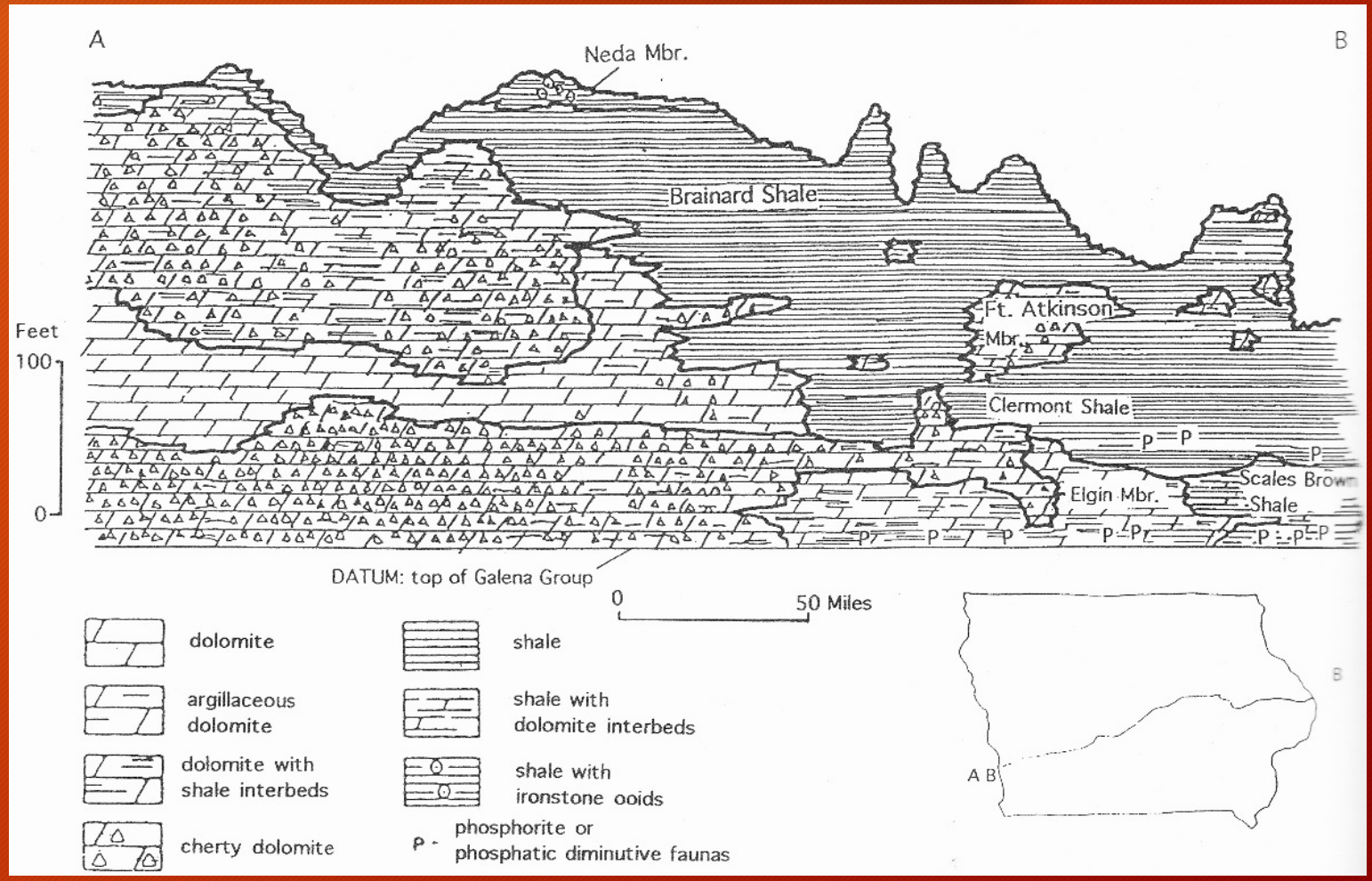
How does Galena & Zinc form in Limestone?

- 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

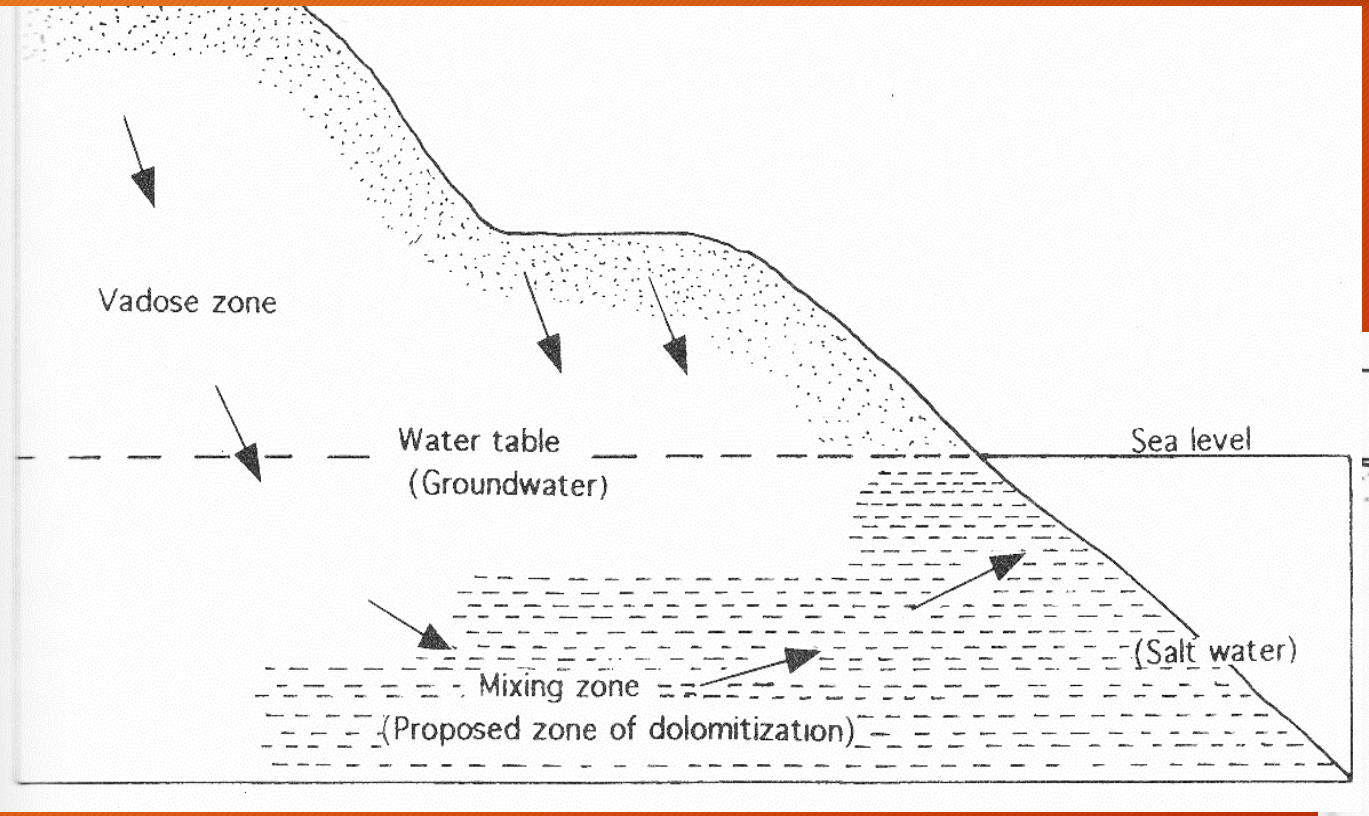


Maquoketa Formation

- 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



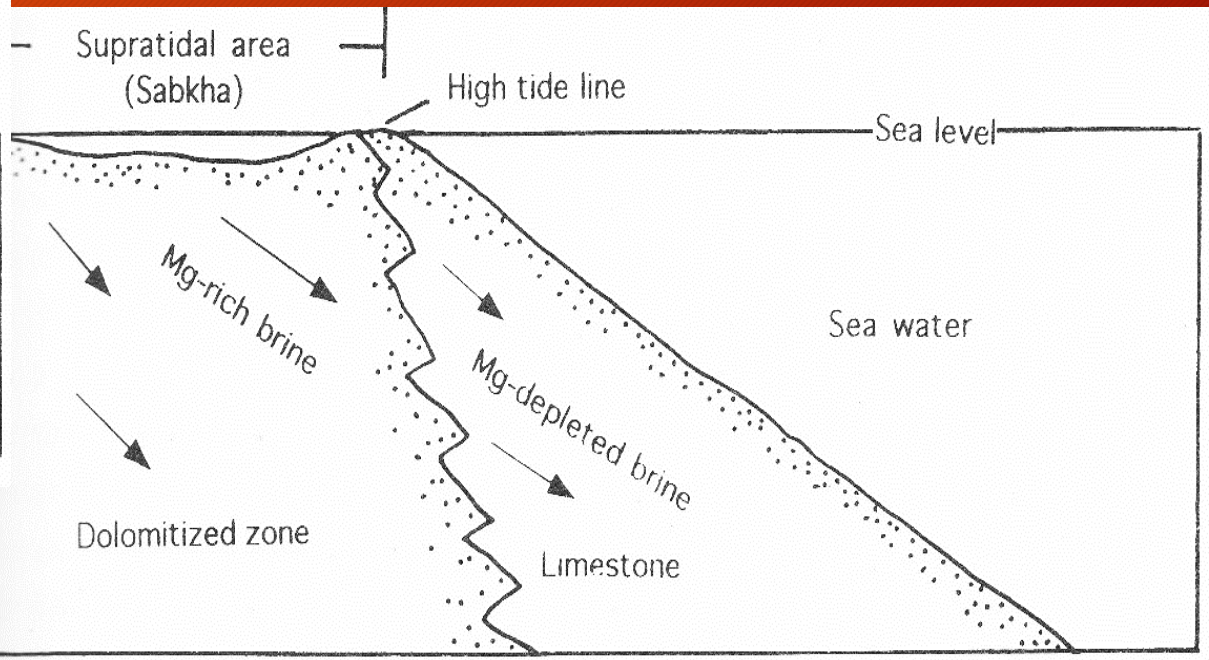
Process of Dolomitization



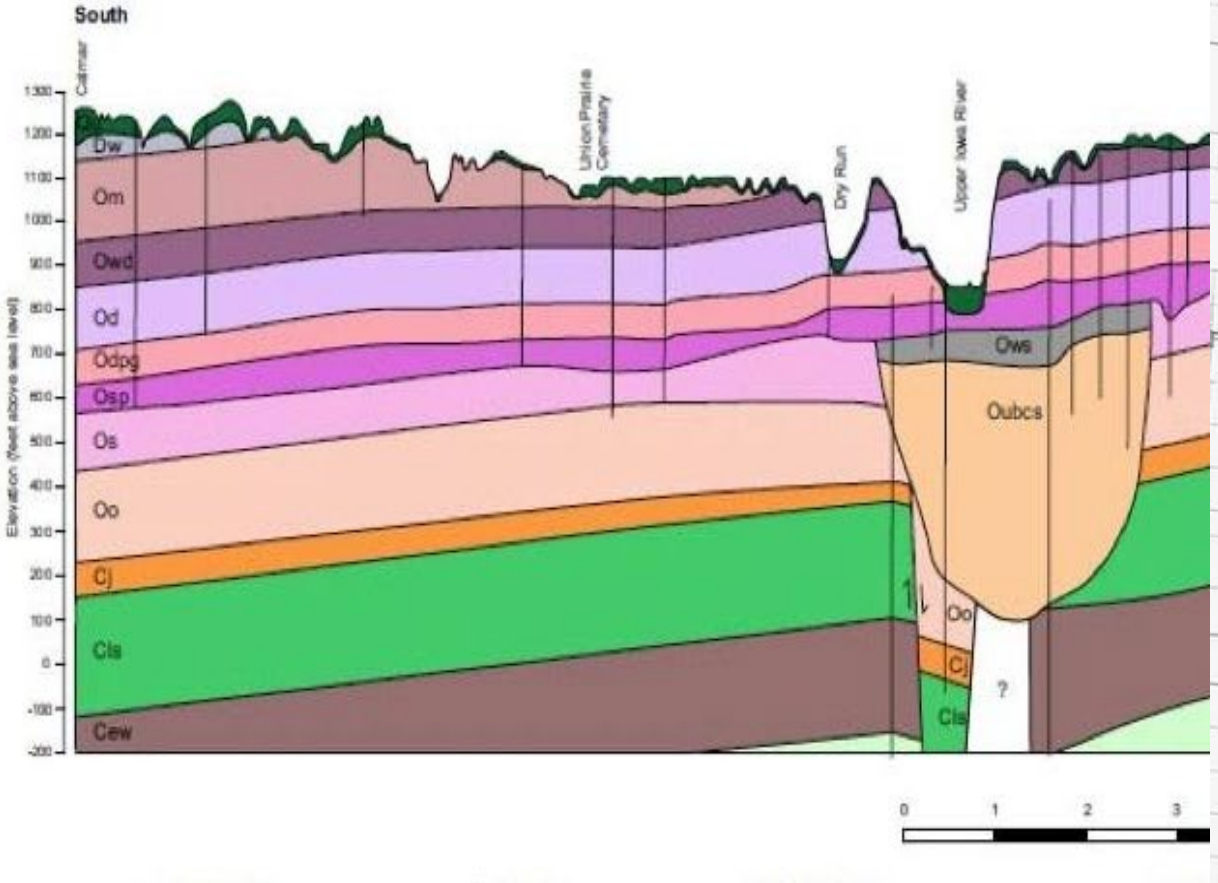
$CaCO_3$

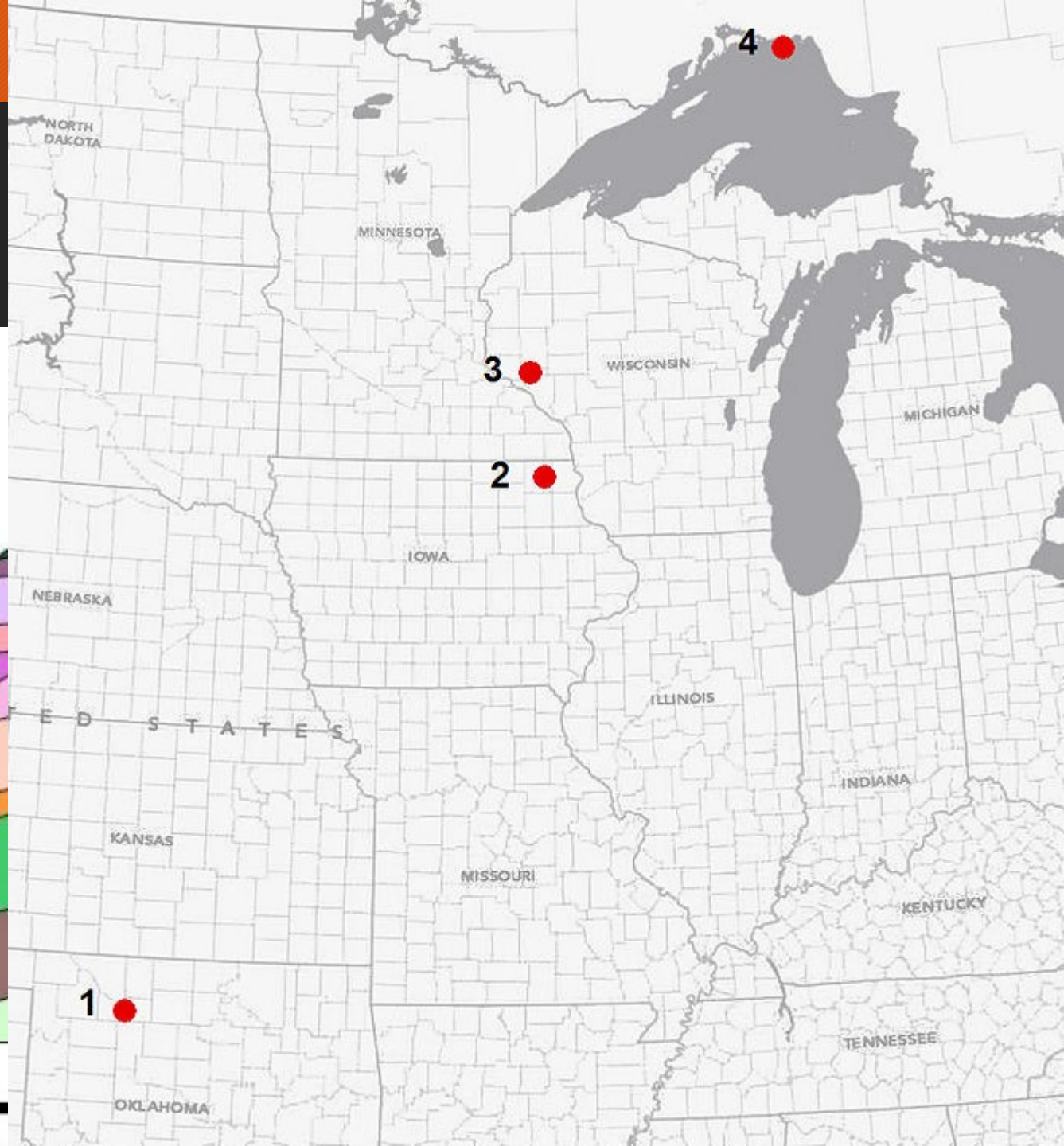
Mg replaces some Ca

$CaMg(CO_3)_2$



Decorah Impact Structure





Silurian – Dolomite and Carbonate Mounds

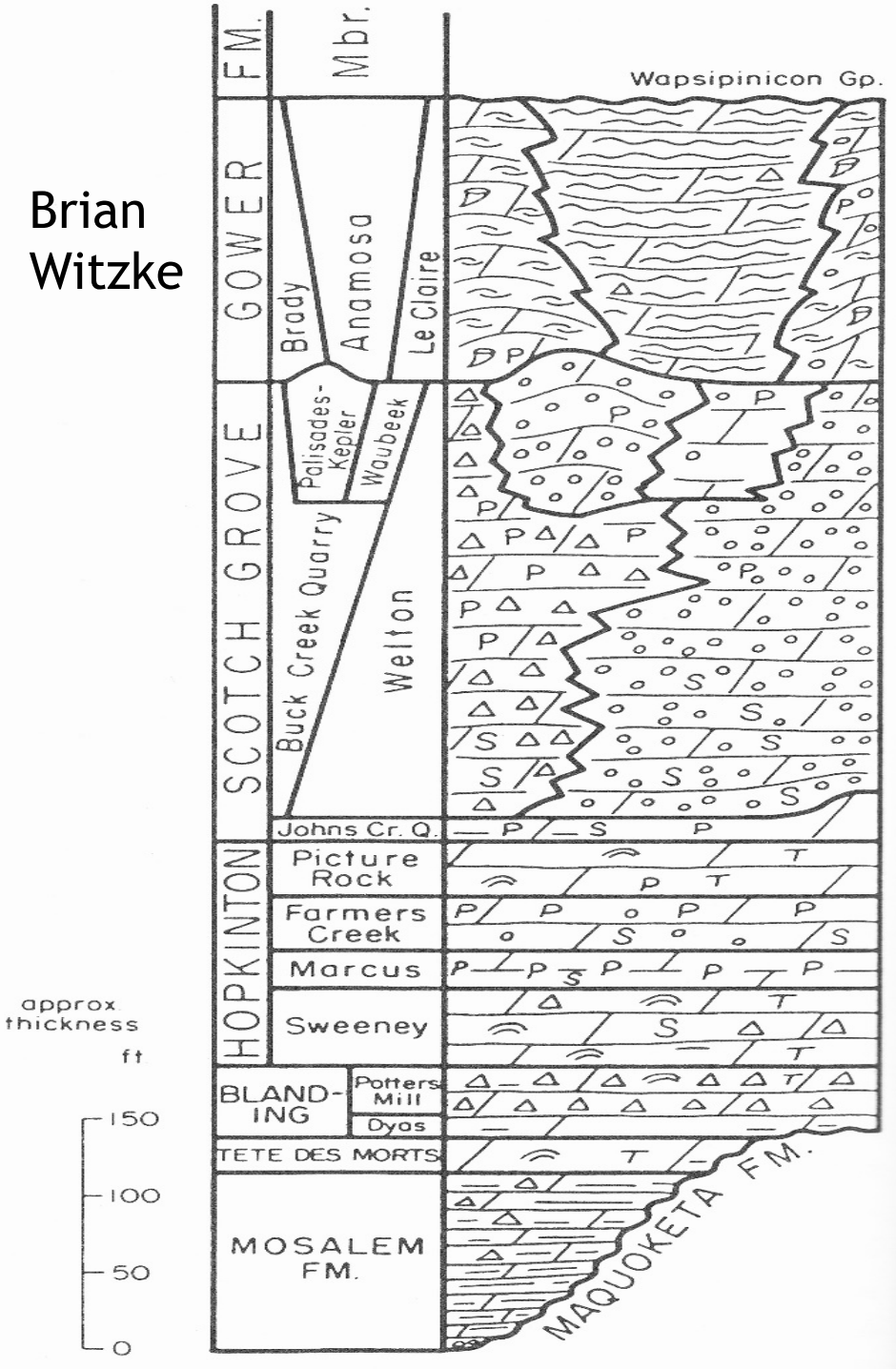
419 Ma
To
443 Ma

- 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

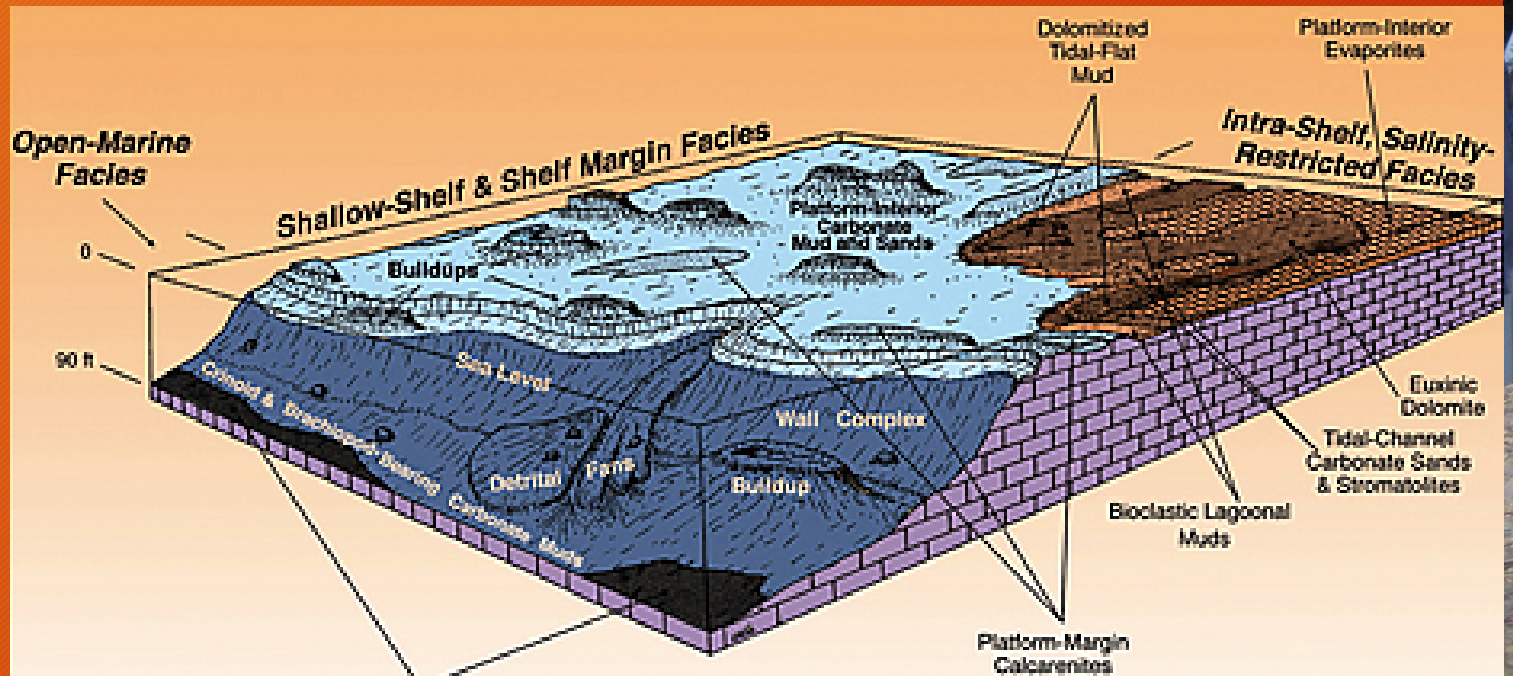
- Common in eastern Iowa
- Very-fine to coarsely crystalline dolostones with areas of nodular chert
- Contains four members
  - Sweeney
  - Marcus
  - Farmers Creek
  - Picture Rock

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

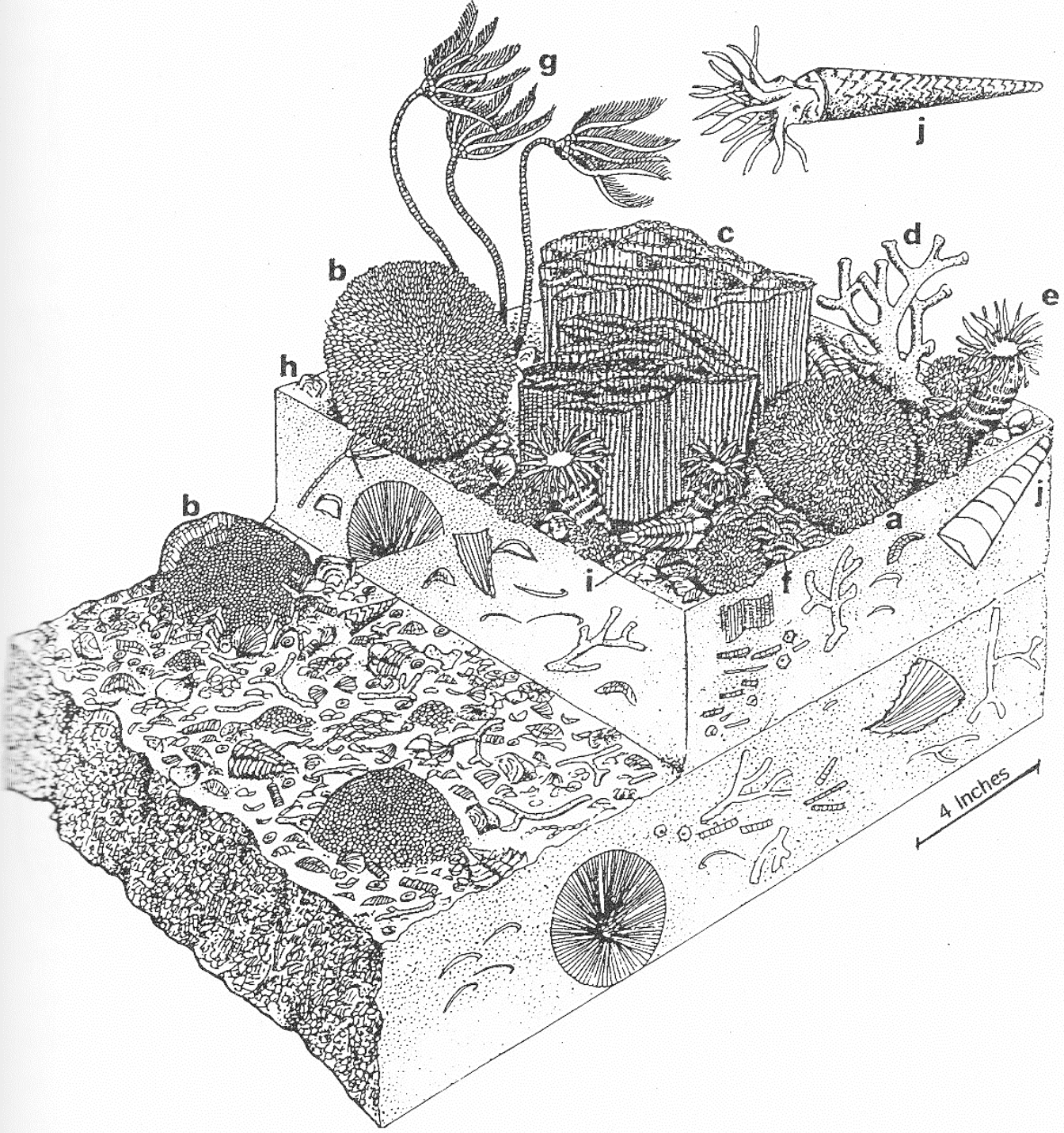


Anamosa Facies – Ideal building stone

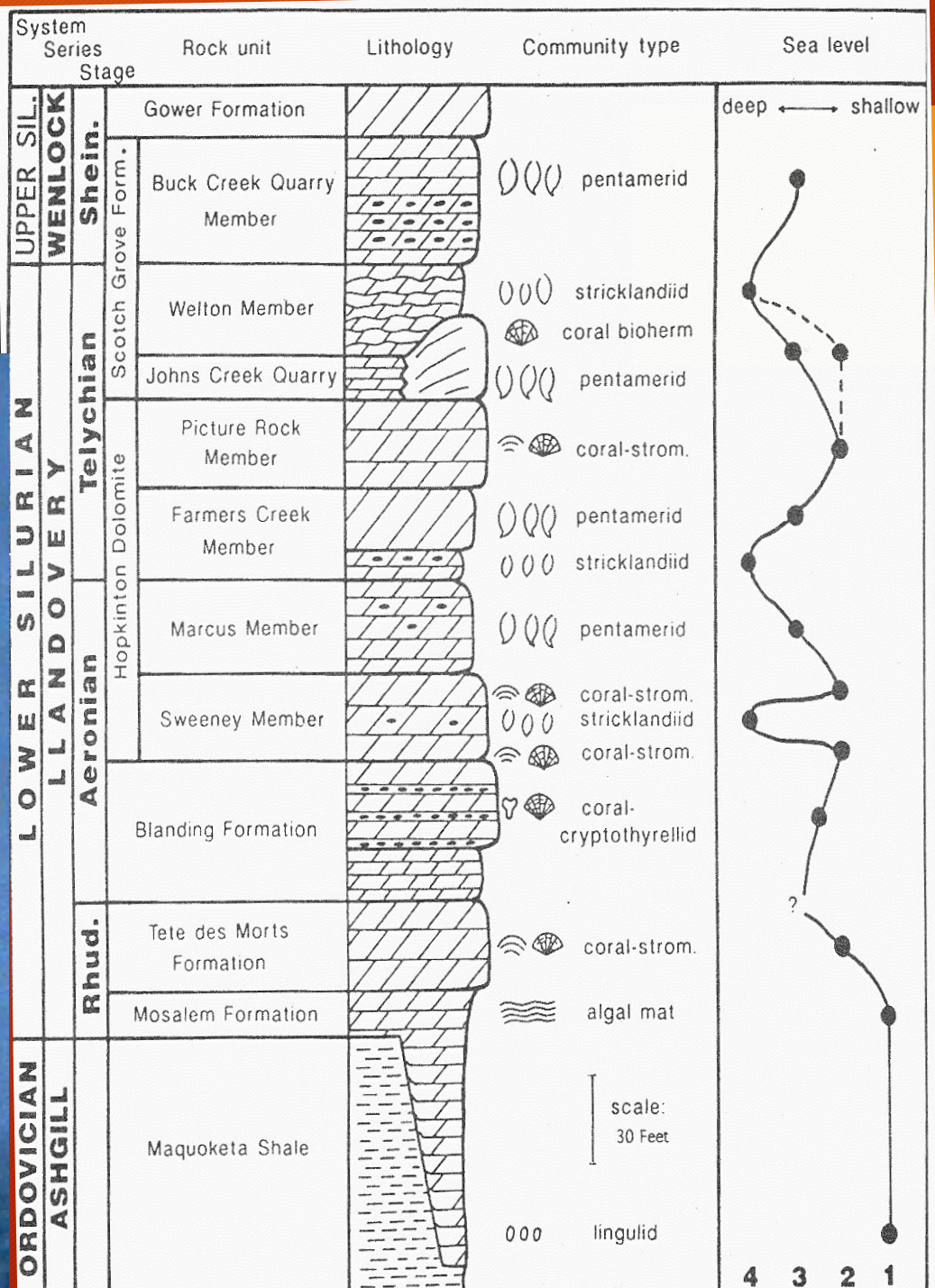
- Uniform bedding
- Fine consistent texture
- Used for many of Iowa's early buildings
  - Rock Island Arsenal (IL)
  - Anamosa Prison
  - Stone City, IA
  - Cornell College
  - Herbert Hoover Presidential Lib.
  - Three large buildings in downtown Minneapolis

Silurian Life

- Colonial corals
  - Favosites
  - Halysites
- Solitary corals
- Brachiopods
- Algea



Applied paleontology



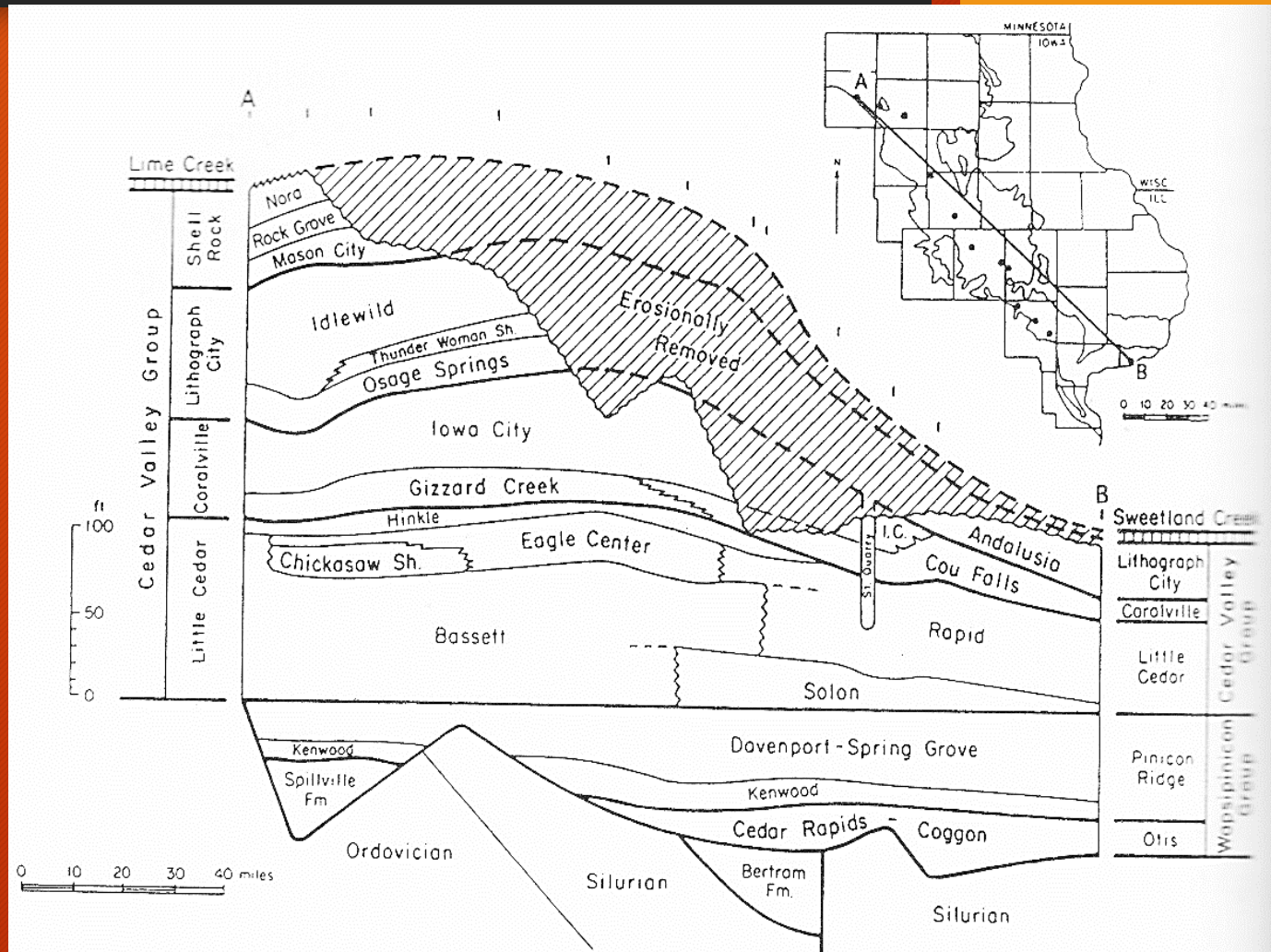
Devonian – A Marine Extravaganza ☺

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

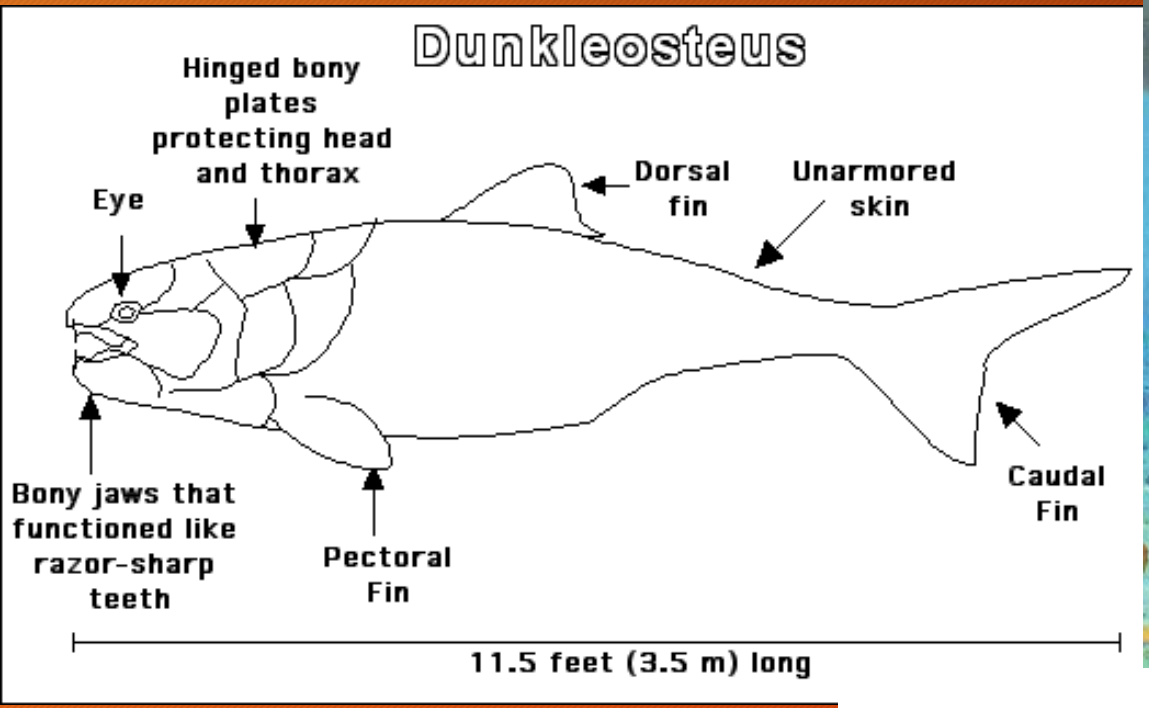
- Basal Fm. of the Cedar Valley Group
- Solon Member is mostly limestone with abundant fossils
- Rapid Member fine-grained argillaceous limestone that is also fossil rich

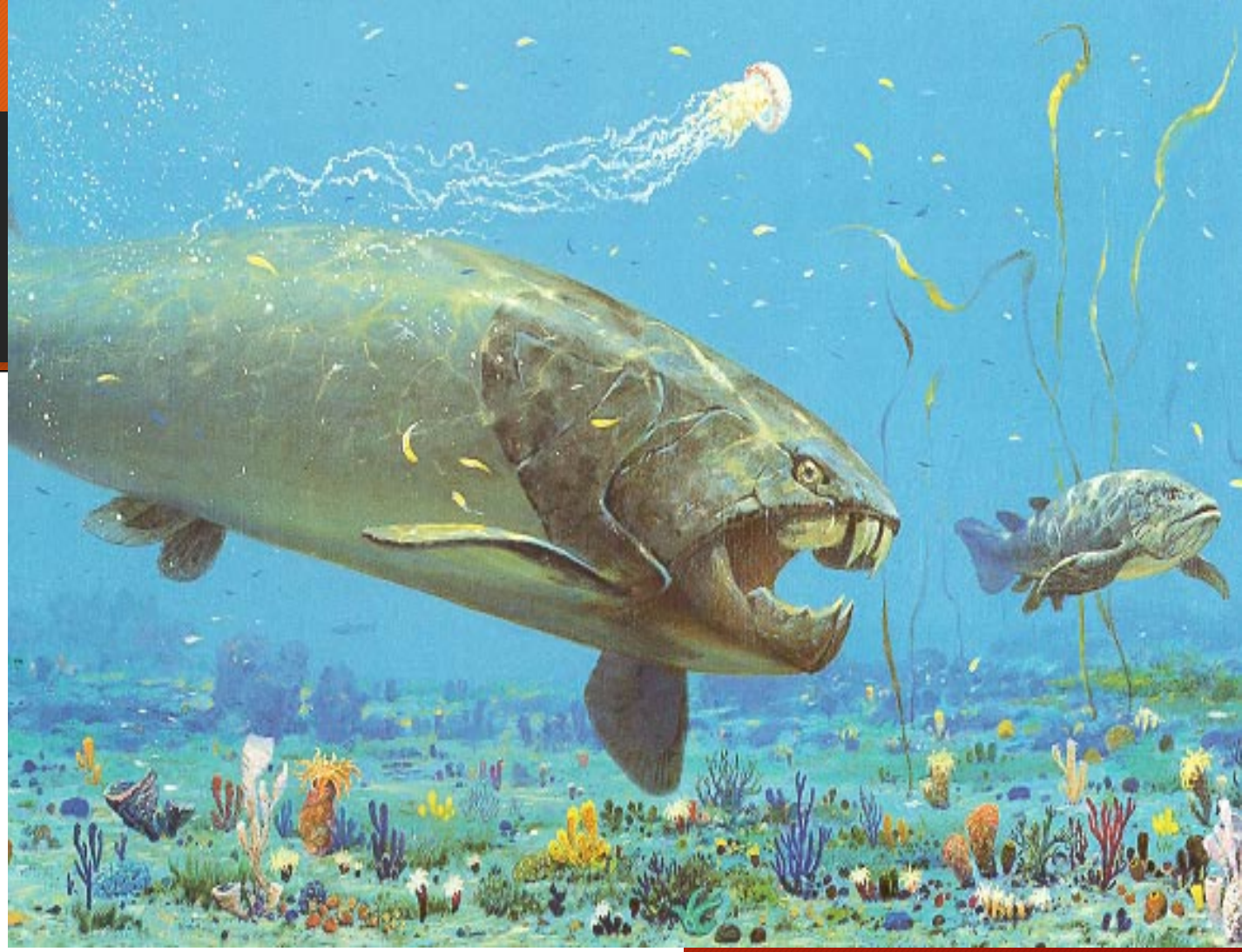


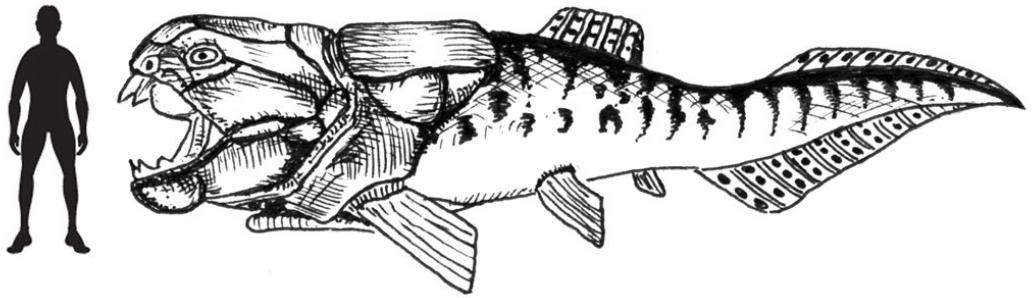
Lithograph City Formation

- 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

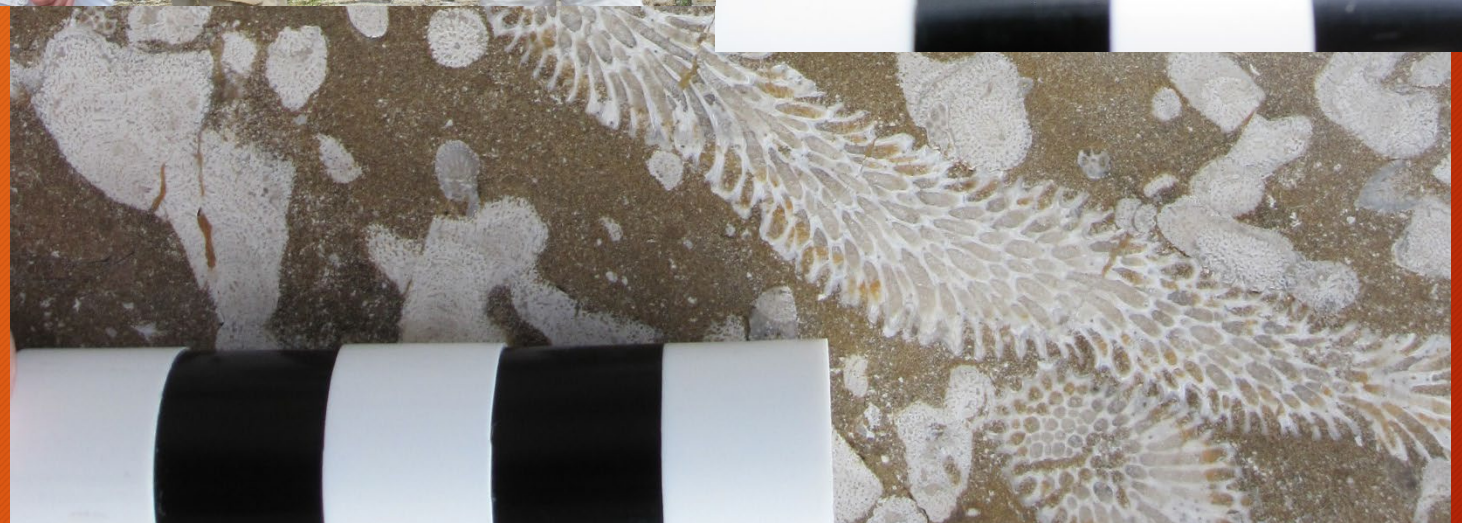
Devonian Life





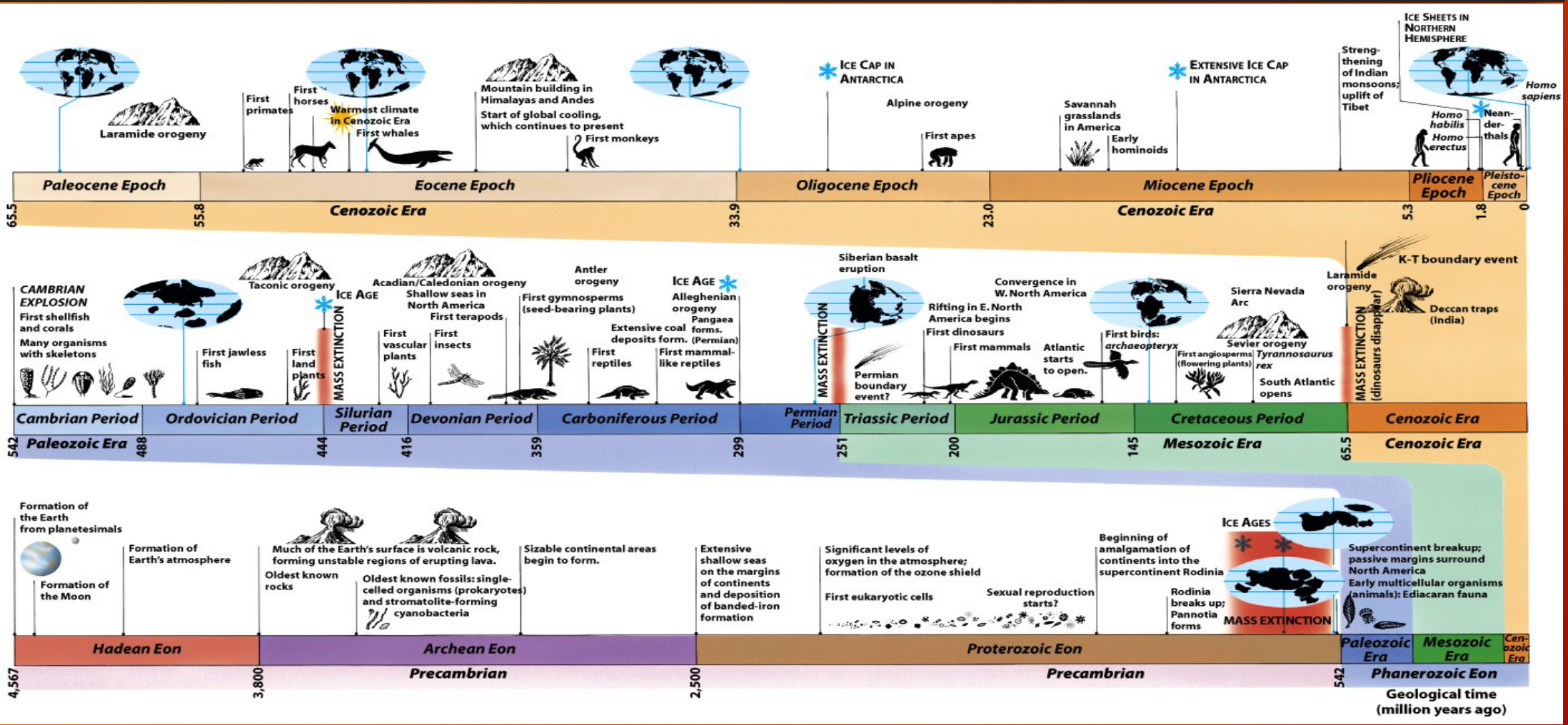


Devonian Life – Via the Devonian Fossil Gorge



Carboniferous – Mississippian – Last major sea

323 Ma
To
358 Ma

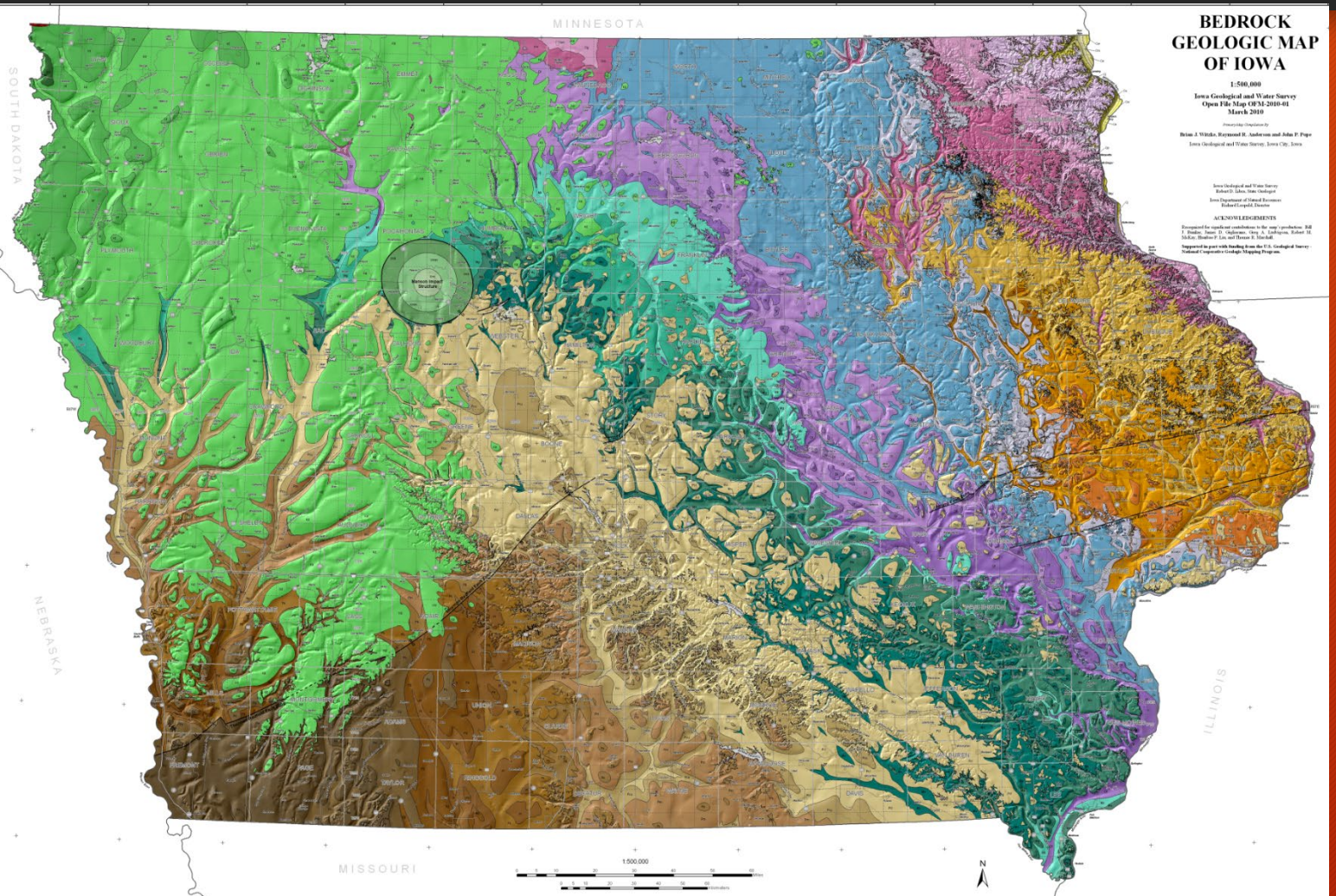


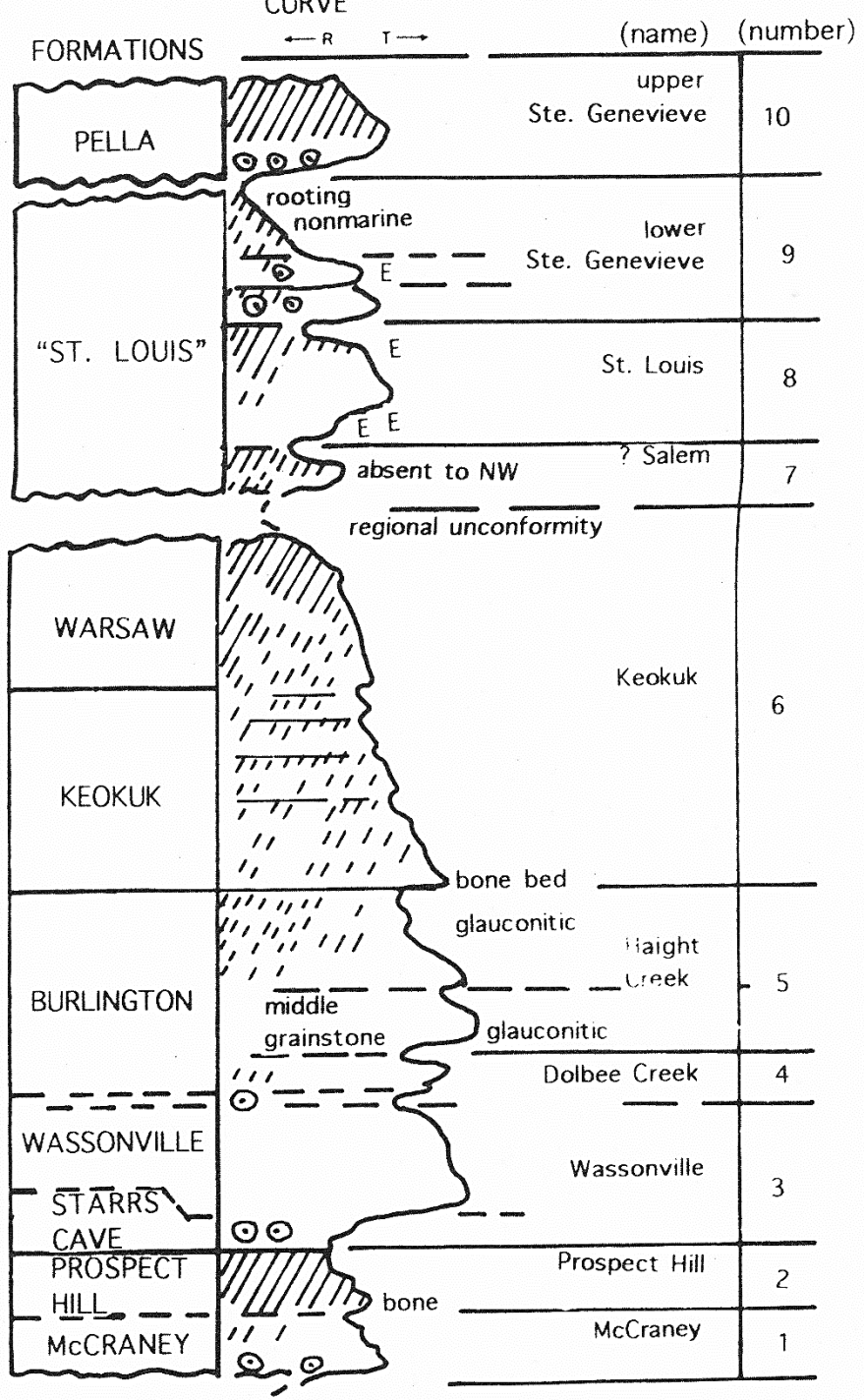
Carboniferous – Mississippian – Last major sea

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

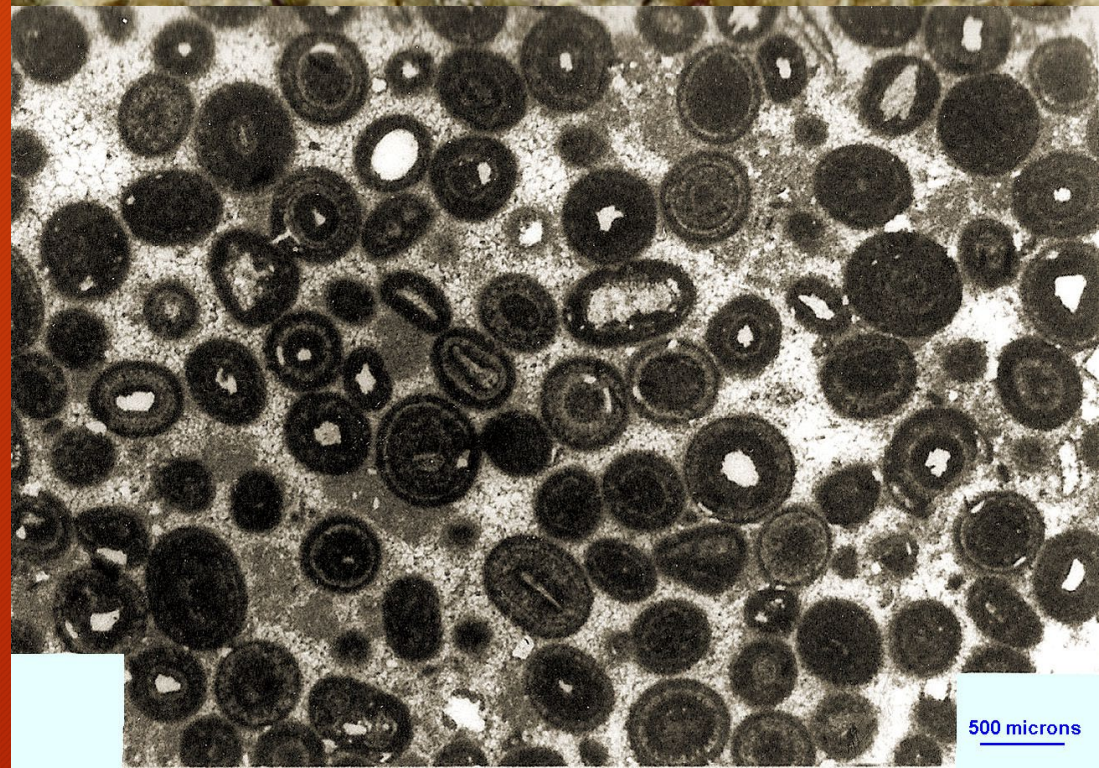
Mississippian





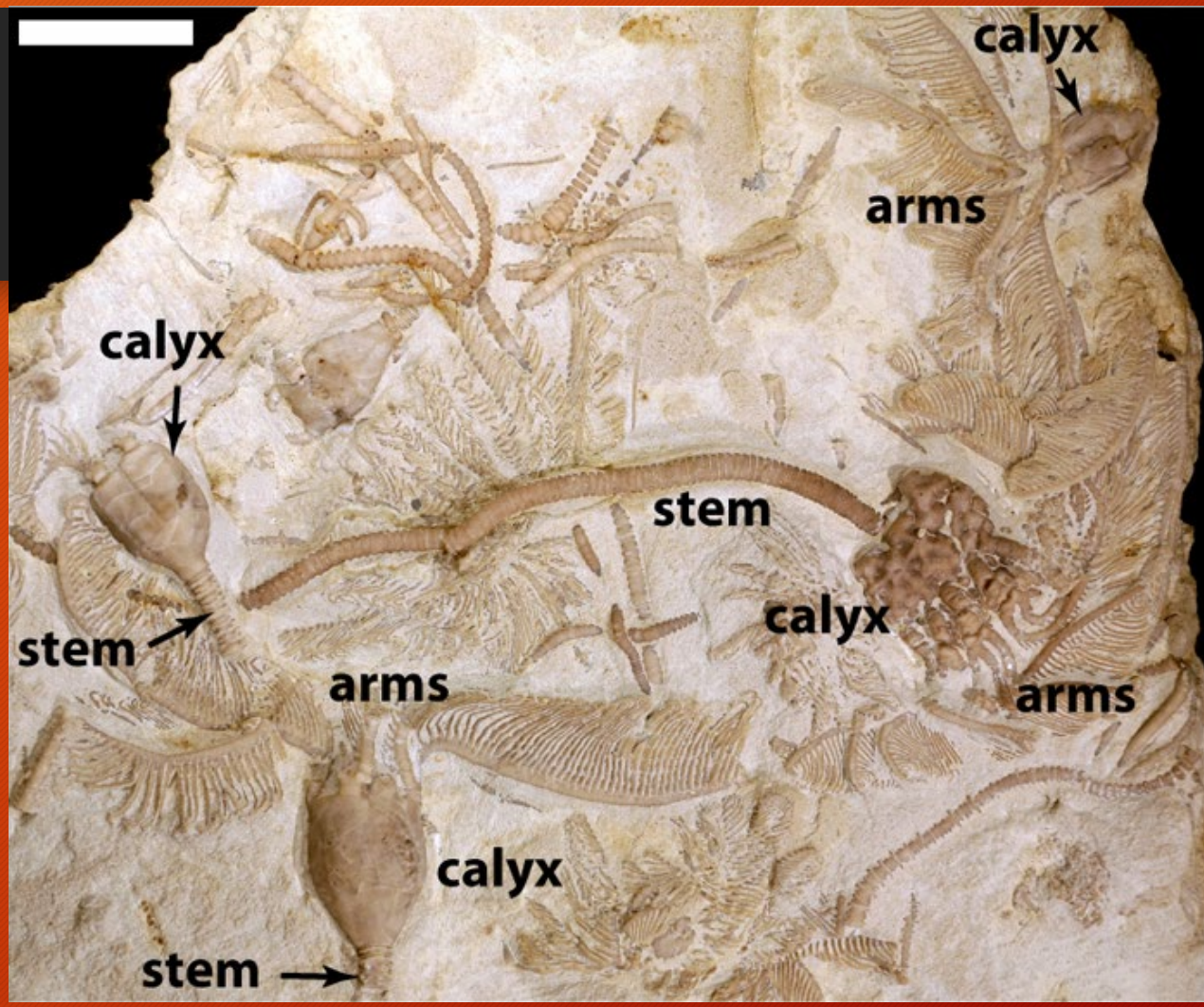
Starrs Cave Formation

- Burlington, Iowa along Flint Creek
- Oolitic grainstone



Burlington Formation

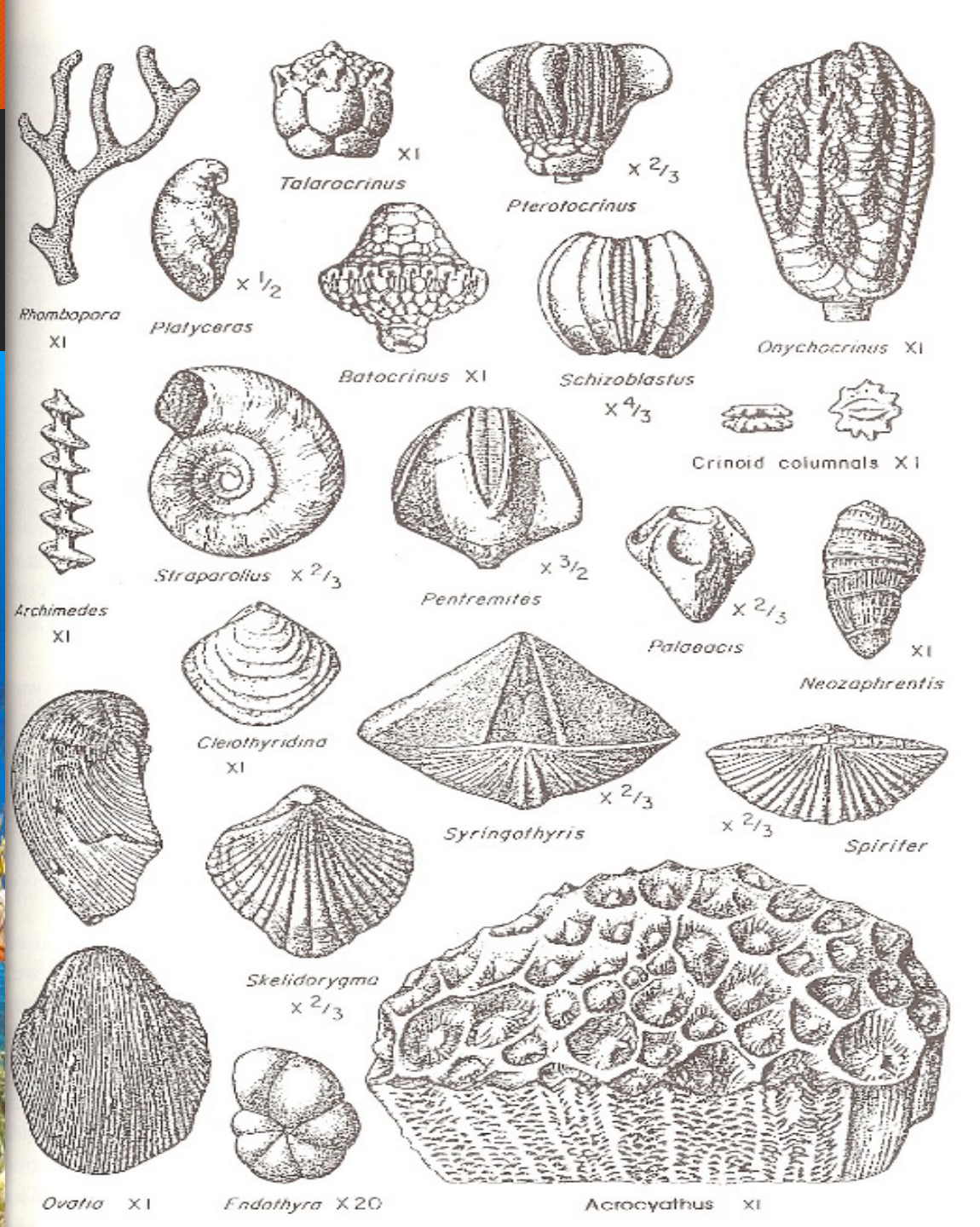
- One of Iowa's most well-known formations
- Excellent source for flint/chert used by native Americans
- Crinoidal limestone (packstone and grainstone)

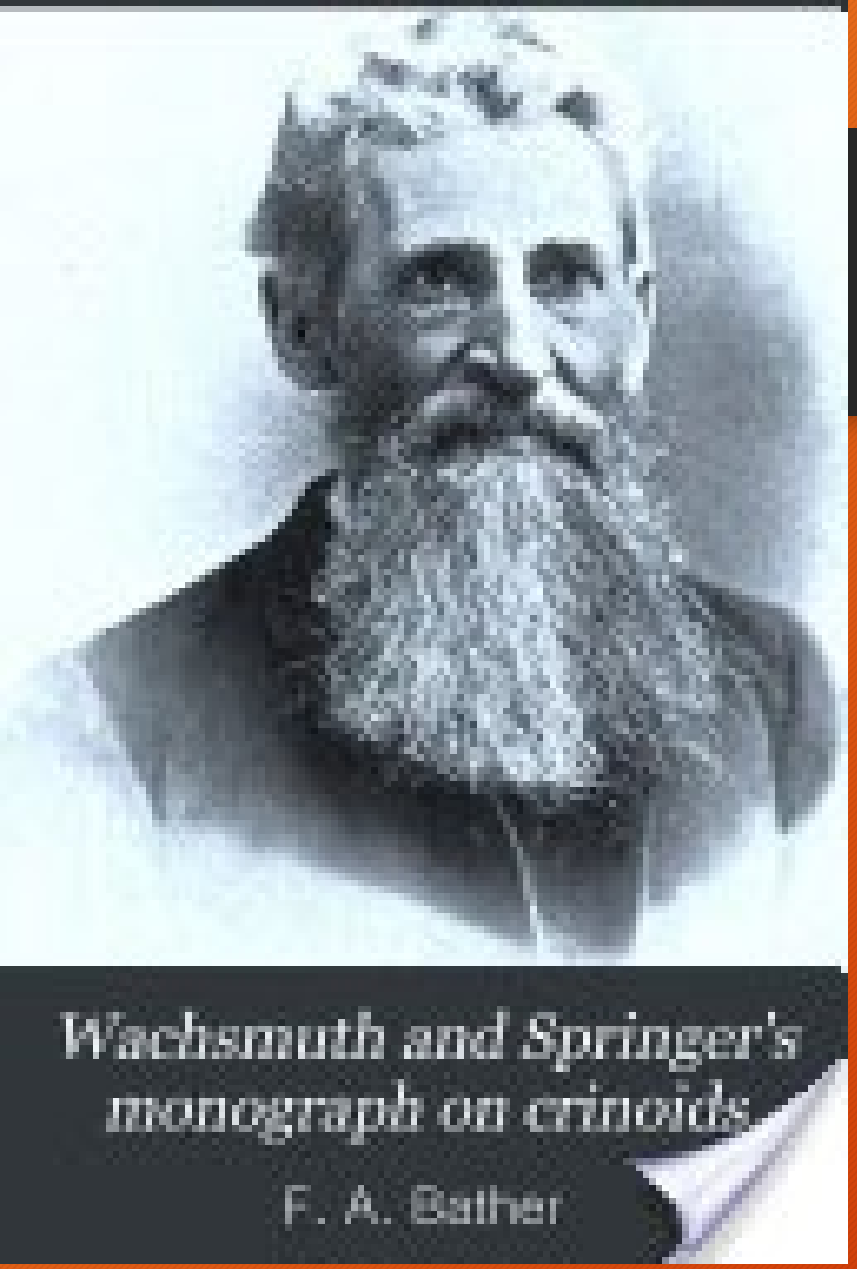


Warsaw Formation

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

Mississippian Life

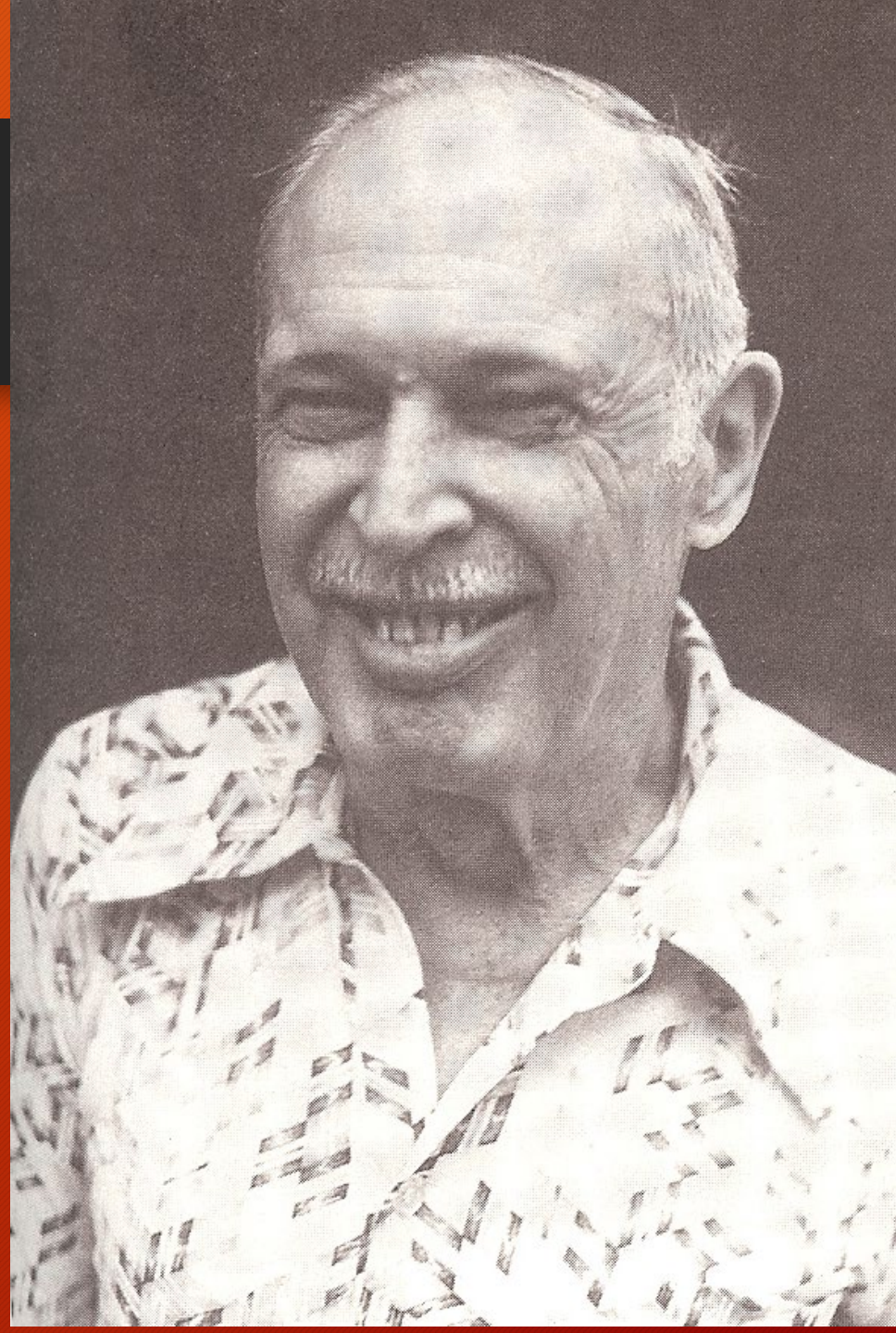




Charles Wachsmuth
1850s

Paleontologists of all kinds!

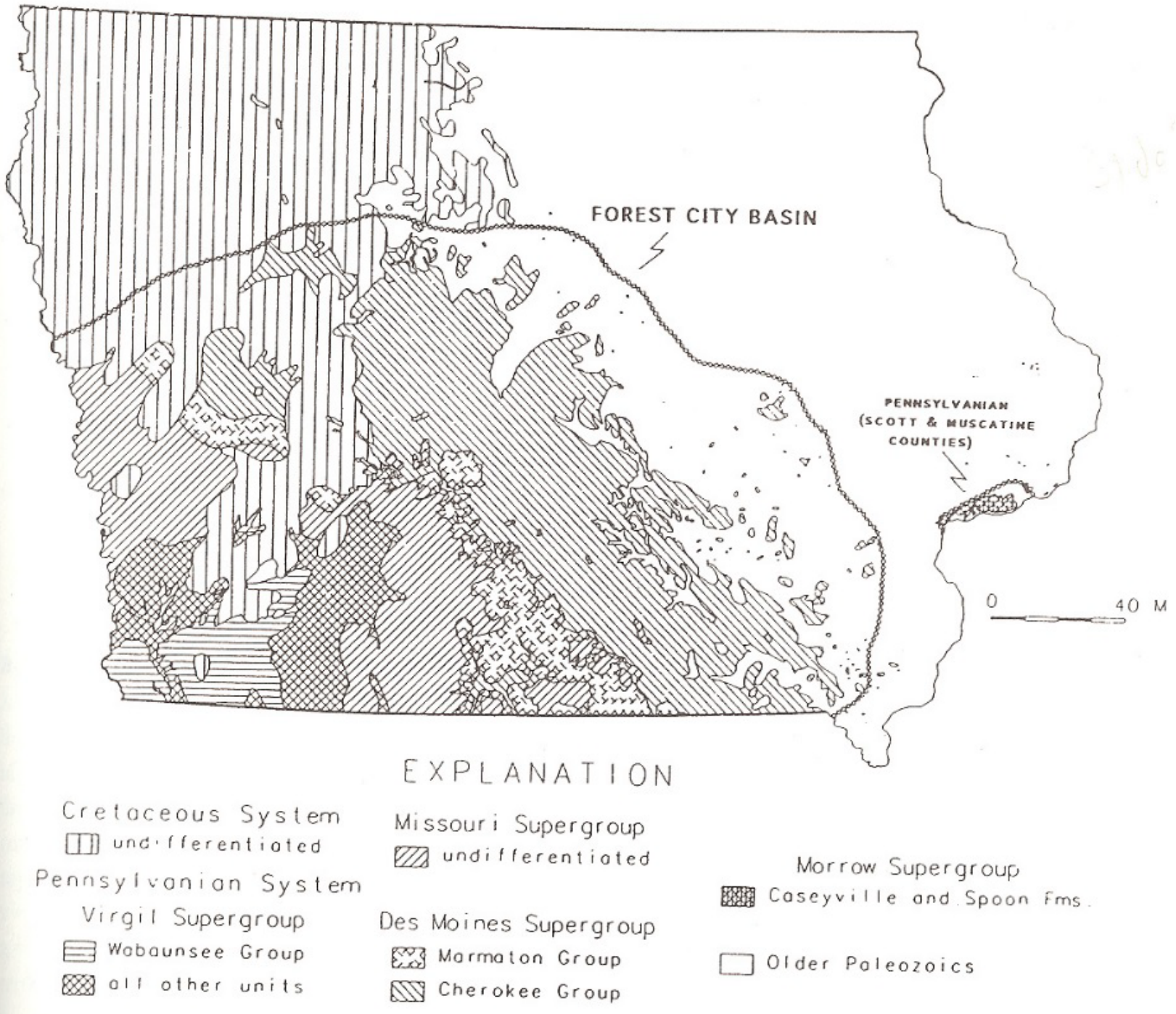
Harrell Strimple
1970s

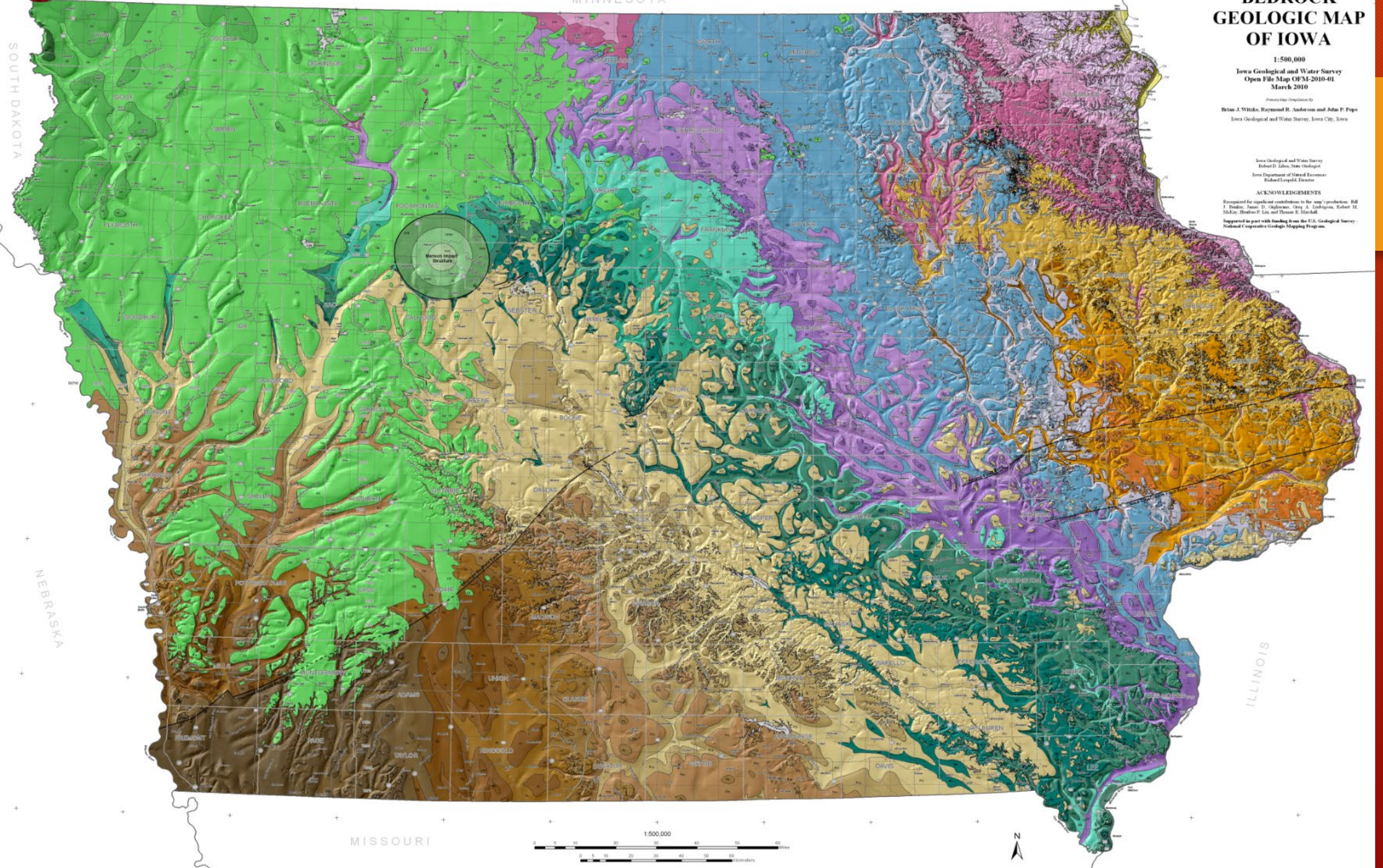


Carboniferous – Pennsylvanian – Coal swaps

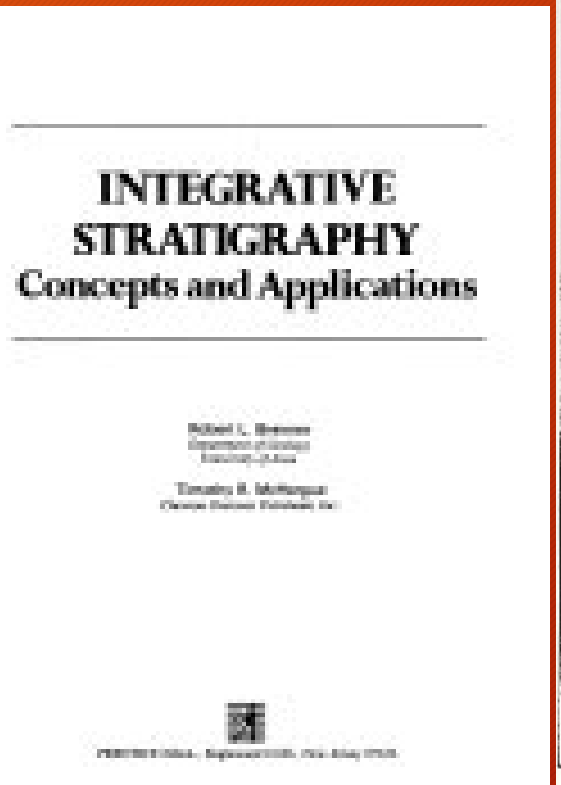
232 Ma
to
298 Ma

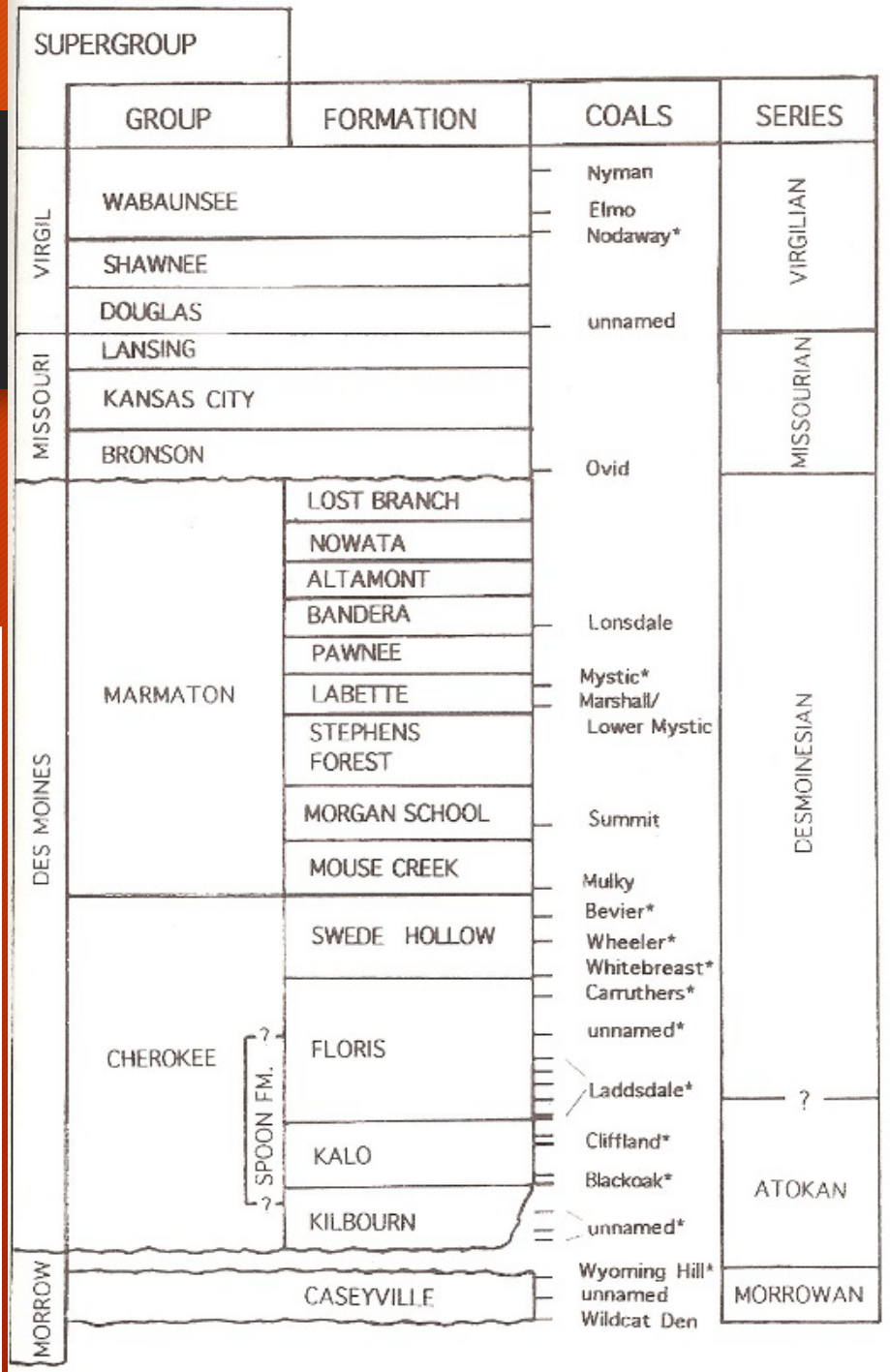
- Coastal shorelines
  - Coal deposits
  - Cliff-forming Sandstone
    - Dolliver Memorial State Park
    - Ledges State Park
    - Wildcat Den State Park
    - Red Rock Reservoir
    - Pilot Knob County Park
- Deltas


FOREST CITY BASIN
PENNSYLVANIAN
(SCOTT & MUSCATINE
COUNTIES)
0
40 M
EXPLANATION
Cretaceous System
undifferentiated
Pennsylvanian System
Virgil Supergroup
Wabaunsee Group
all other units
Missouri Supergroup
undifferentiated
Des Moines Supergroup
Marmaton Group
Cherokee Group
Morrow Supergroup
Caseyville and Spoon Fms.
Older Paleozoics


BEDROCK GEOLOGIC MAP OF IOWA
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
Recognized for significant contributions to the map's production: Bill J. Bunker, James D. Giglierano, Greg A. Lindquist, Robert M. McKay, Bhaskar P. Lin, and Thomas E. Marshall.
Supported in part with funding from the U.S. Geological Survey - National Cooperative Geologic Mapping Program.
Manson Impact Structure
SOUTH DAKOTA
MINNESOTA
NEBRASKA
ILLINOIS
MISSOURI
1:500,000
N

Cherokee Group





Lepidodendron

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’

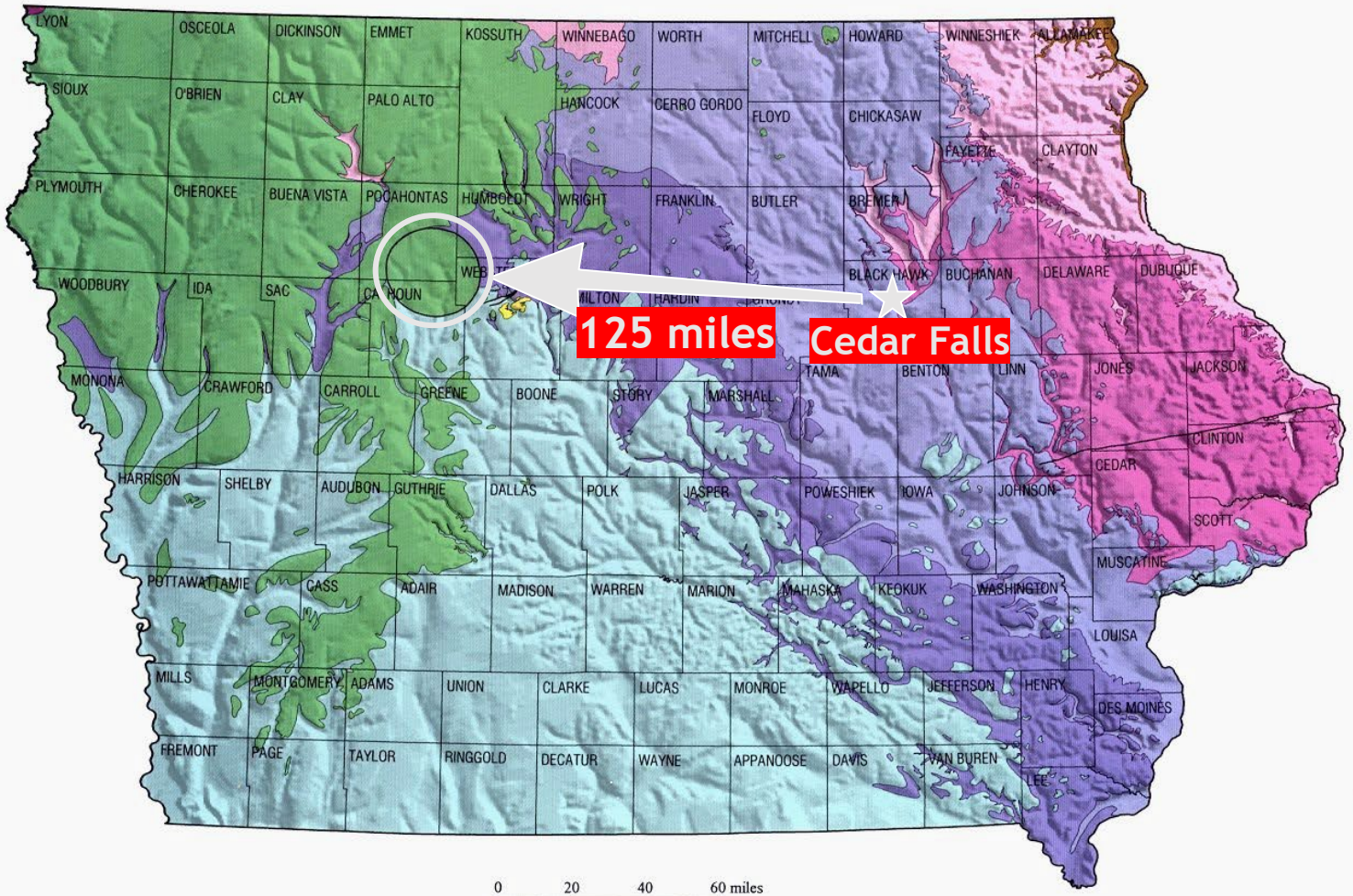
“People are gullible”
- George Hull


The photograph published in *Strand* Magazine in 1895.

Cretaceous

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

BEDROCK GEOLOGIC MAP OF IOWA
1998



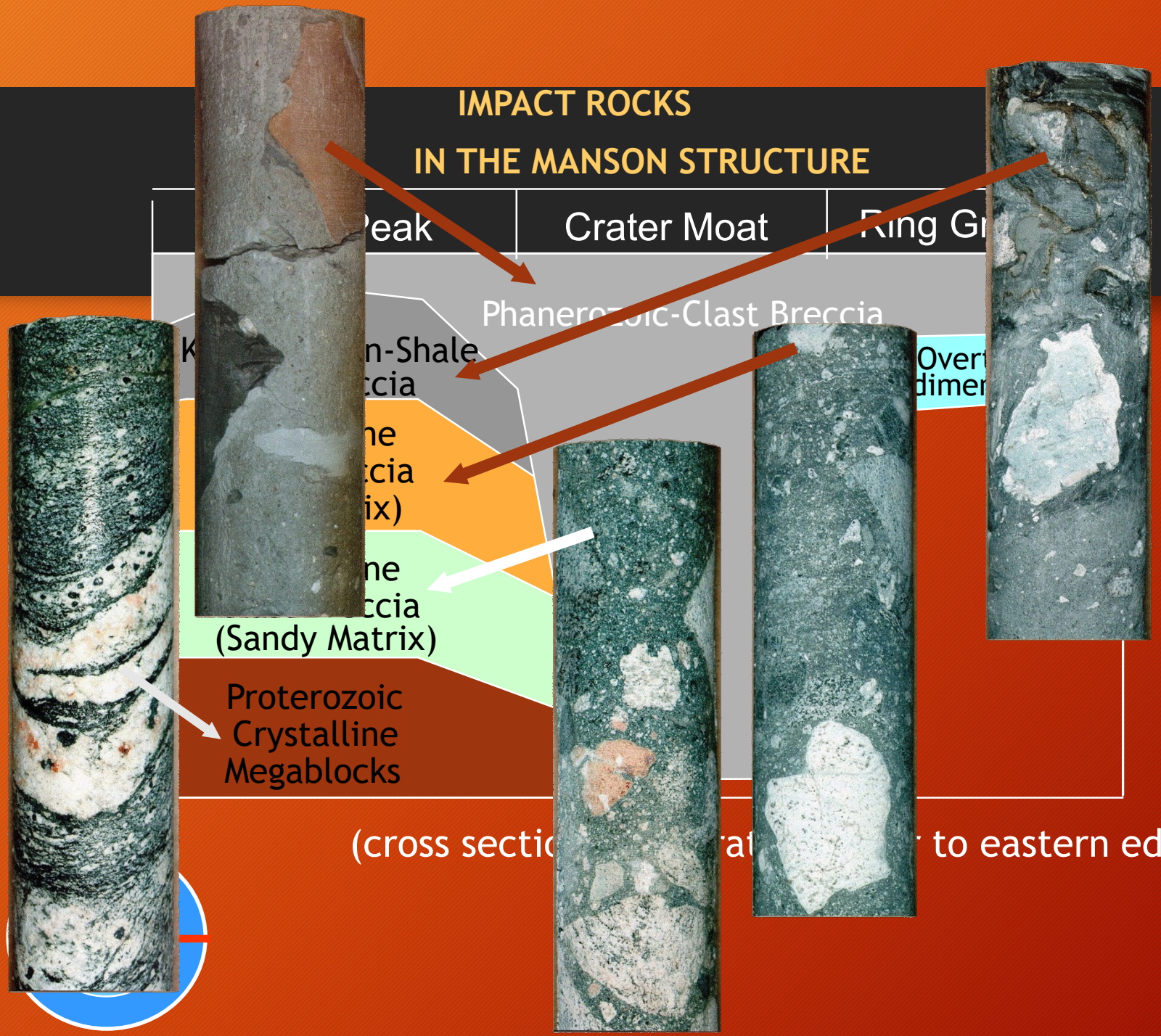
Geologic Systems
Age of rocks in Iowa
(million years before present)

- **Cretaceous** (74–102)
- **Jurassic** (160)
- **Pennsylvanian** (298–320)
- **Mississippian** (325–353)
- **Devonian** (355–385)
- **Silurian** (415–435)
- **Ordovician** (439–505)
- **Cambrian** (505–530)
- **Precambrian** (600?–2,910+)
- Fault trace
- Manson Impact Structure

Shading highlights relief on the bedrock surface.

Iowa Department of Natural Resources
Geological Survey Bureau • 109 Trowbridge Hall • Iowa City, Iowa 52242-1319

IMPACT ROCKS
IN THE MANSON STRUCTURE



(cross sectio to eastern edge)