MICHIGAN'S GEOLOGY

Christopher R. Byrum, Ph.D., P.E.

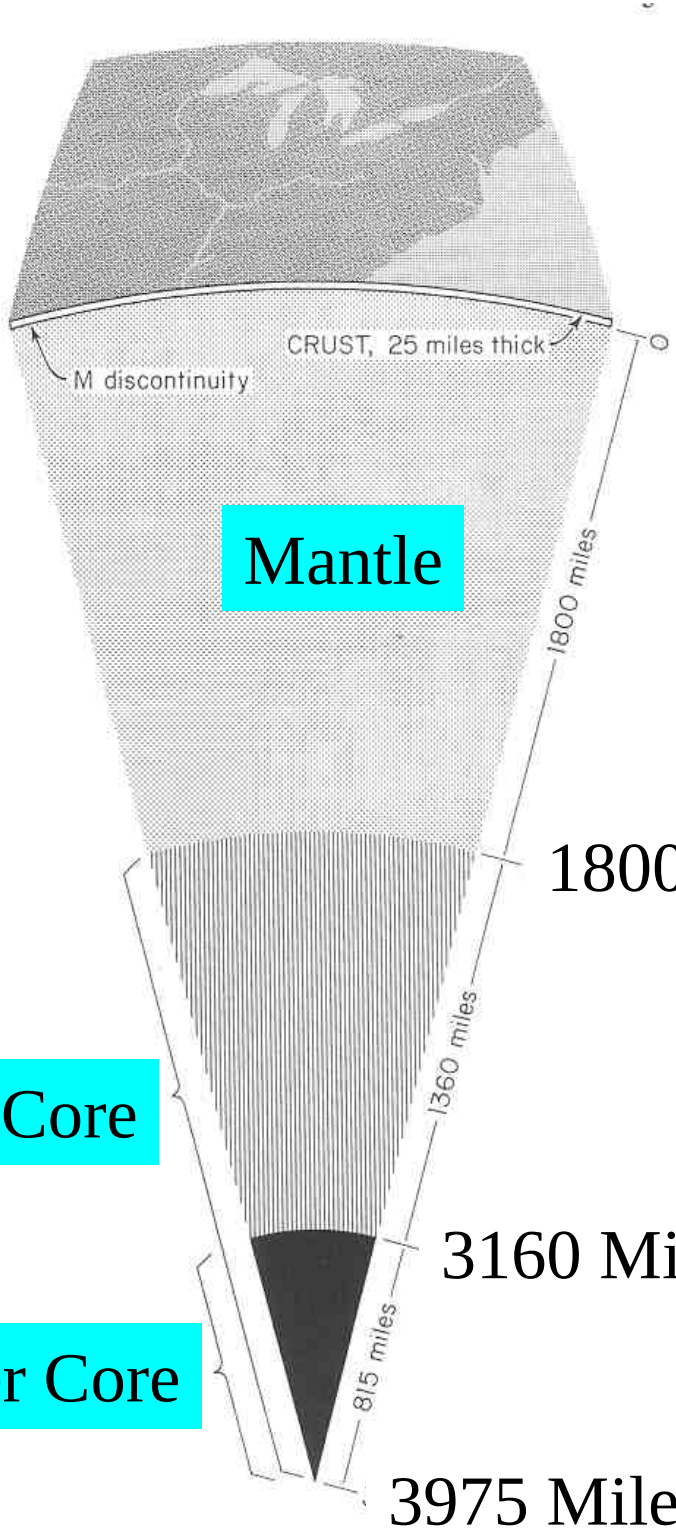
BS-MTU, 1989-Structural

MS-UM, 1993-Geotechnical

PhD-UM, 2000-Soil/Structure Interaction

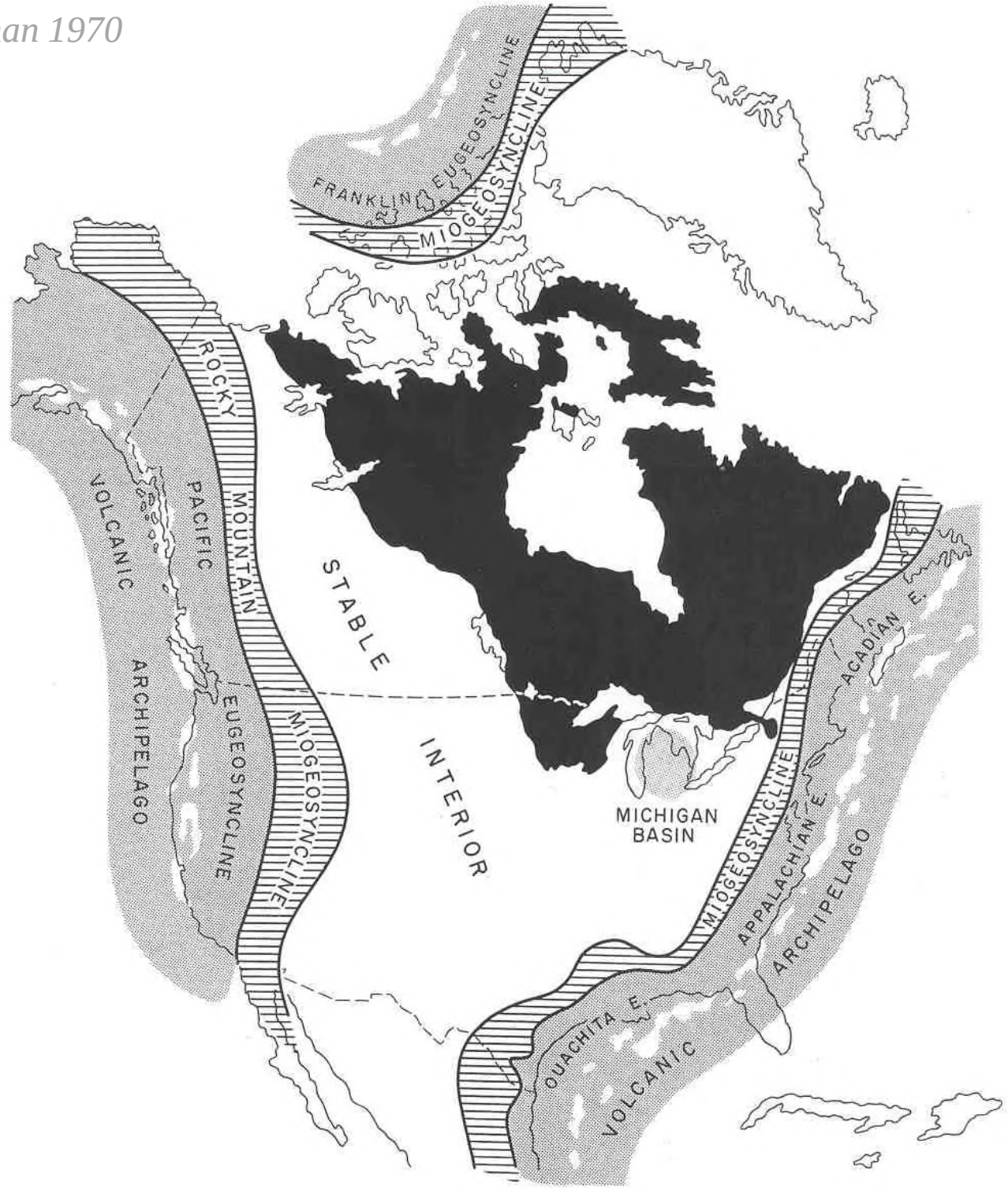
from Dorr & Eschman 1970

The Big Picture

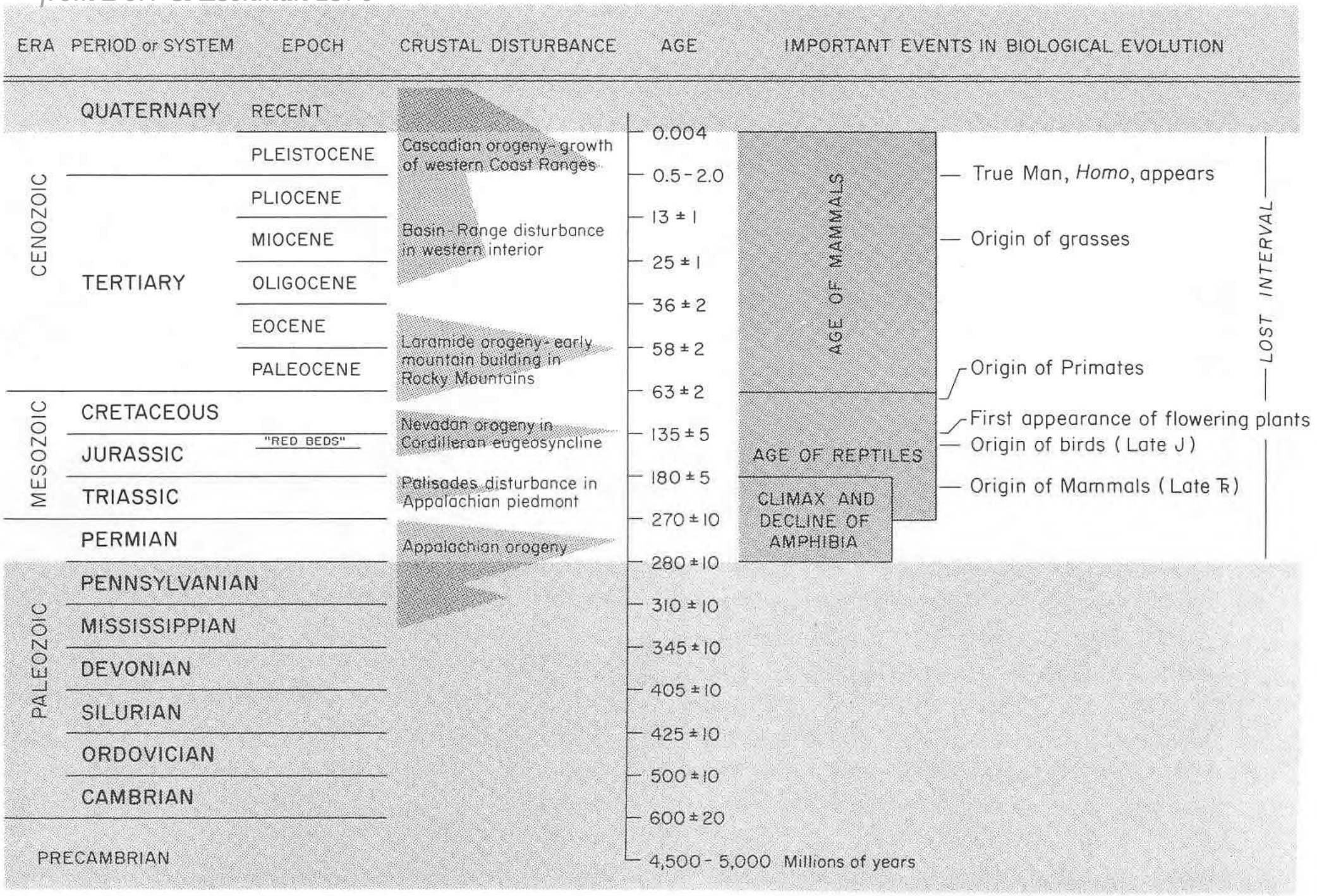


The Earth's Interior

from Dorr & Eschman 1970

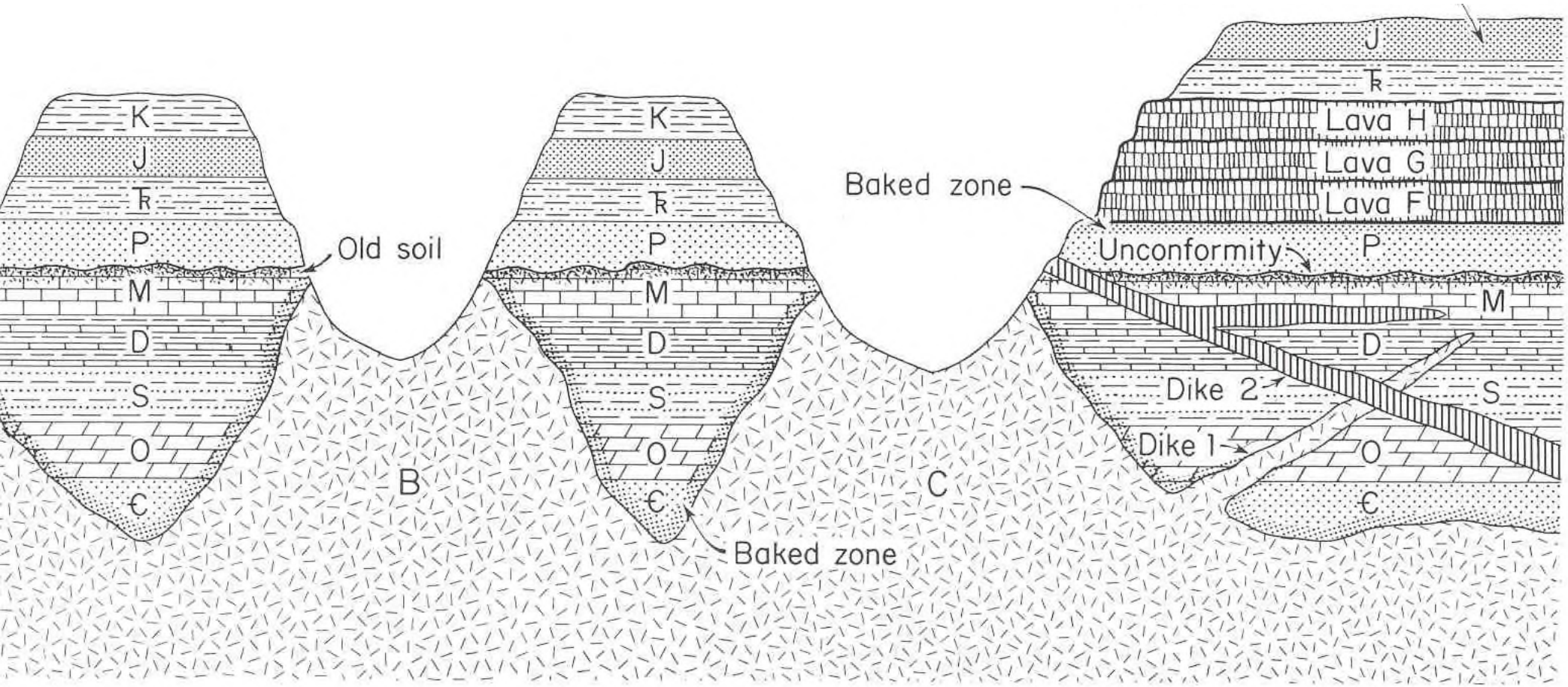


from Dorr & Eschman 1970

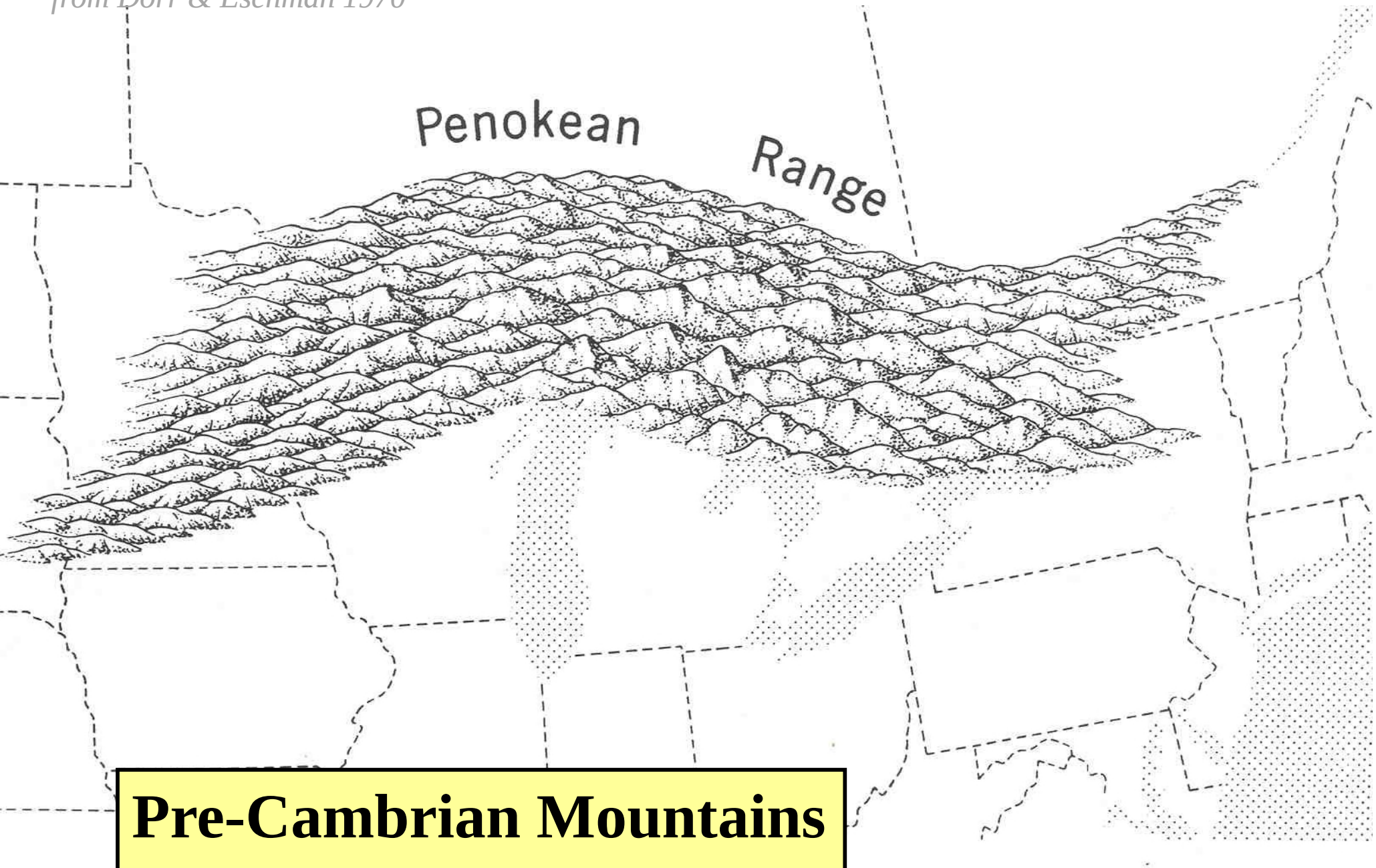


from Dorr & Eschman 1970

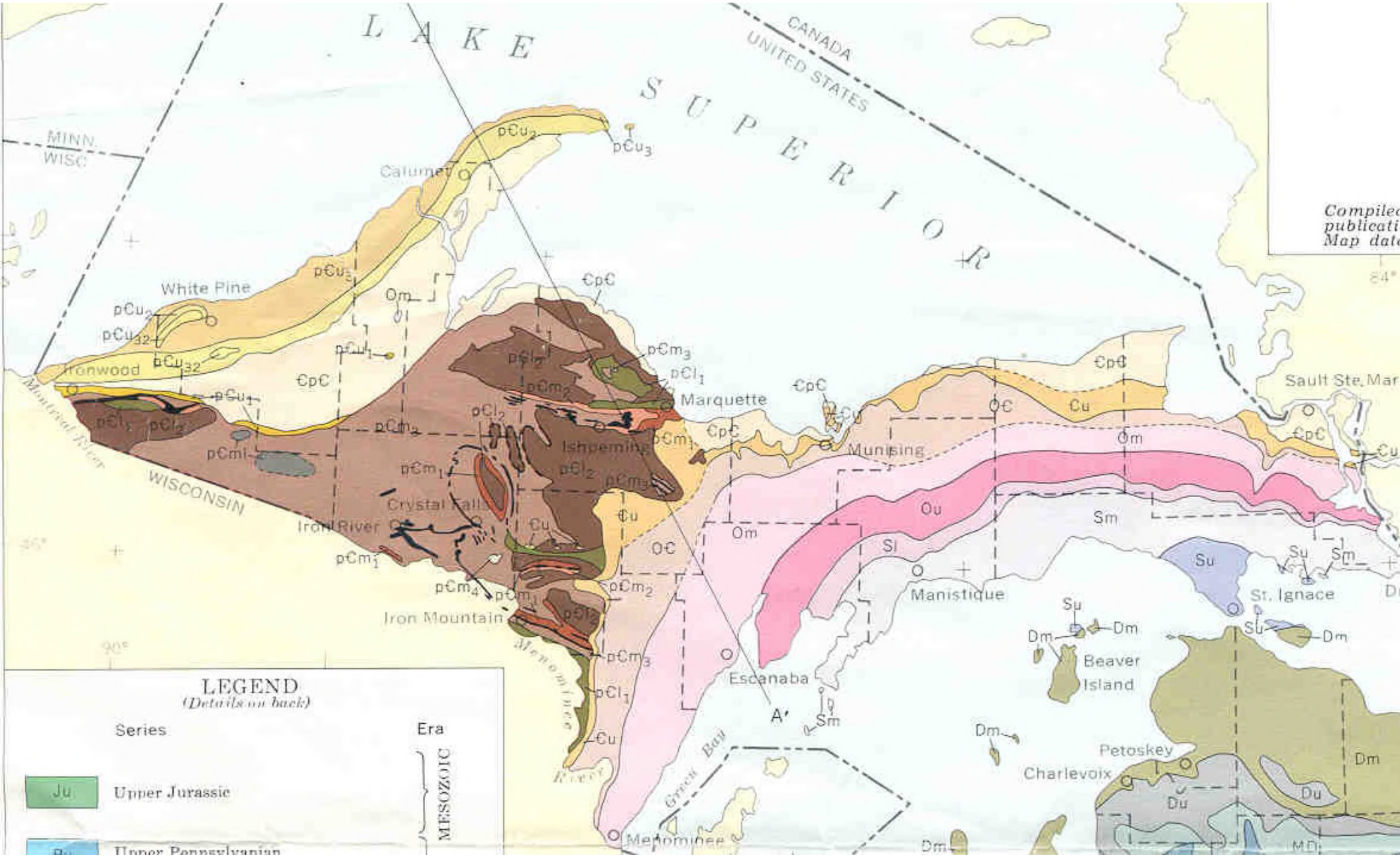
General Terminology

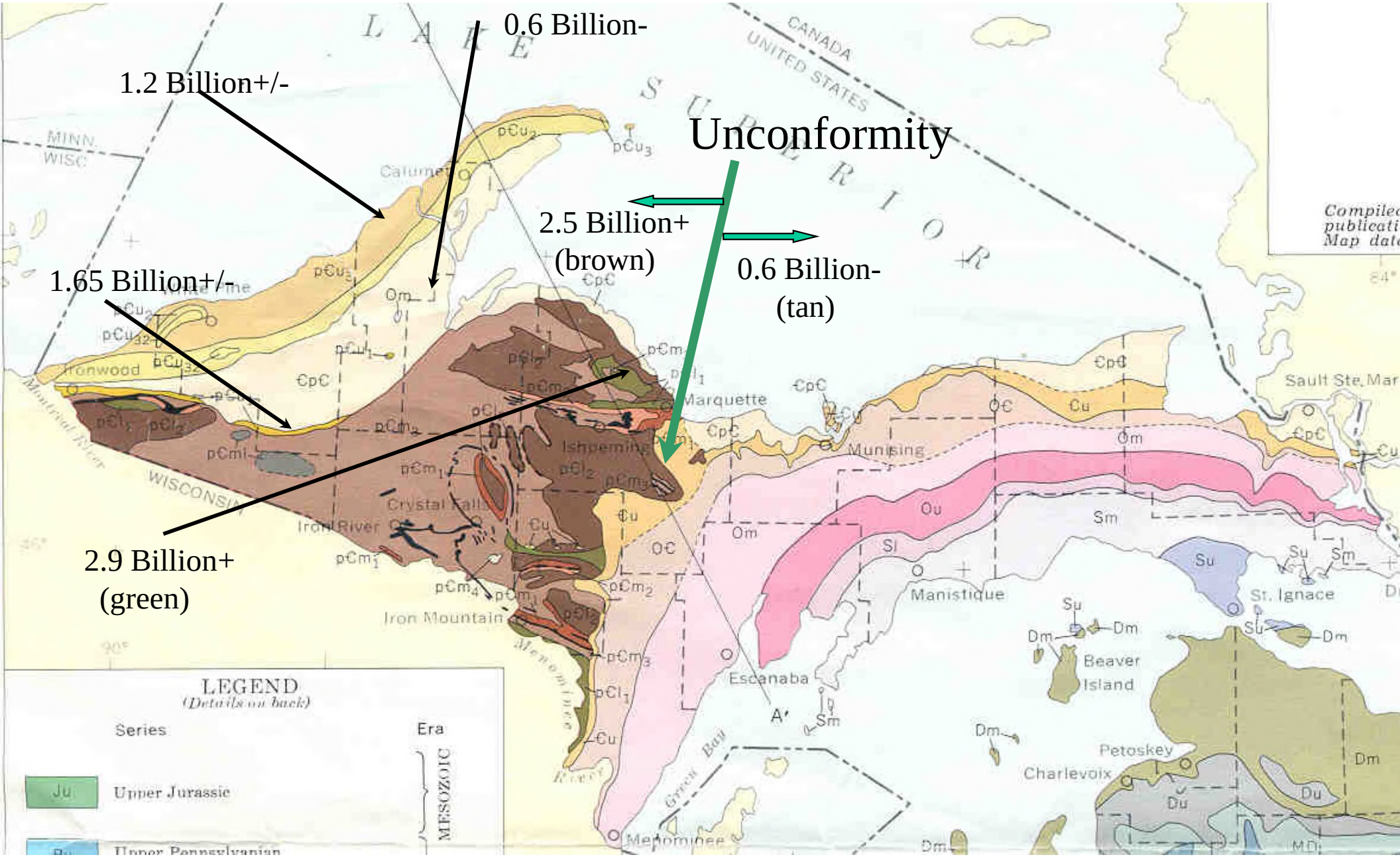


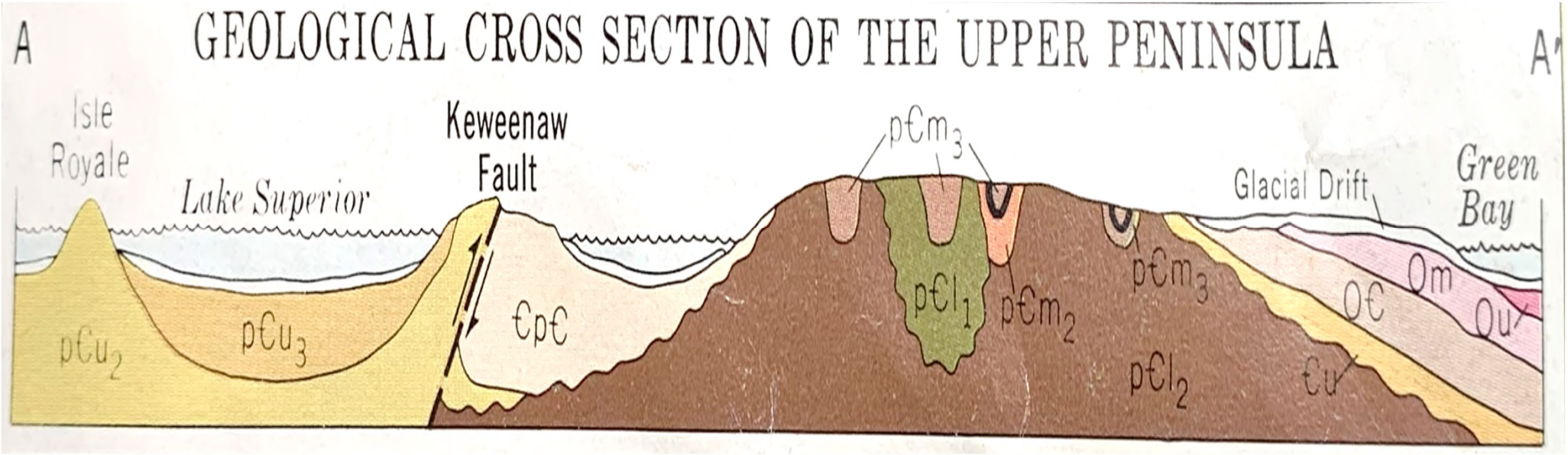
from Dorr & Eschman 1970



Pre-Cambrian Mountains
2.5 to 3 billion Years Ago

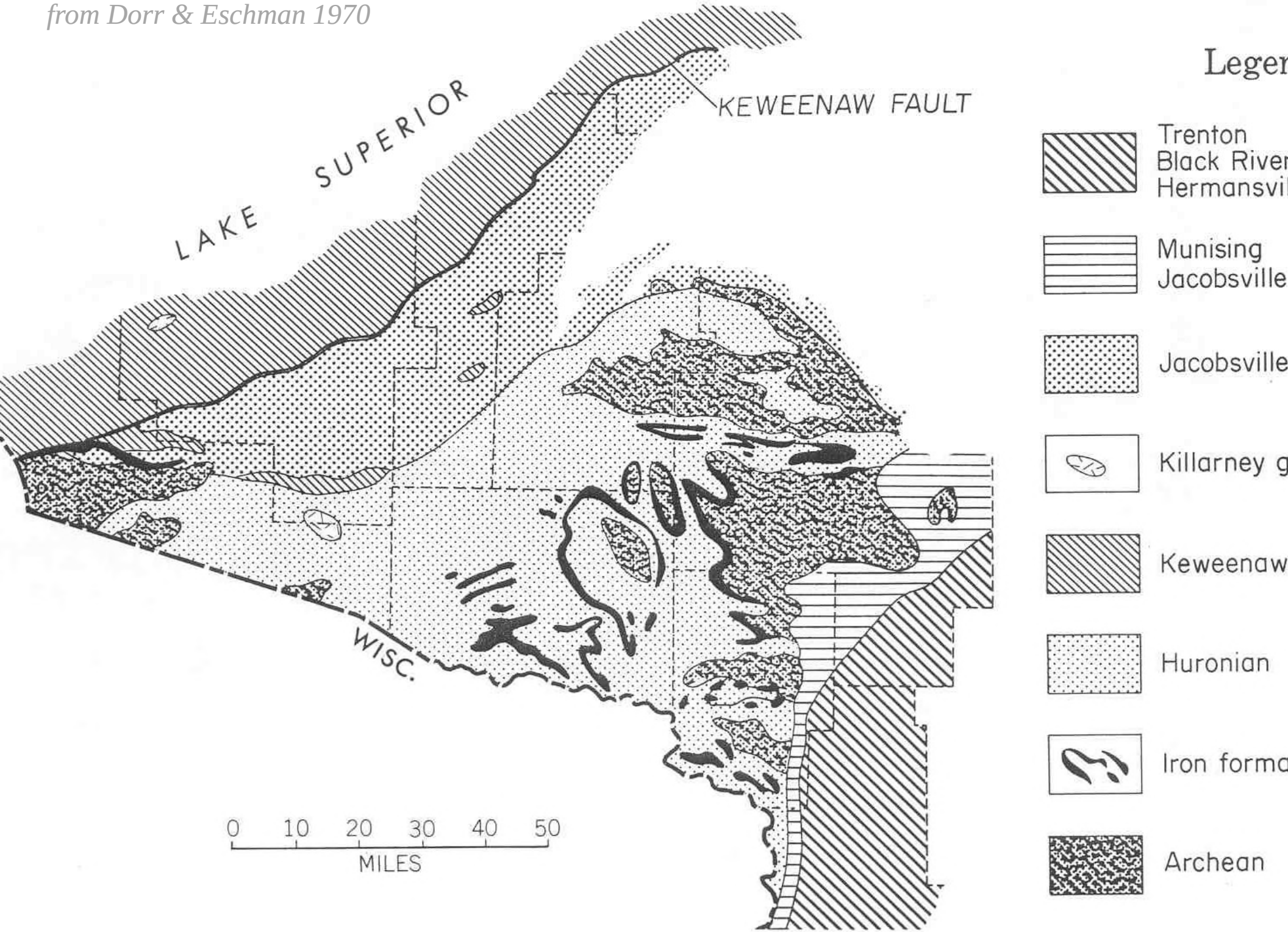

LAKE SUPERIOR
CANADA
UNITED STATES
MINN.
WISC.
WISCONSIN
Calumet
White Pine
Ironwood
Marquette
Ishpeming
Crystal Falls
Iron River
Iron Mountain
Menominee
Escanaba
Manistique
Munising
Sault Ste. Marie
St. Ignace
Beaver Island
Petoskey
Charlevoix
Green Bay
A'
A
Compiled
publicati
Map date
LEGEND
(Details on back)
Series
Era
MESOZOIC
Ju Upper Jurassic
Upper Pennsylvanian


0.6 Billion-
1.2 Billion+/-
Unconformity
2.5 Billion+
(brown)
0.6 Billion-
(tan)
1.65 Billion+/-
2.9 Billion+
(green)
LAKE SUPERIOR
CANADA
UNITED STATES
MINN.
WISC.
WISCONSIN
Calumet
Ironwood
Marquette
Ishpeming
Crystal Falls
Iron River
Iron Mountain
Menominee
Escanaba
Manistique
Munising
Sault Ste. Marie
St. Ignace
Beaver Island
Petoskey
Charlevoix
Green Bay
A'
LEGEND
(Details on back)
Series
Era
Ju
Upper Jurassic
MESOZOIC

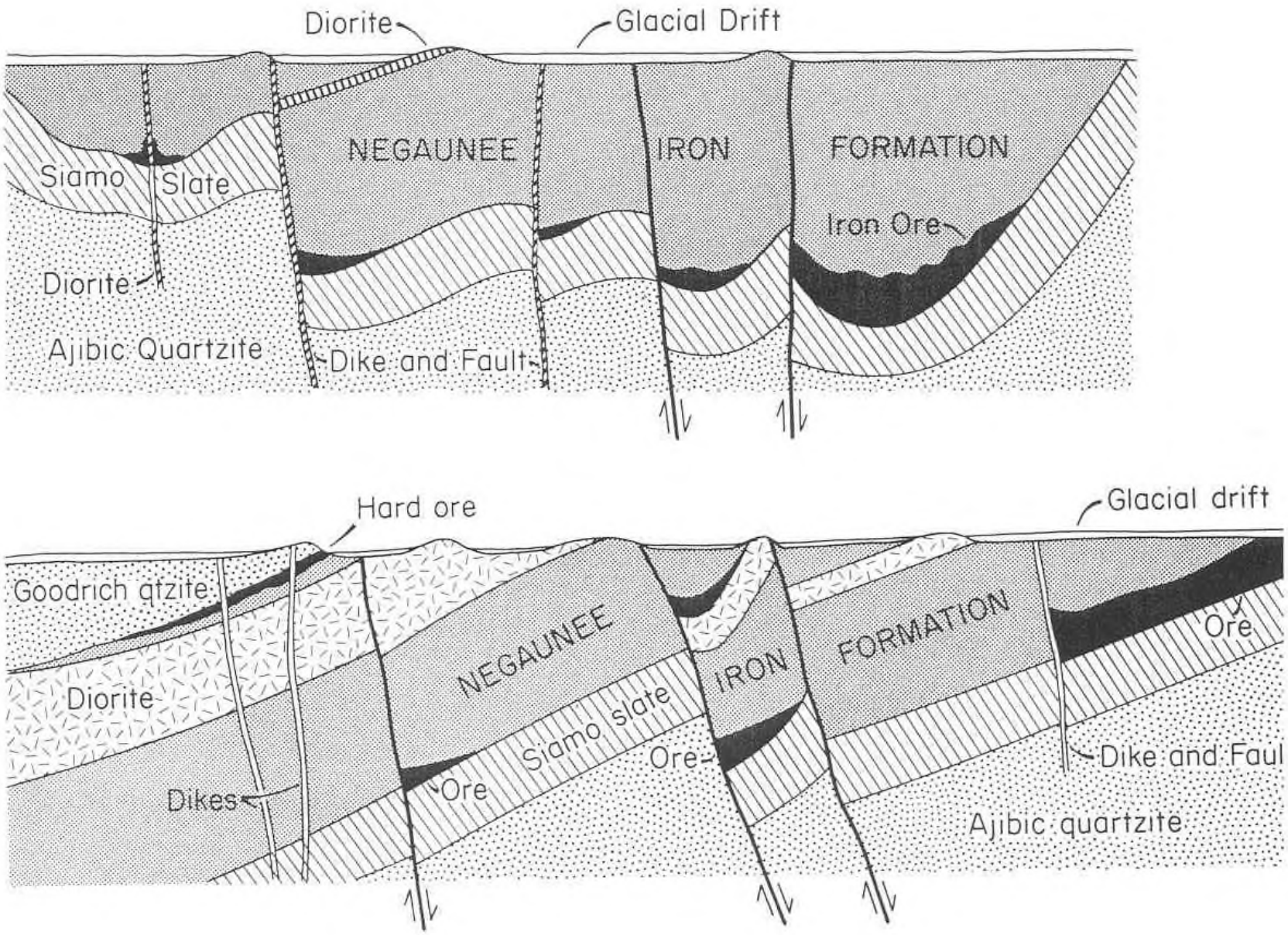


from R.W. Kelley 1968, Mi DNR

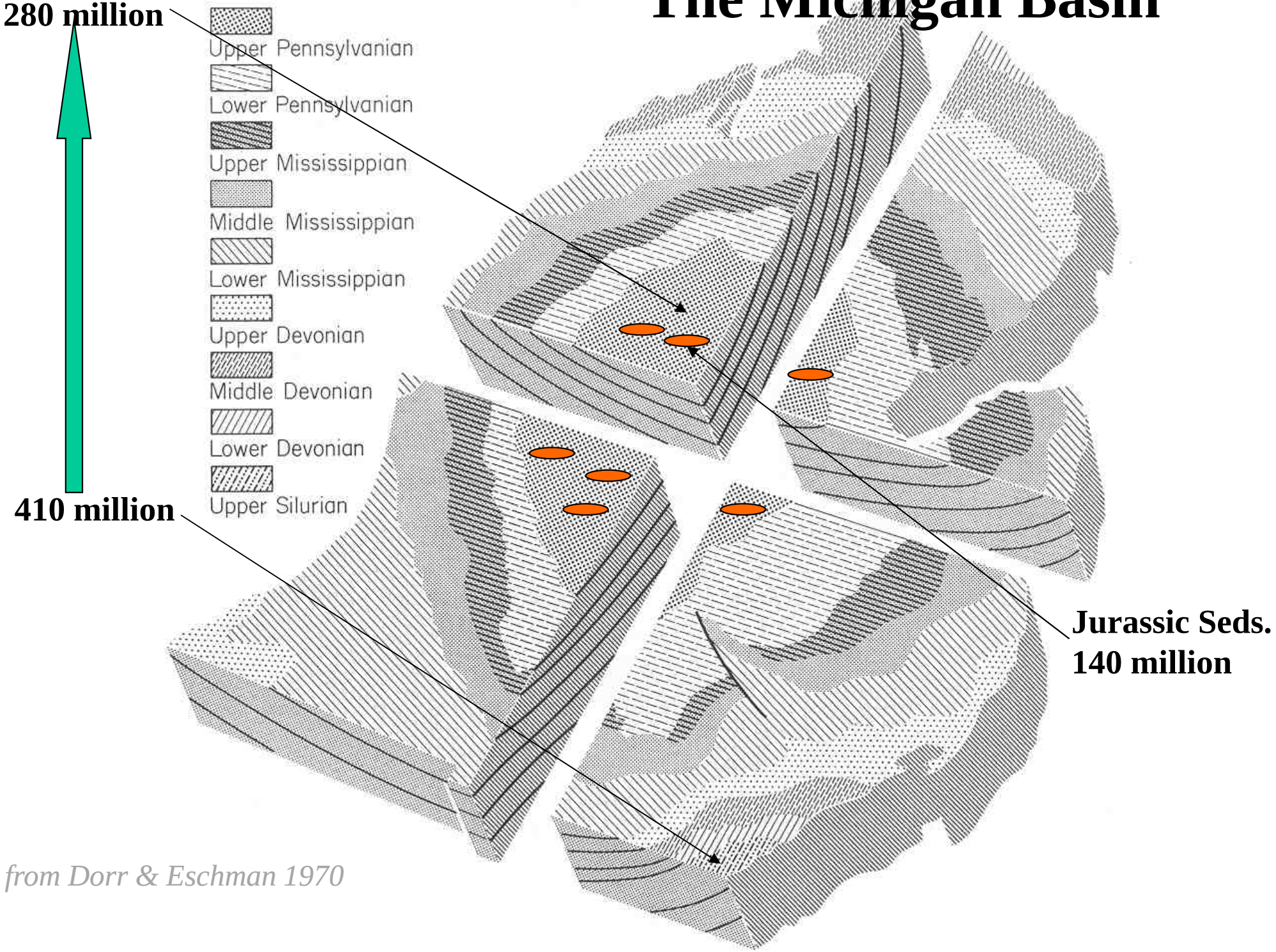
from Dorr & Eschman 1970



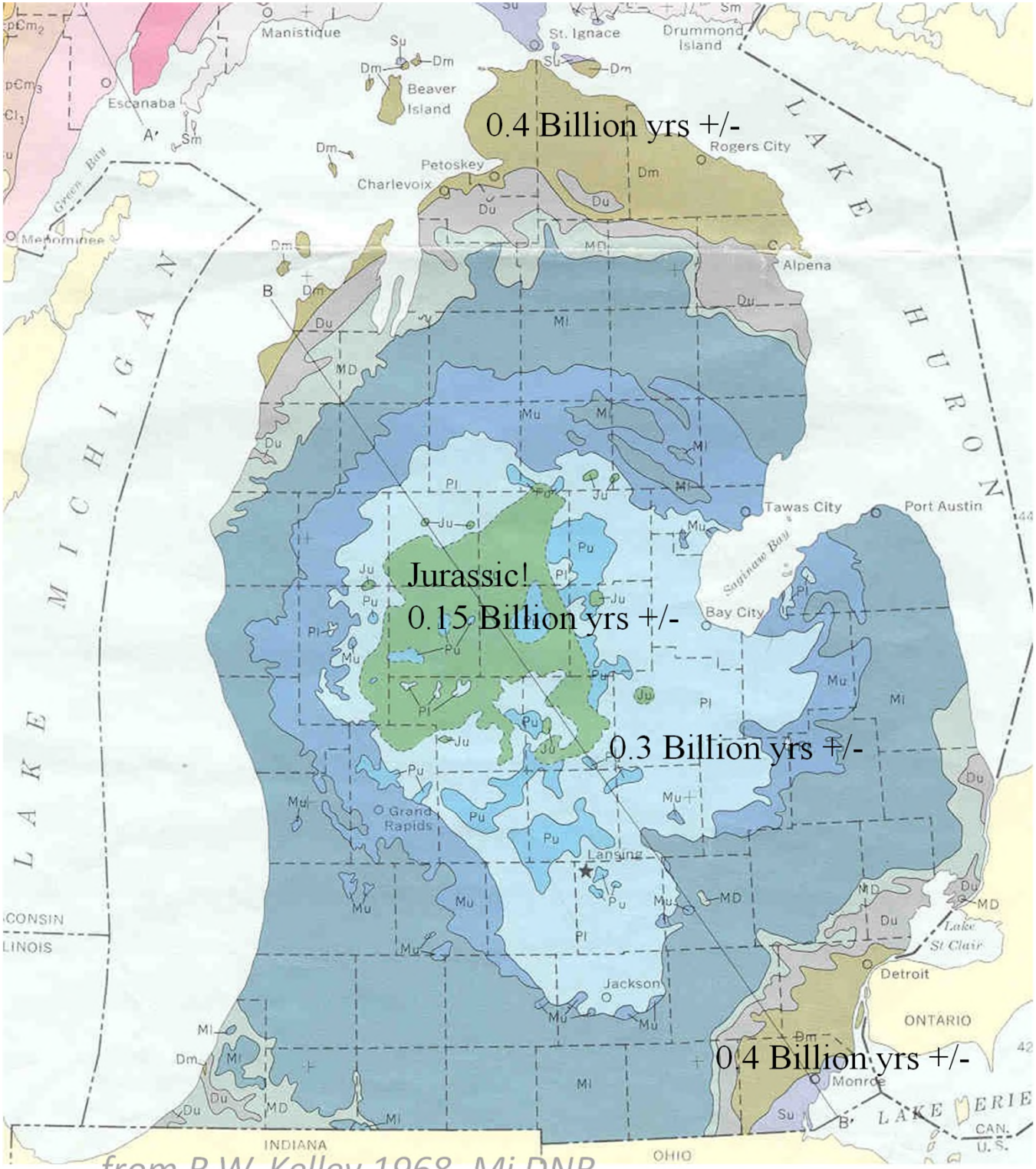
from Dorr & Eschman 1970



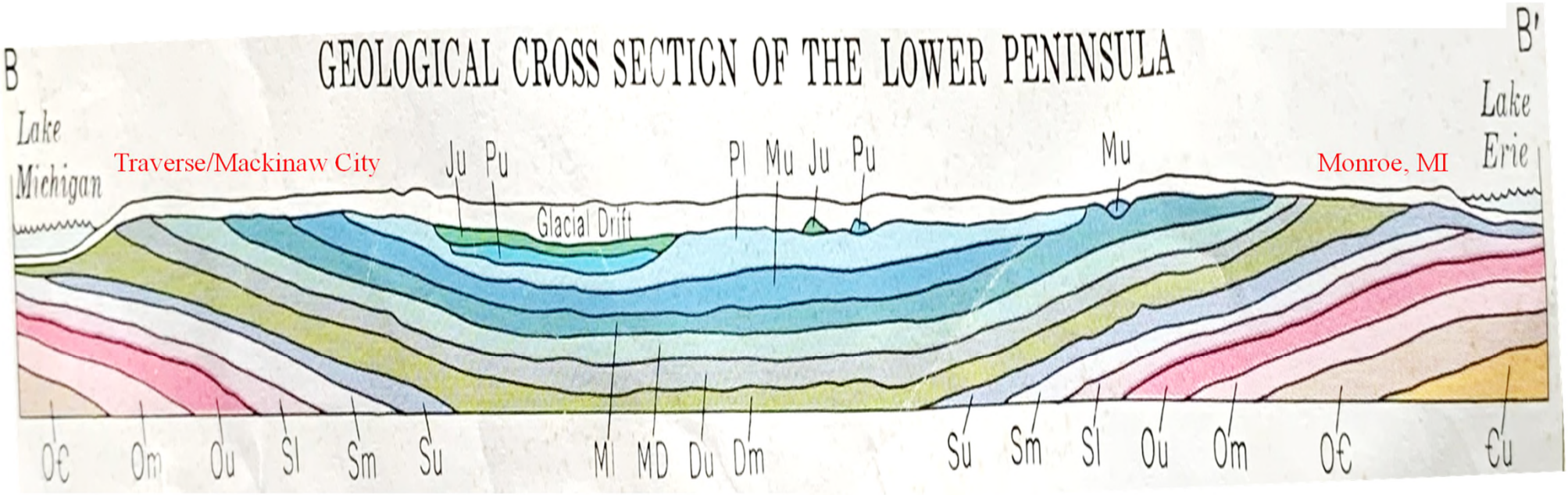
The Michigan Basin



from Dorr & Eschman 1970



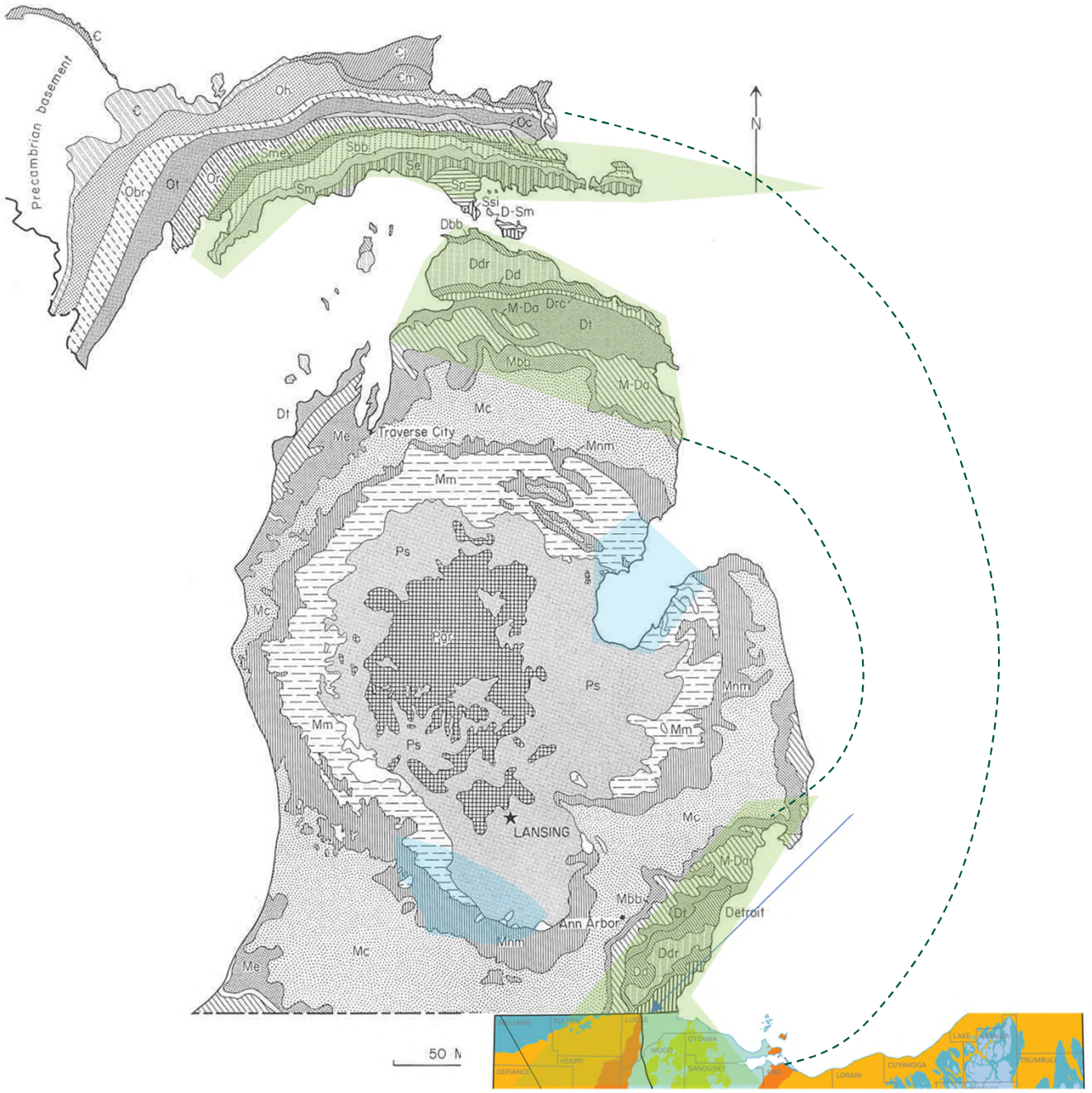
from R.W. Kelley 1968, Mi DNR



from R.W. Kelley 1968, Mi DNR

CARBONATES

	Pennsylvanian
Pgr	Grand River
Ps	Saginaw
	Mississippian
Mb	Bayport
Mm	Michigan
Mnm	Napoleon-Marshall
Mc	Coldwater
Mbb	Berea-Bedford
Mc	Ellsworth-Antrim
	Mississippian Devonian
M-Da	Antrim
	Devonian
Dt	Traverse
Drc	Rogers City
Dd	Dundee
Ddr	Detroit River
Dbb	Bois Blanc
	Devonian Silurian
D-Sm	Mackinac breccia
	Silurian
Sbi	Bass Island
Ssi	St. Ignace
Sp	Point Aux Chenes
Se	Engadine
Sm	Manistique
Sbb	Burnt Bluff
Sme	Mayville



from Dorr & Eschman 1970

CARBONATES

Frz Exp = 0.038%
Sp Gr = 2.67
Abs = 0.93 / 1.02 %

Frz Exp = 0.042%
Sp Gr = 2.69
Abs = 1.12 / 1.30 %

Frz Exp = 0.001%
Sp Gr = 2.78
Abs = 0.49 / 0.82 %

Frz Exp = 0.000%
Sp Gr = 2.92
Abs = 0.26 / 0.27 %
basalt trap rock
Canada

Frz Exp = 0.003%
Sp Gr = 2.80
Abs = 0.35 / 0.63 %

Frz Exp = 0.014%
Sp Gr = 2.64
Abs = 2.04 / 2.77 %

Frz Exp = 0.014%
Sp Gr = 2.61
Abs = 1.12 / 1.45 %

Frz Exp = 0.008%
Sp Gr = 2.66
Abs = 0.62 / 0.81 %

Frz Exp = 0.045%
Sp Gr = 2.60
Abs = 1.61 / 2.09 %

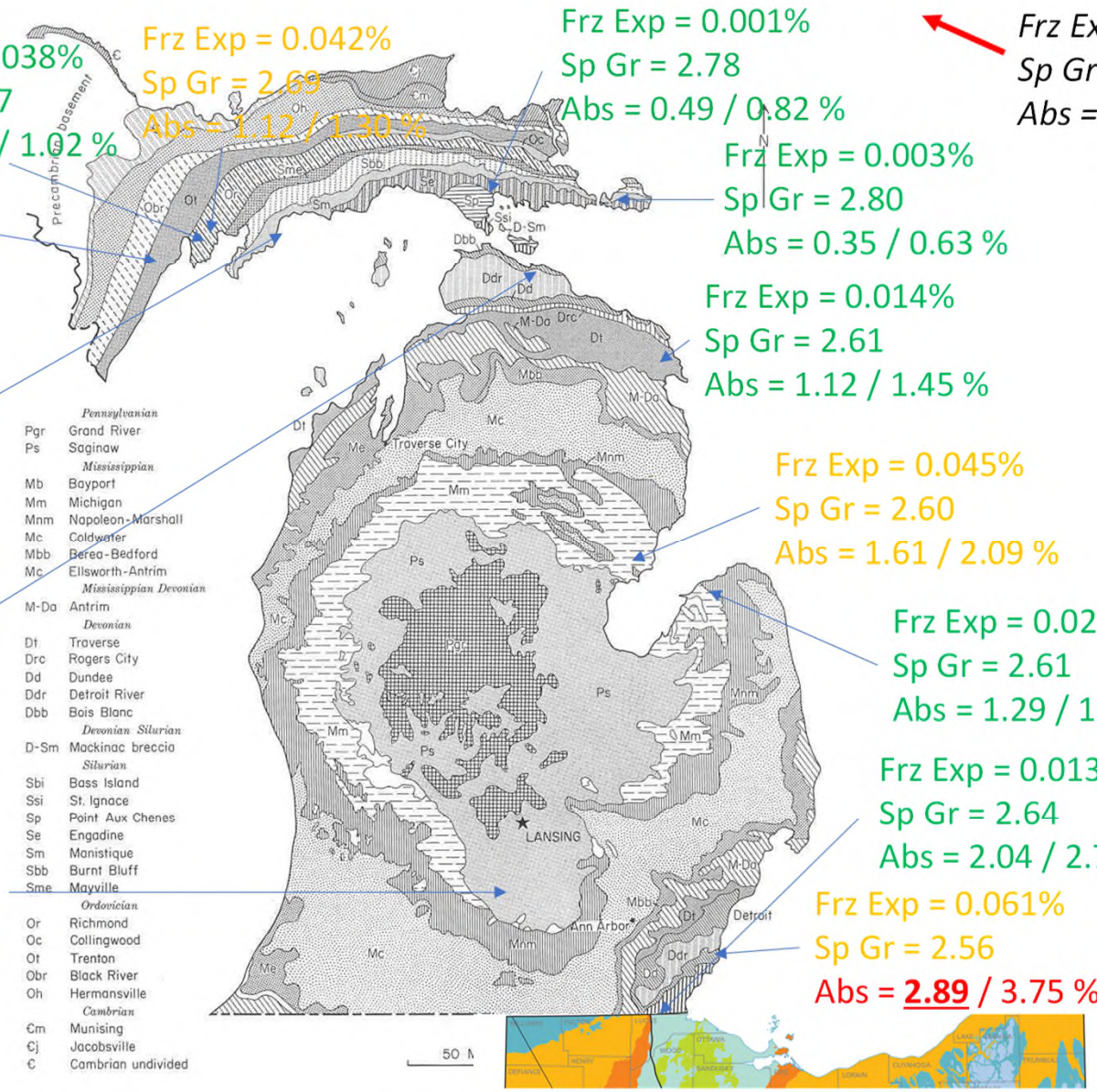
Frz Exp = 0.092%
Sp Gr = 2.54
Abs = 1.79 / 2.59 %

Frz Exp = 0.029%
Sp Gr = 2.61
Abs = 1.29 / 1.38 %

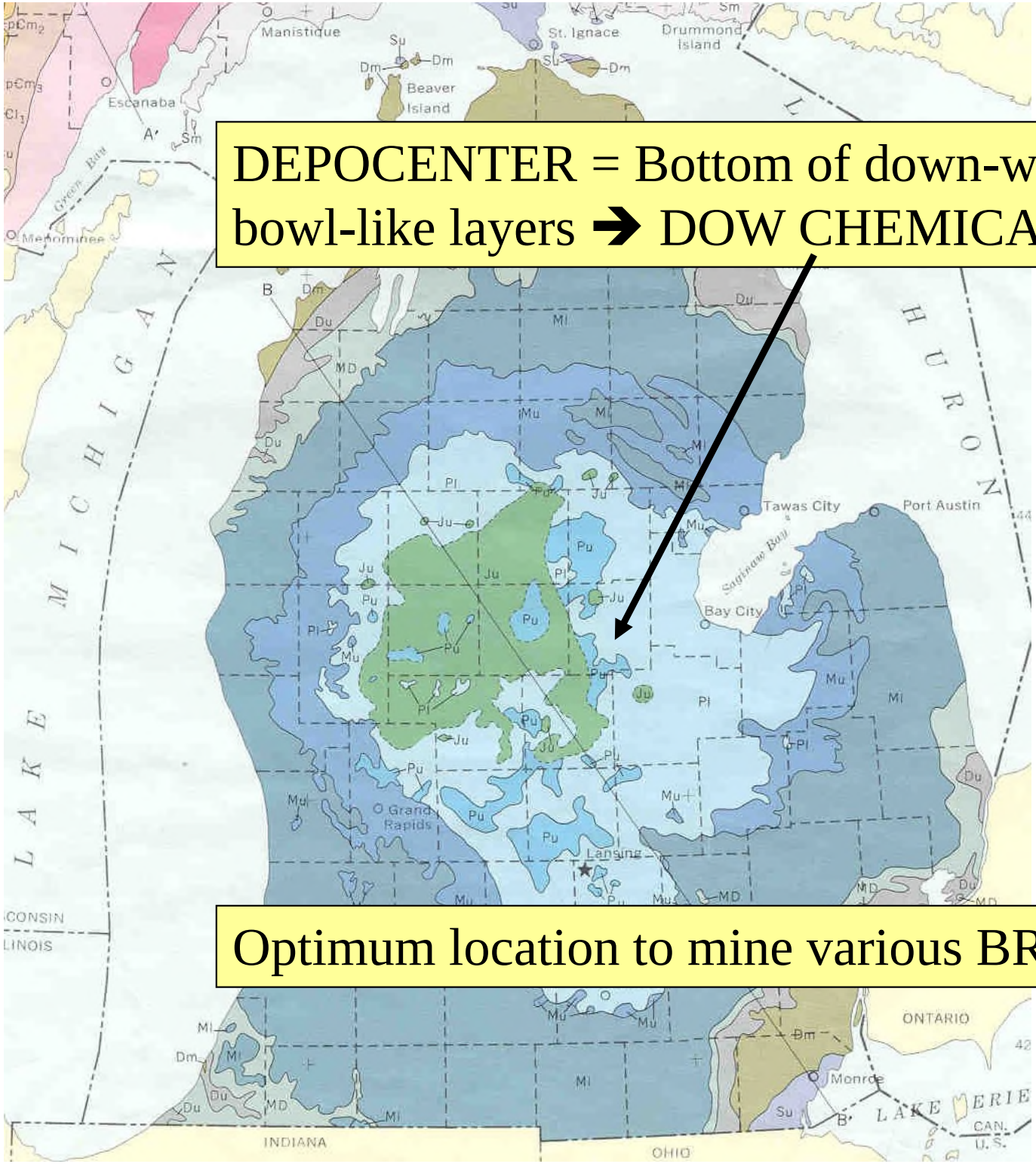
Frz Exp = 0.013%
Sp Gr = 2.64
Abs = 2.04 / 2.77 %

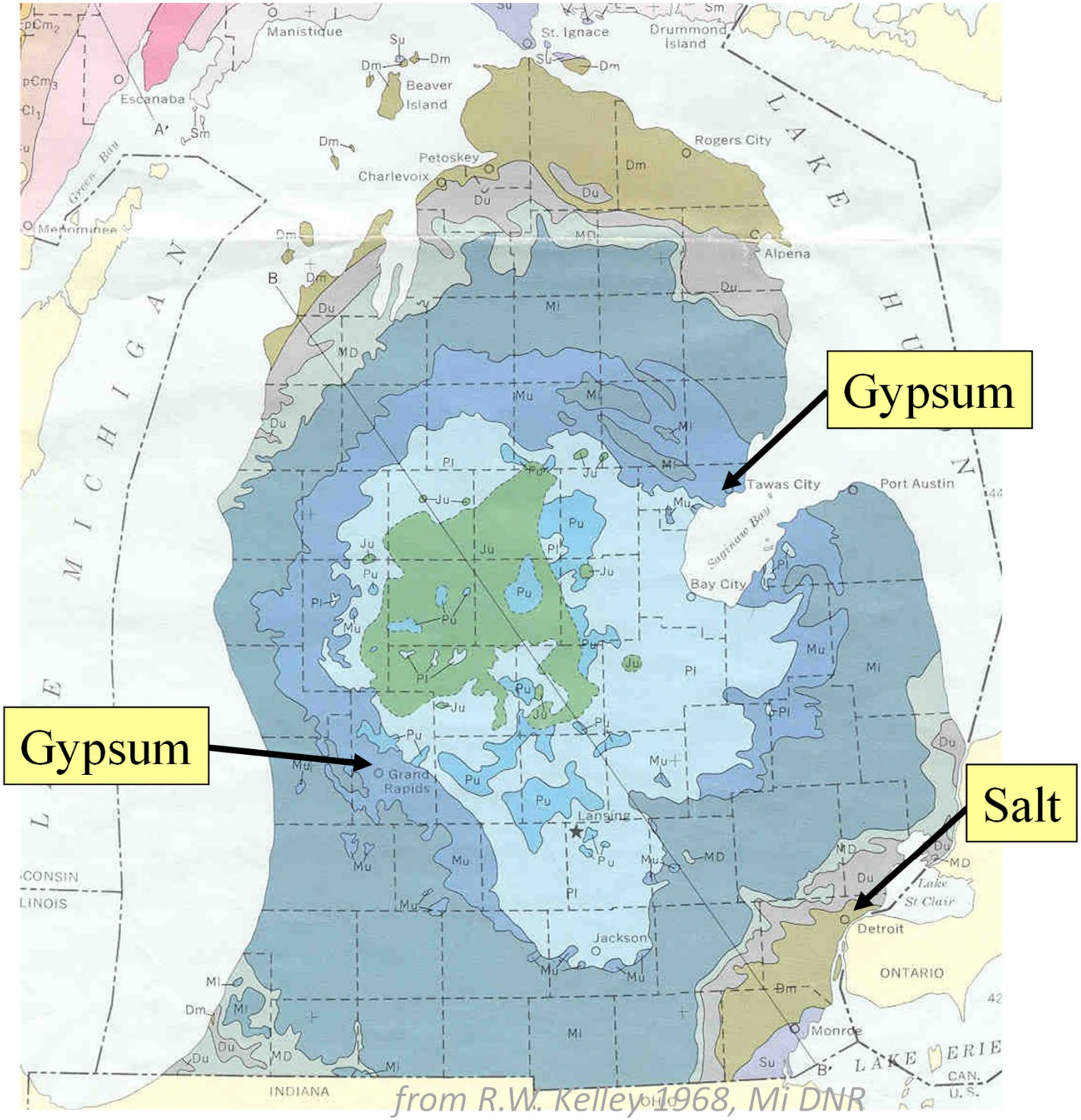
Frz Exp = 0.070%
Sp Gr = 2.55
Abs = 2.09 / 2.533 %

Frz Exp = 0.061%
Sp Gr = 2.56
Abs = **2.89** / 3.75 %



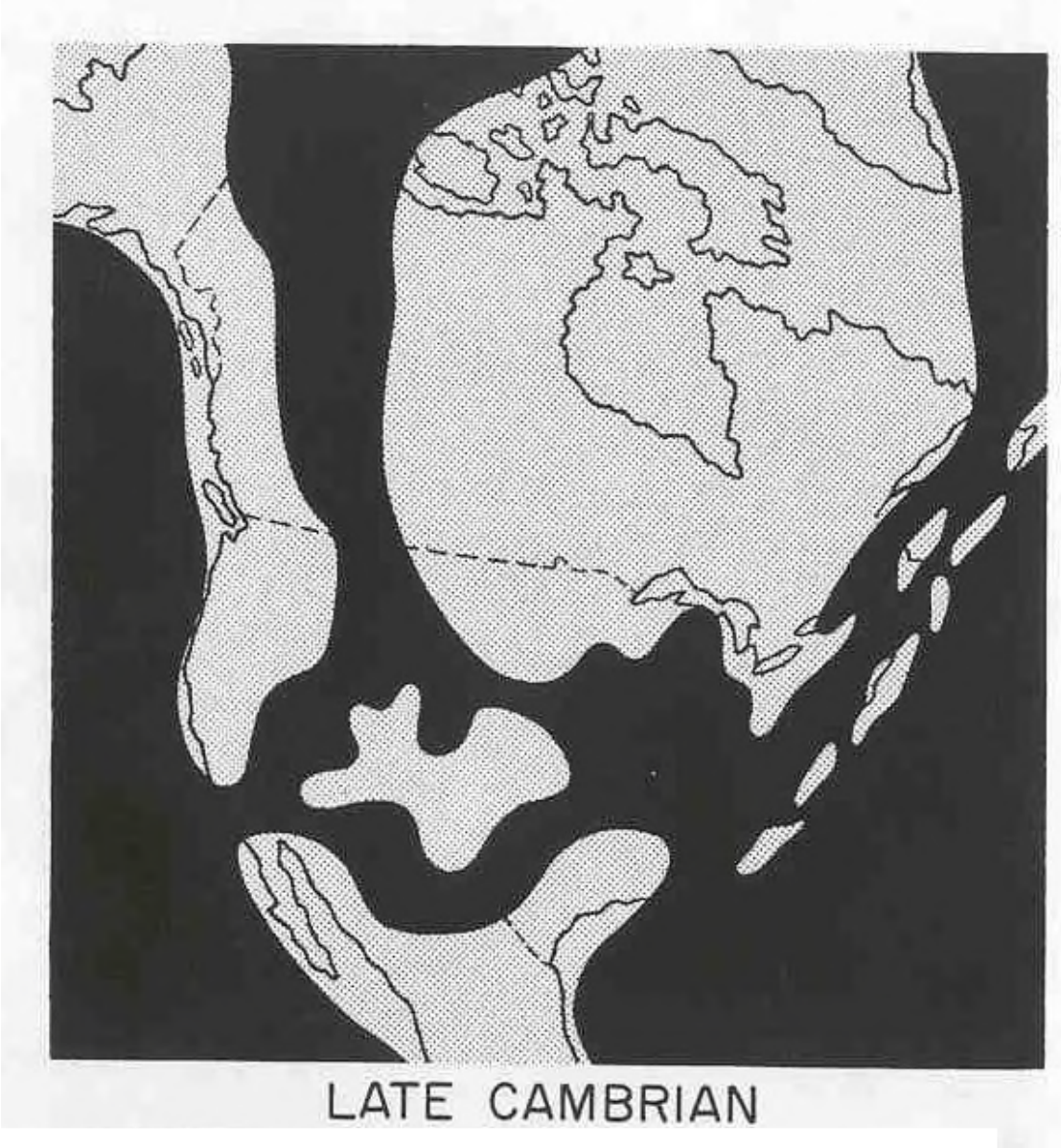
from Dorr & Eschman 1970


DEPOCENTER = Bottom of down-warped bowl-like layers ➔ DOW CHEMICAL
Optimum location to mine various BRINES
Manistique
St. Ignace
Drummond Island
Beaver Island
Escanaba
Menominee
Tawas City
Port Austin
Bay City
Grand Rapids
Lansing
Monroe
ONTARIO
LAKE ERIE
CAN.
U.S.
INDIANA
OHIO
MICHIGAN
HURON



from R.W. Kelley 1968, Mi DNR

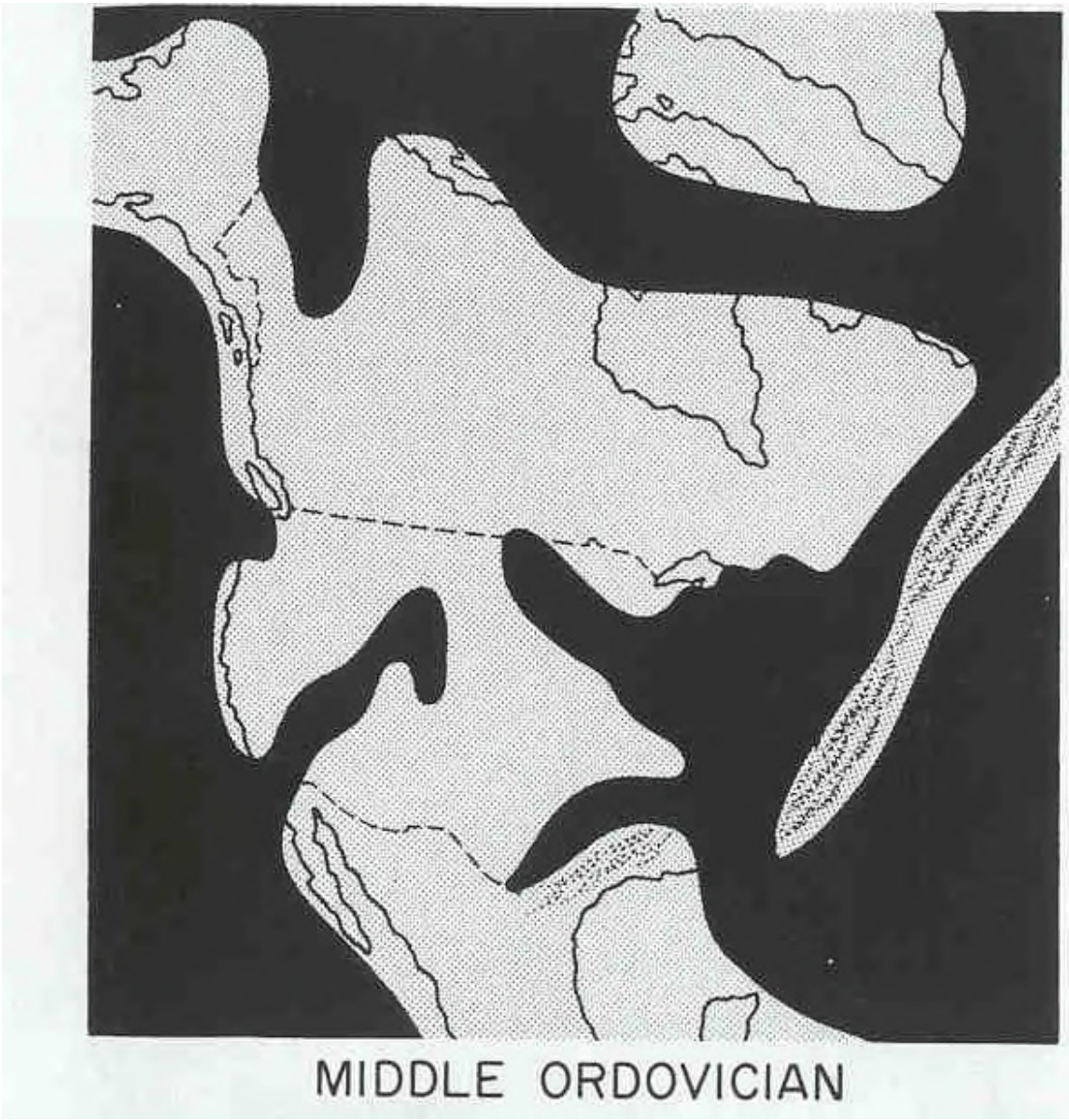
from Dorr & Eschman 1970



Primarily sandstones and conglomerates, sedimentary deposits from rivers flowing from the eroded Penokian “hills”.

500± Million Years Ago

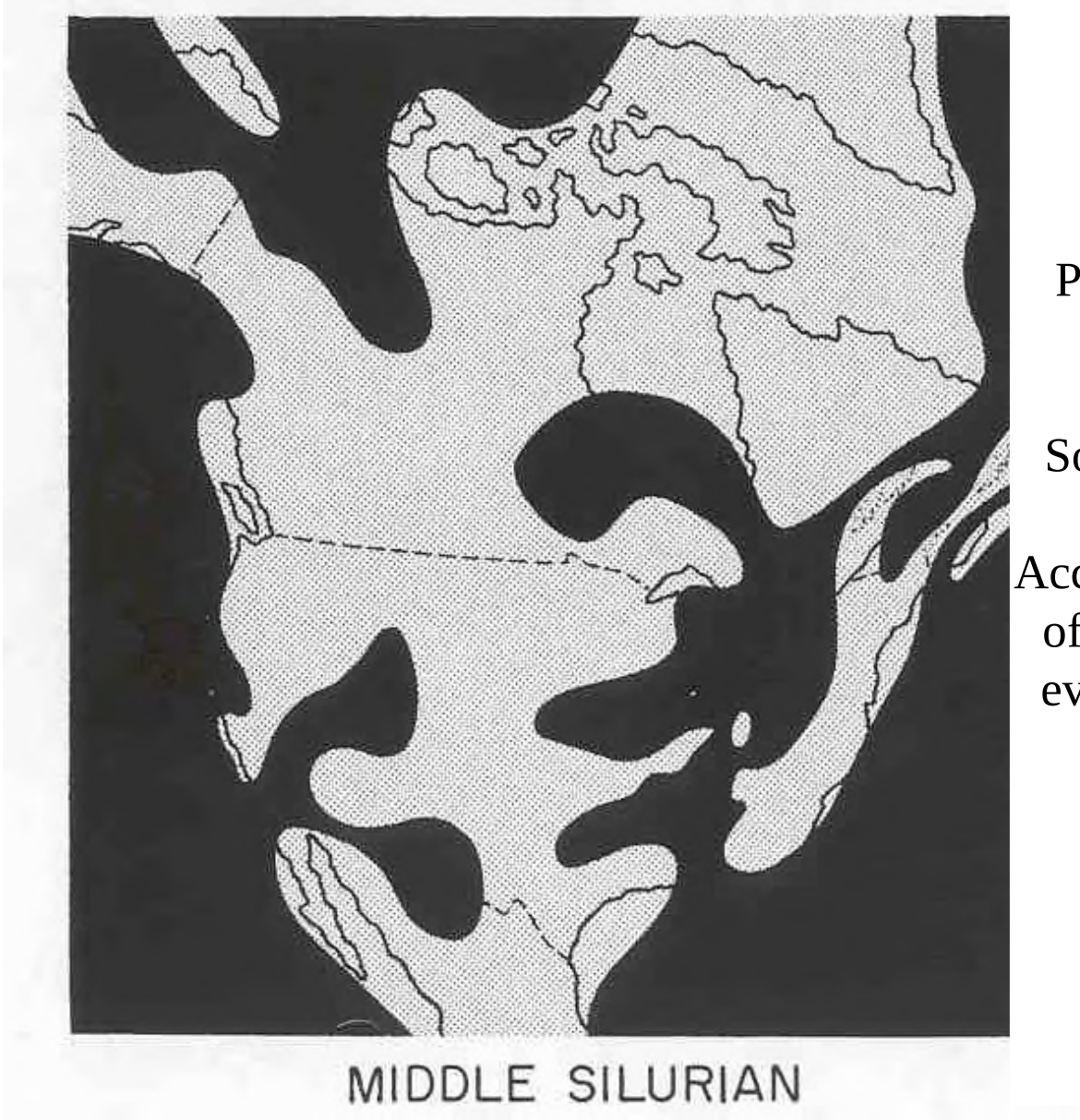
from Dorr & Eschman 1970



Primarily marine deposits of sand/silt stones and shales.

425± Million Years Ago

from Dorr & Eschman 1970

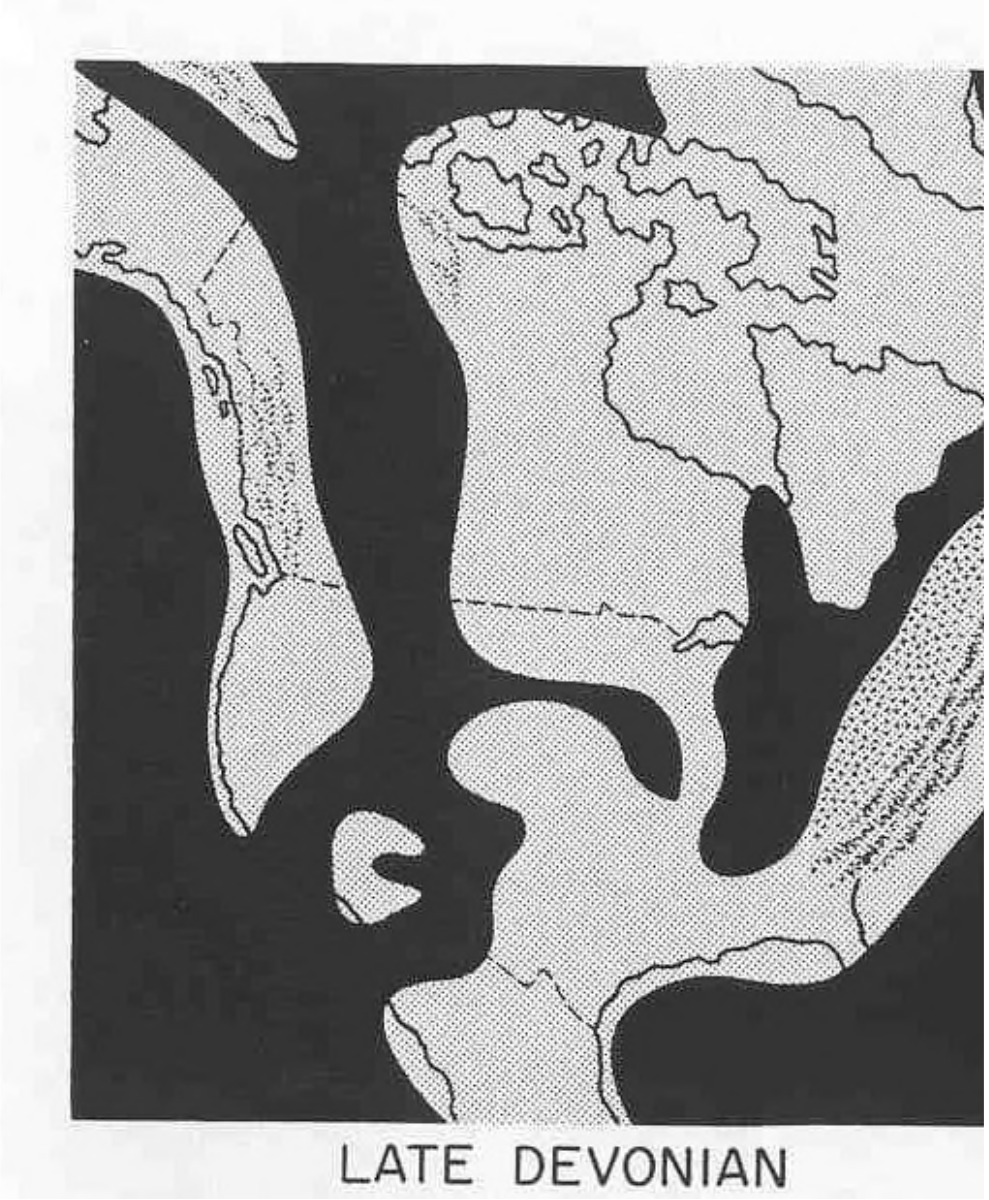


400± Million Years Ago

Primarily fine grained dolomite and lime-Stones, reefs, and Some halite, anhydrite.

Accelerated downwarping of the basin and strong evaporation-evaporites.

from Dorr & Eschman 1970



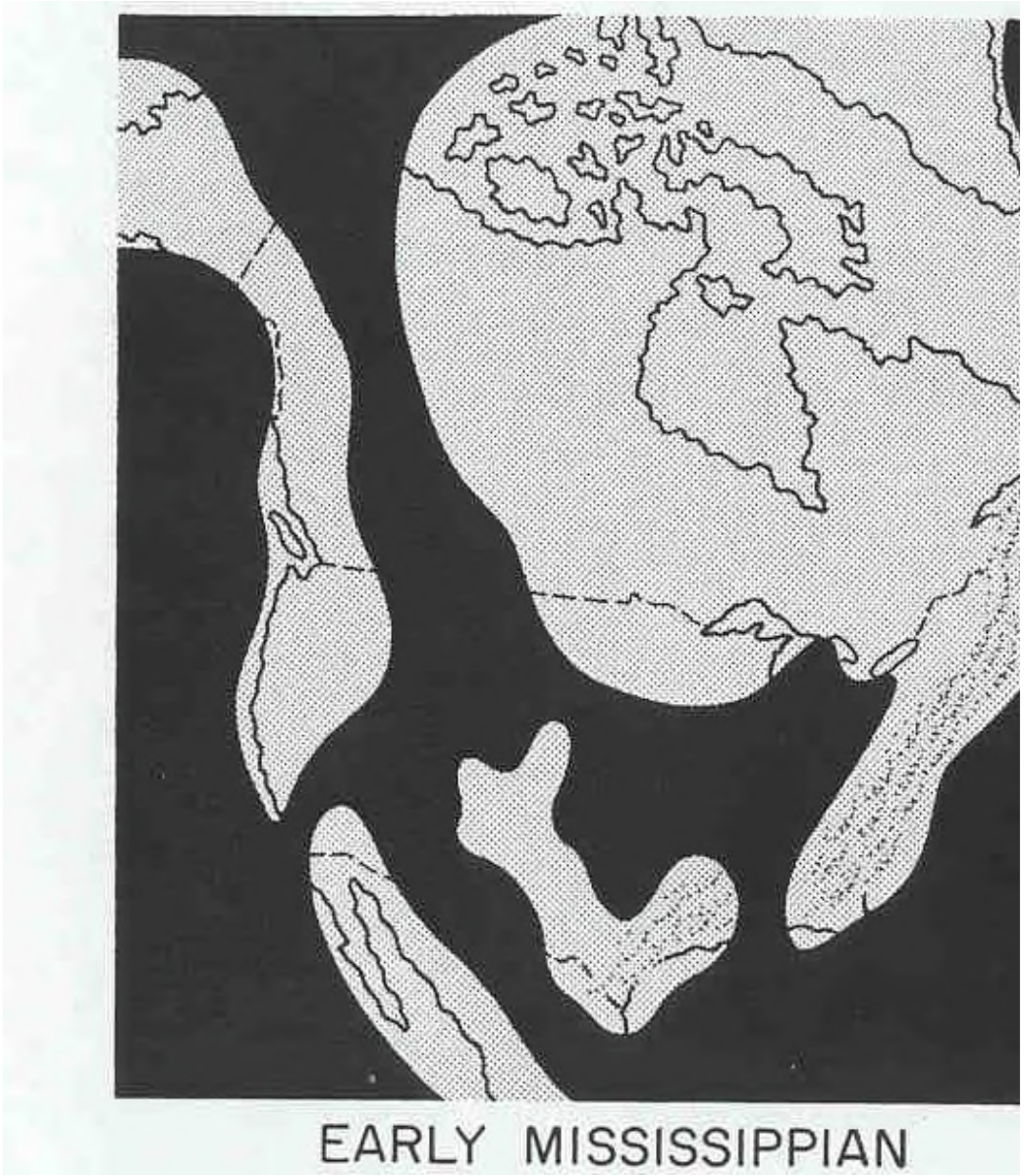
Primarily fine grained dolomite and lime-Stones, reefs, and Some halite, anhydrite.

Mackinac Breccia.

SE was uplifted.

350± Million Years Ago

from Dorr & Eschman 1970



Primarily fine grained shales and siltstones. Some evaporites

"Dark Muds"

Antrim Shale-Appalachia

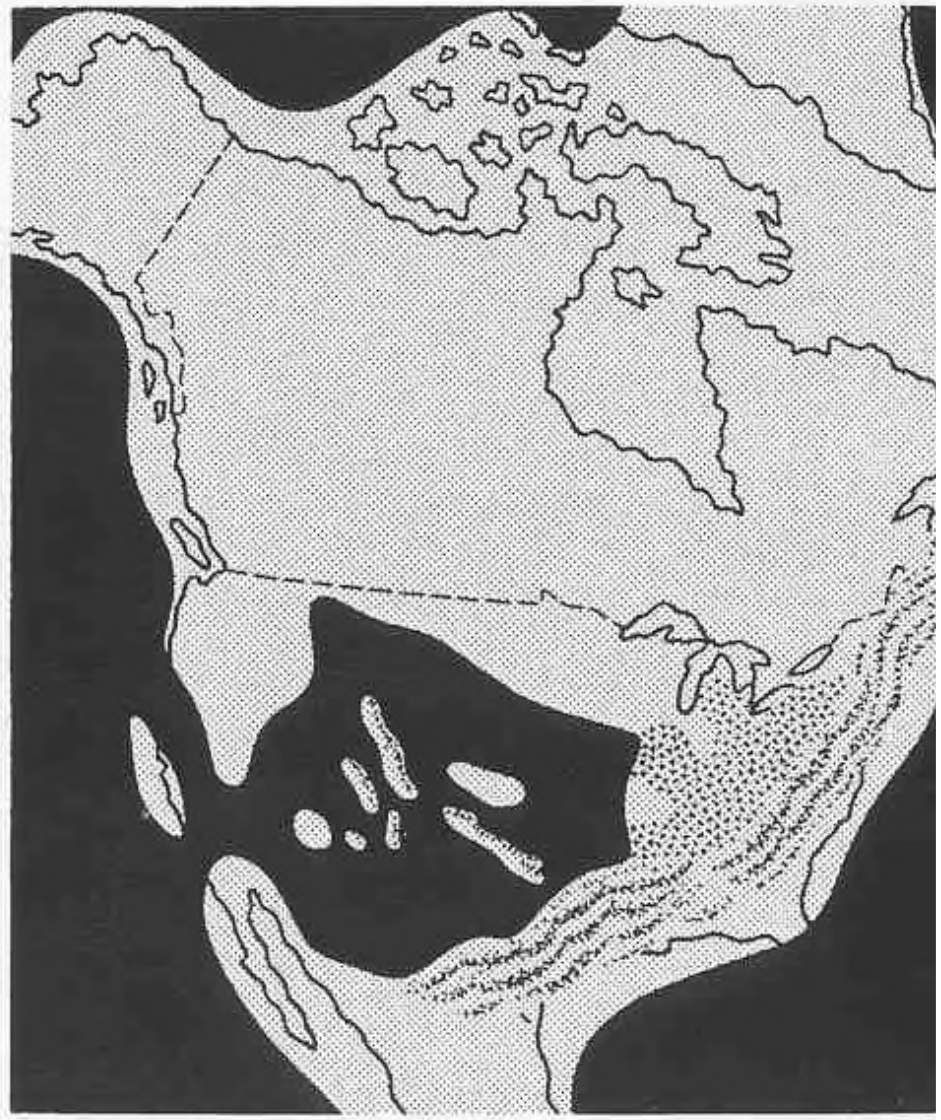
Ellsworth Shale-WI area

Coldwater shale

Grand Rapids Gypsum

325± Million Years Ago

from Dorr & Eschman 1970



Continental Sediments
COAL-marine deltas and
Swamps, fossils.

Hot climate-no growth
Rings on fossil trees,
No soil accumulation

Heavily vegetated
tidal swamps.

280± Million Years Ago

from Dorr & Eschman 1970

About 420 million years

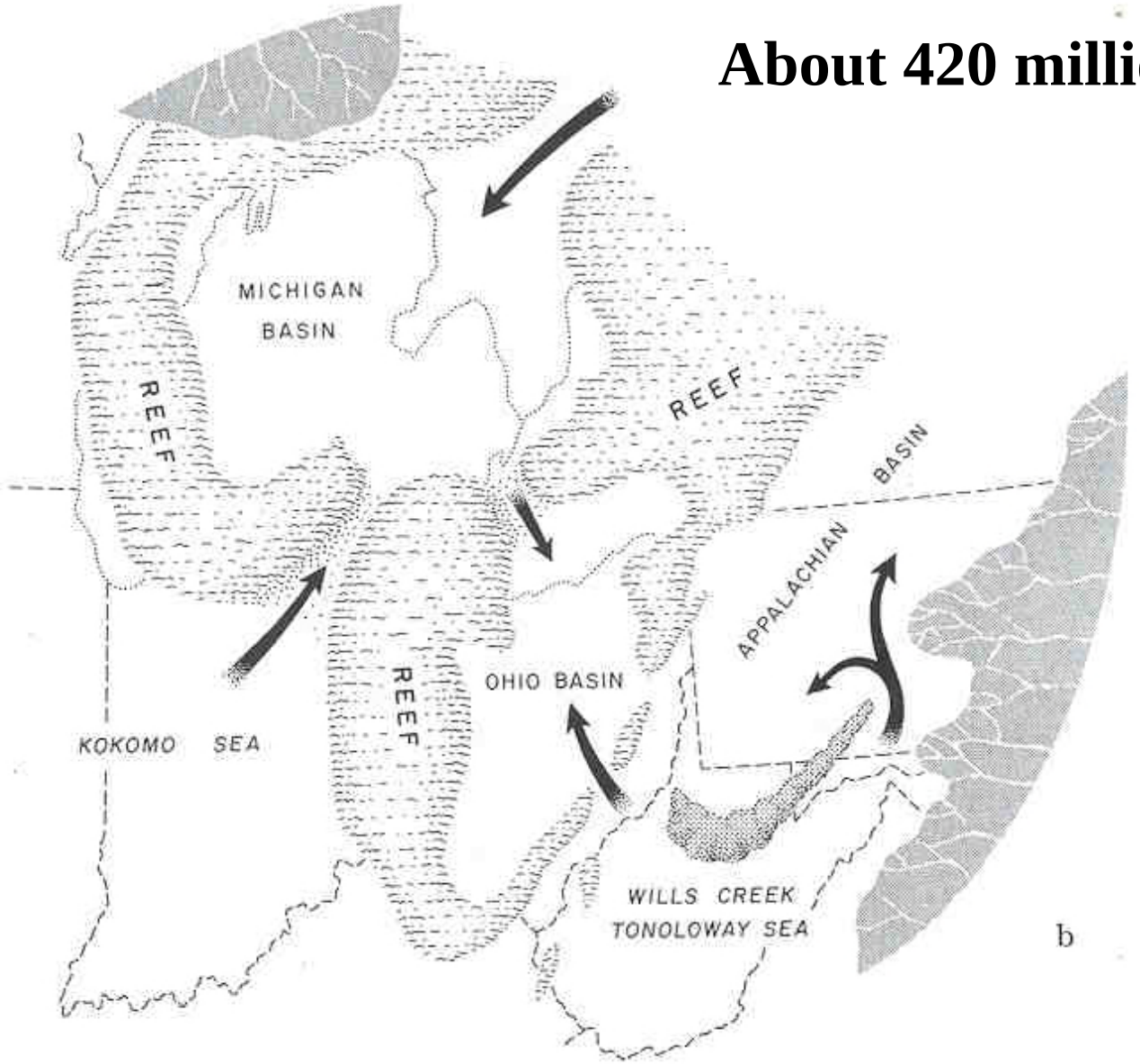
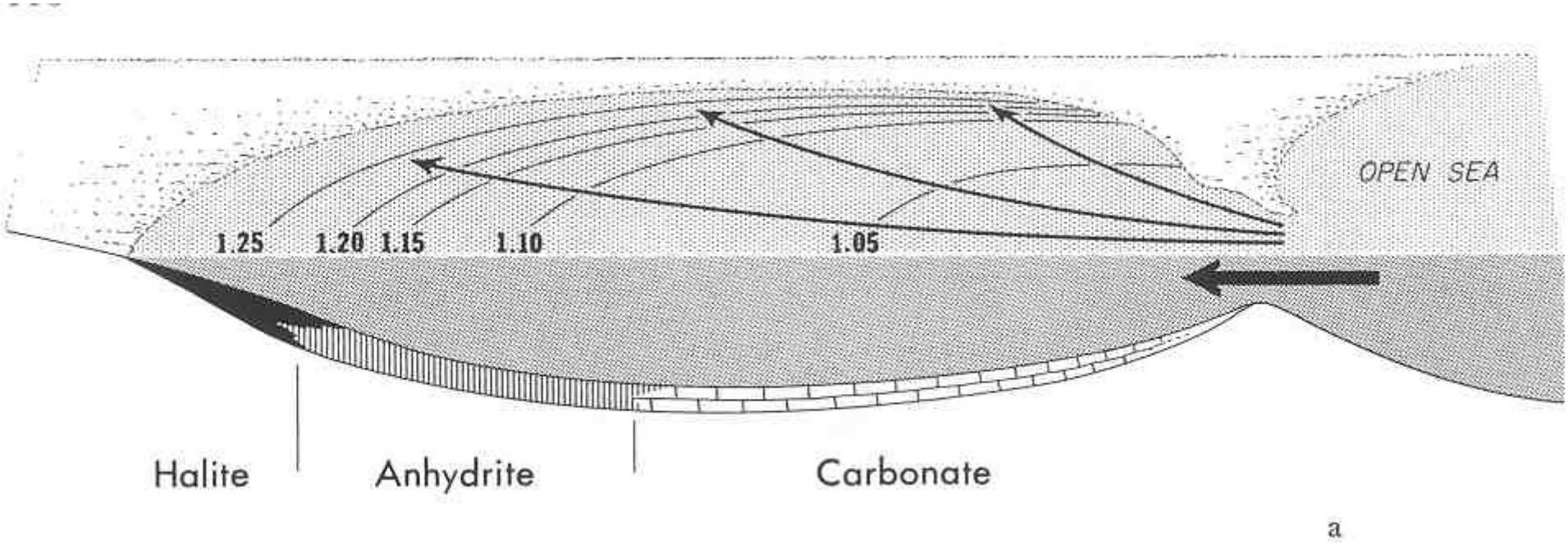


Figure v–18. Deposition of evaporite sediments.

from Dorr & Eschman 1970

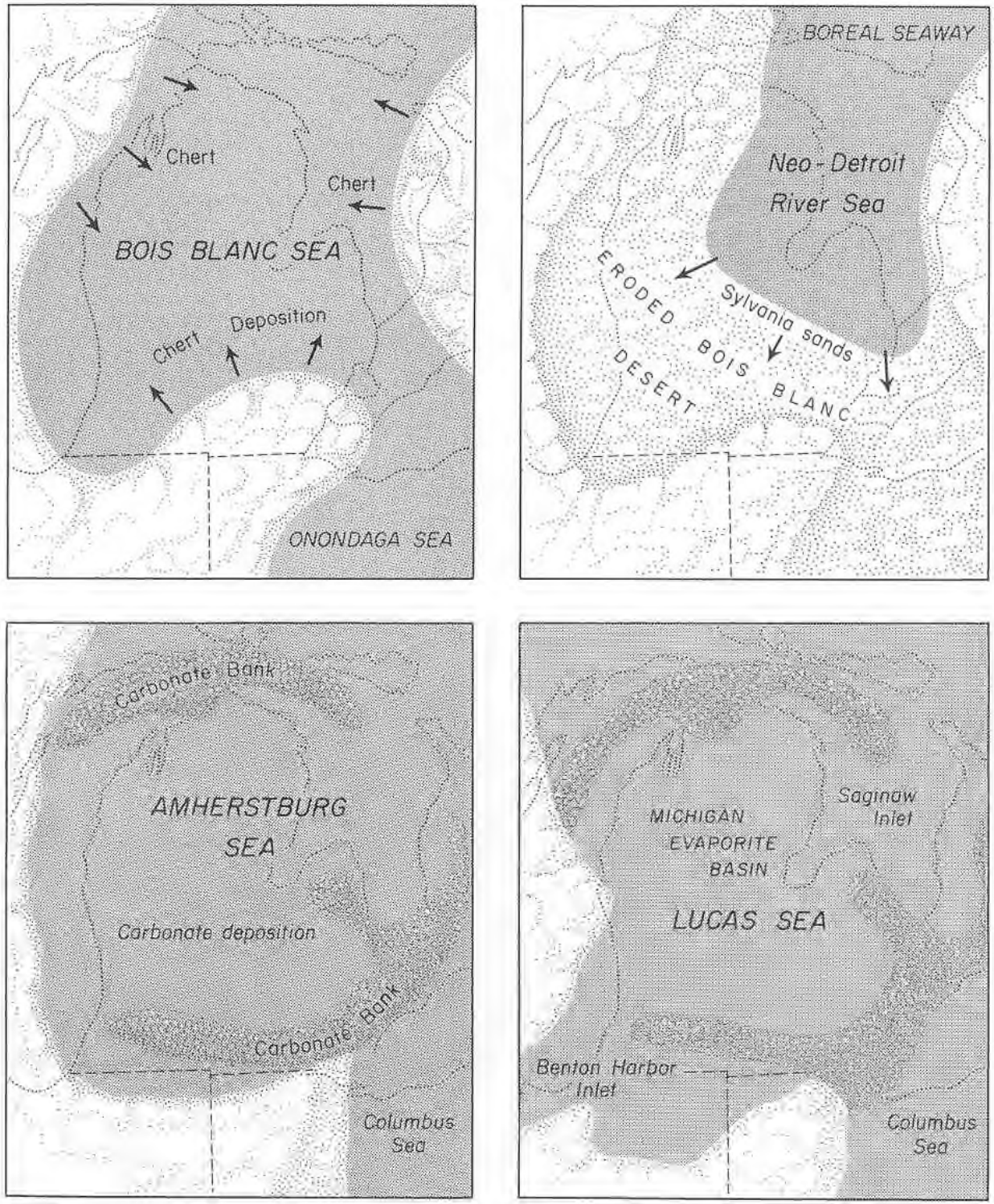


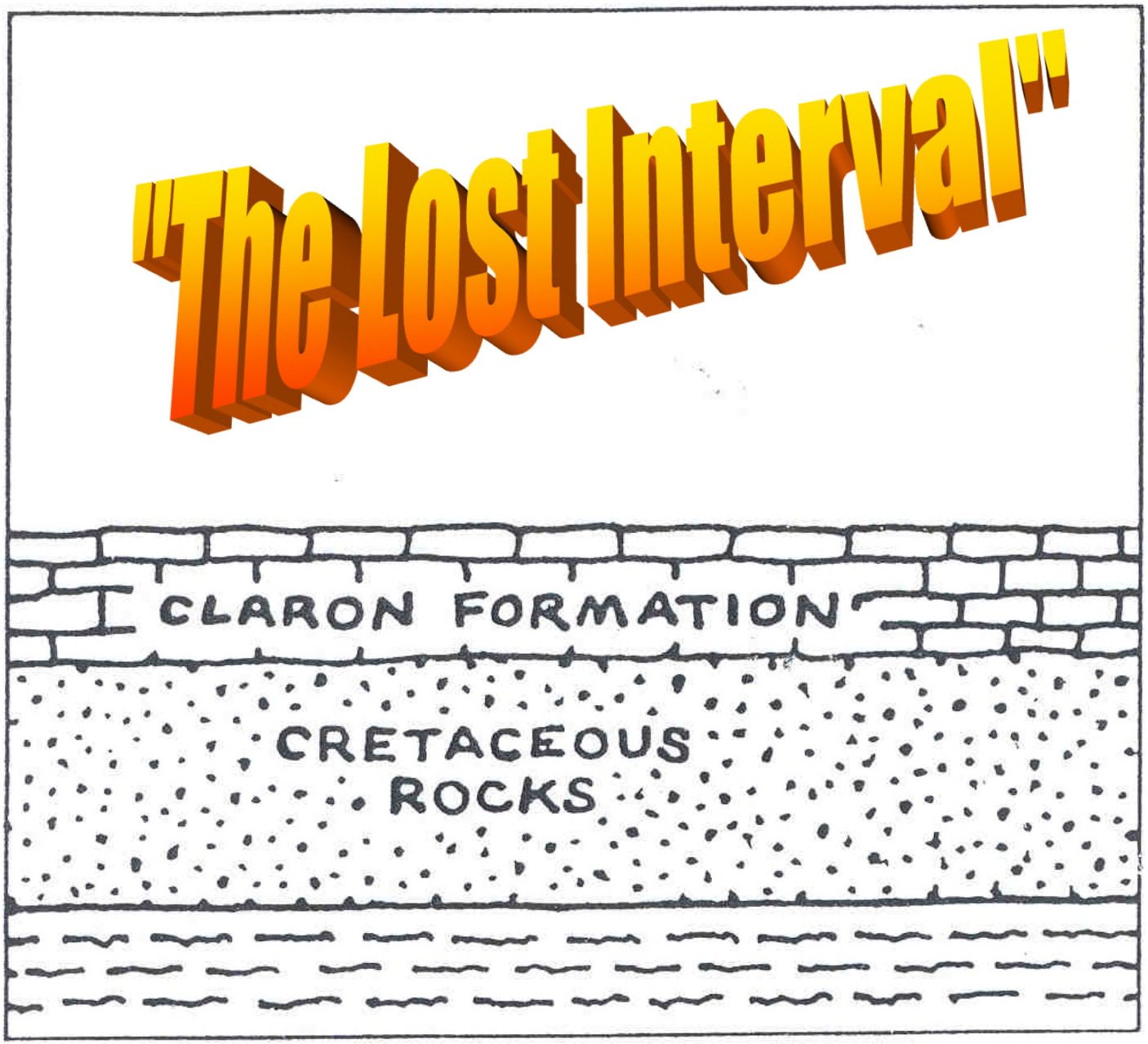
Formation of Evaporites

from Dorr & Eschman 1970

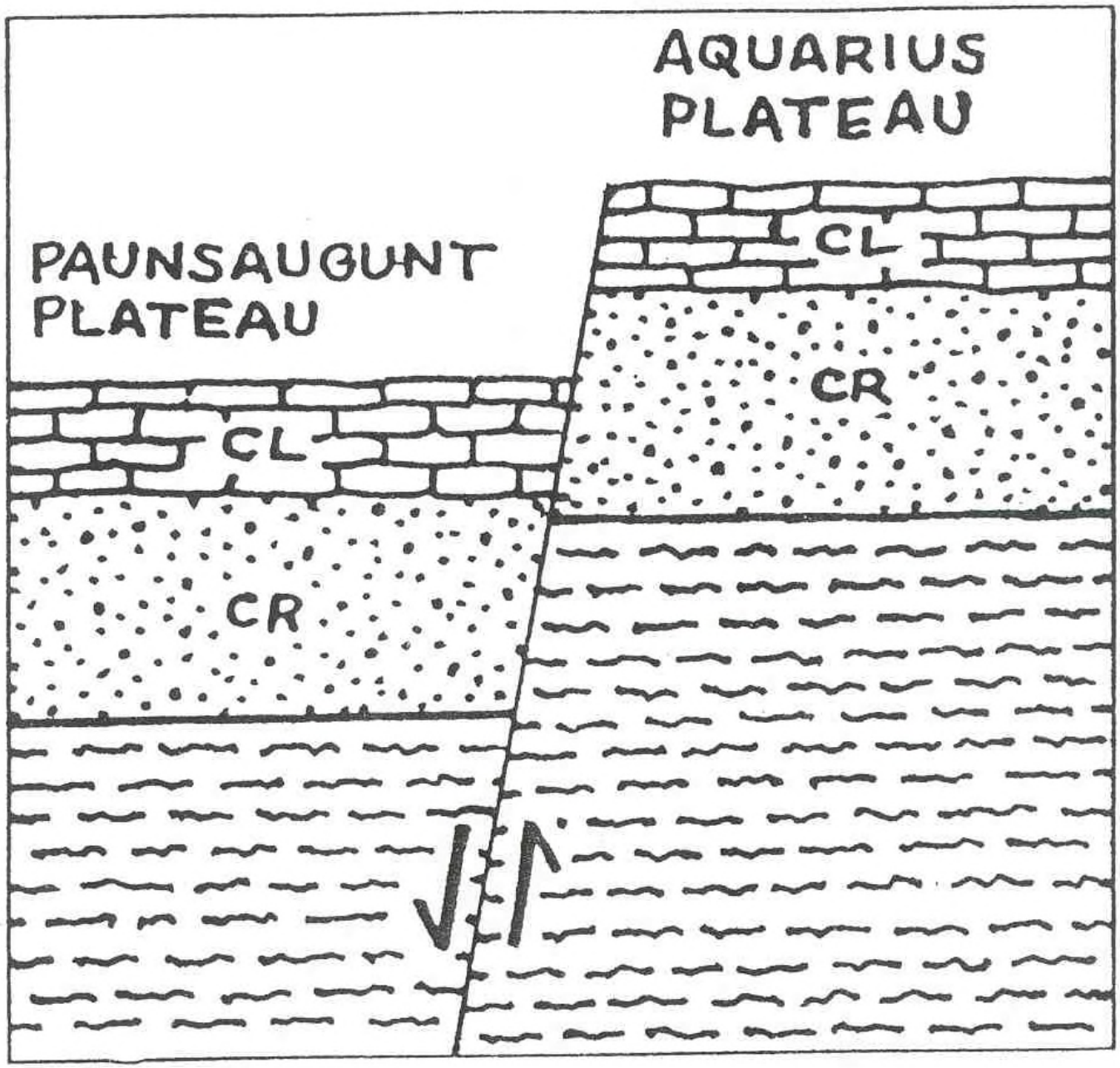
Evaporites and Carbonates 330 million years ago:

Later covered by black mud flowing in from the Appalachians (Antrim Shale)

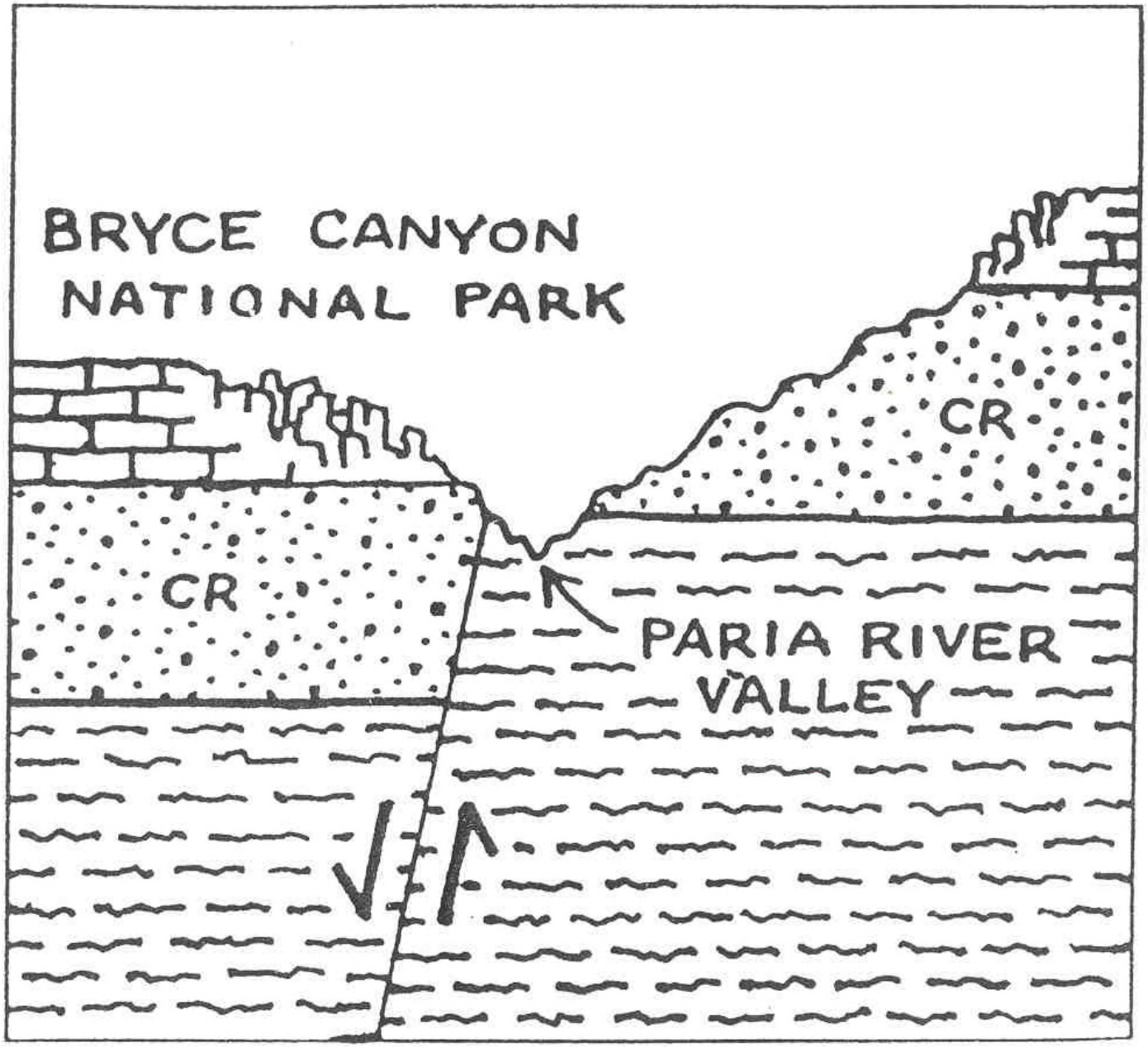




DEPOSITION
(60 Million Years Ago)

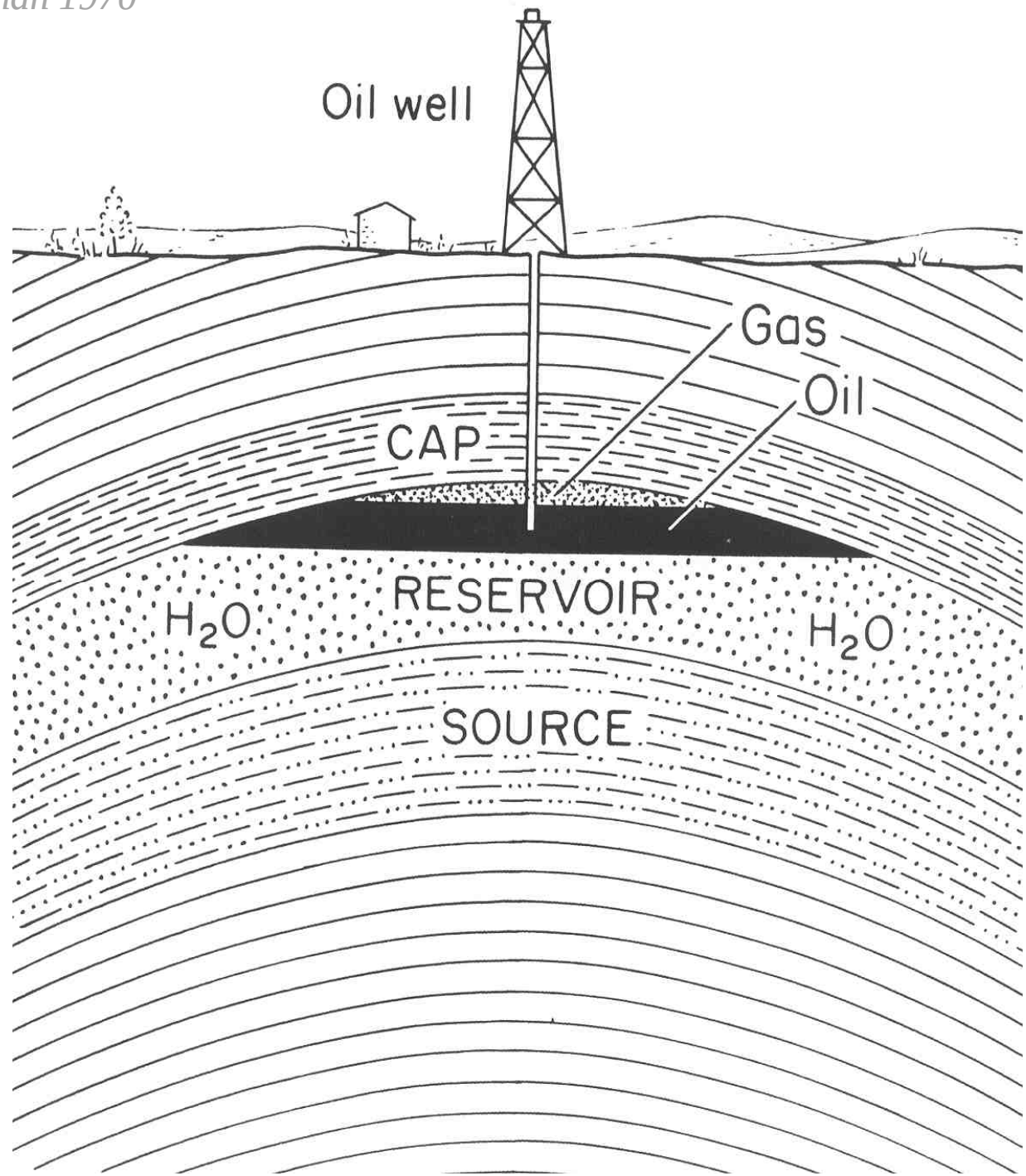


UPLIFT
(10 Million Years Ago)

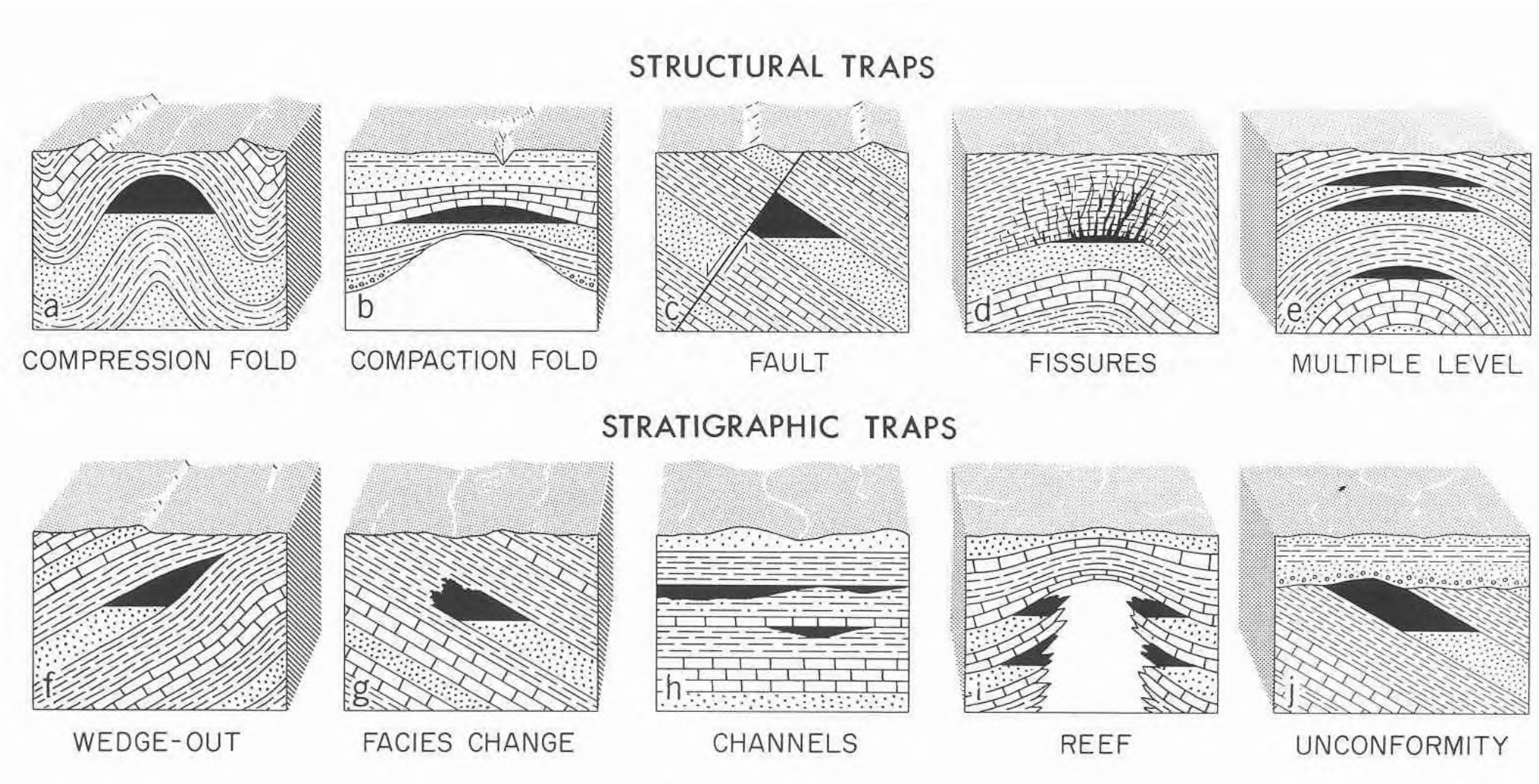


EROSION
(Today)

from Dorr & Eschman 1970



from Dorr & Eschman 1970

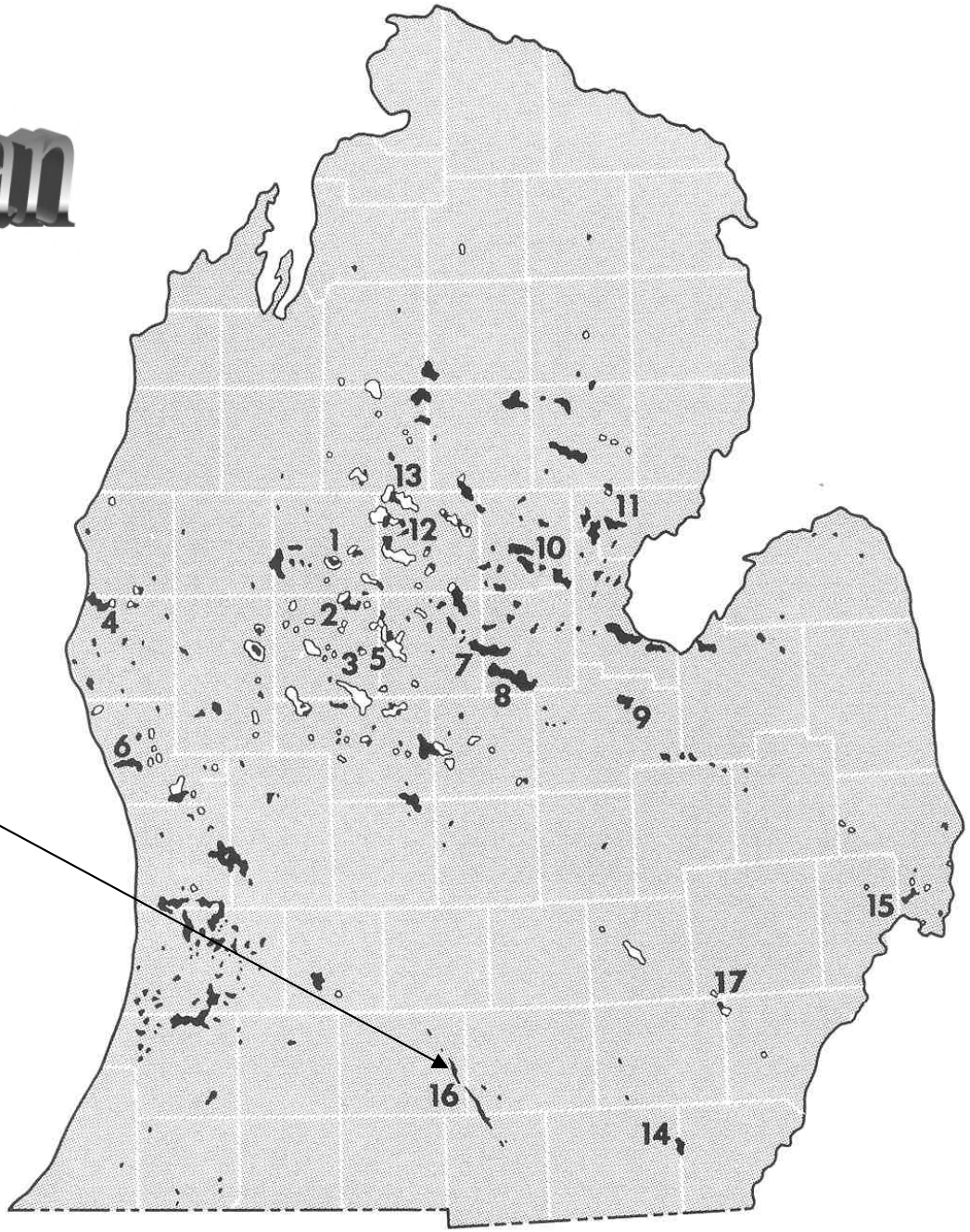


from Dorr & Eschman 1970

Oil in Michigan

Big Hit

Albion-Scipio Trend:
a “fissure” feature



THE SHALE BOOM

The technology for pulling natural gas from deep shale, refined in the 1990s in Texas, has since spread to other "plays"—parts of a shale basin where large quantities of gas have been found. More than a third of U.S. gas now comes from shale.

Richest shale deposits

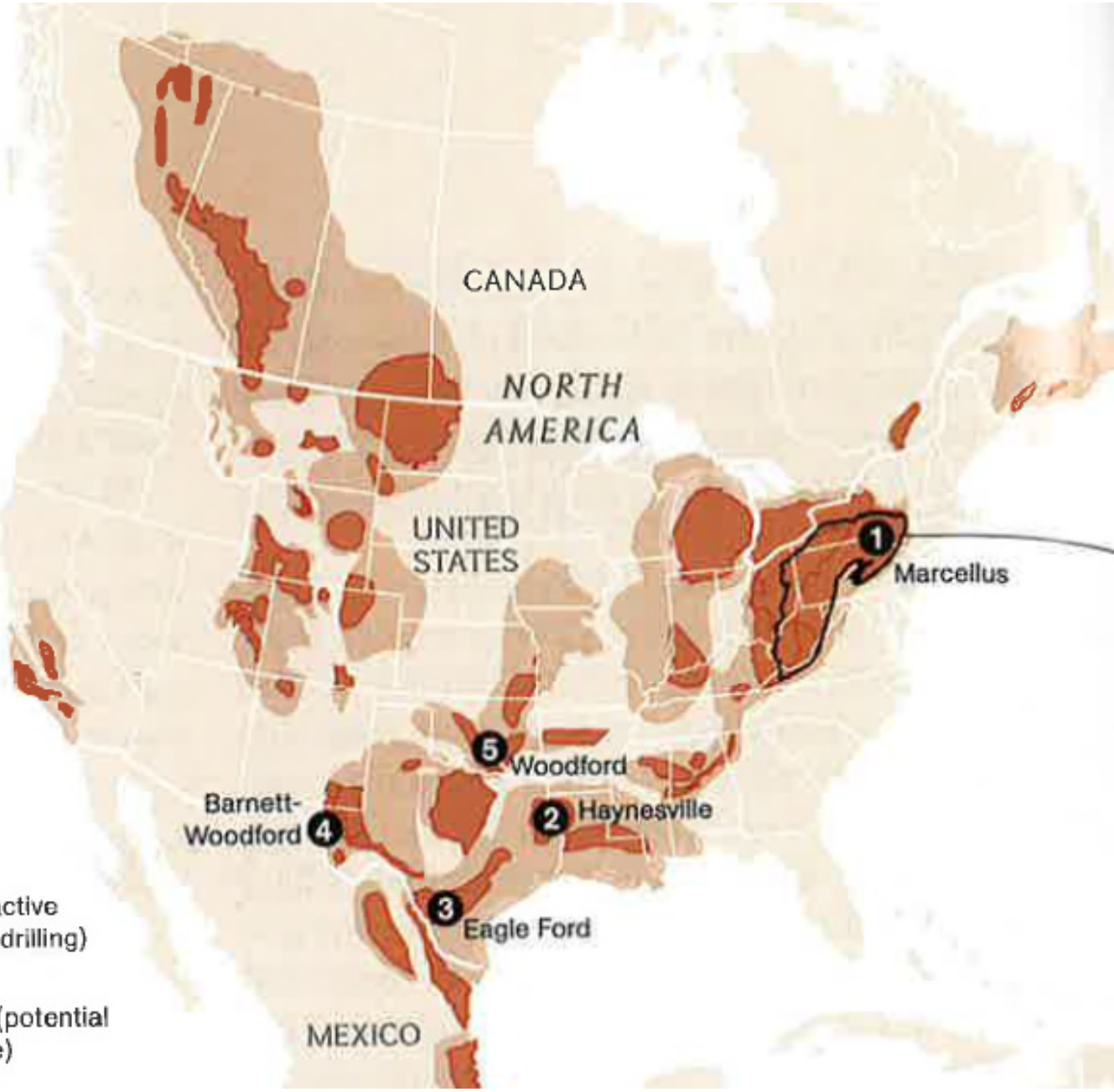
Recoverable gas, in trillion cubic feet (tcf)

Total for continental U.S. **542***

1. Marcellus	**141**
2. Haynesville	**66**
3. Eagle Ford	**50**
4. Barnett-Woodford	**27**
5. Woodford	**24**

Shale play (active or expected drilling)

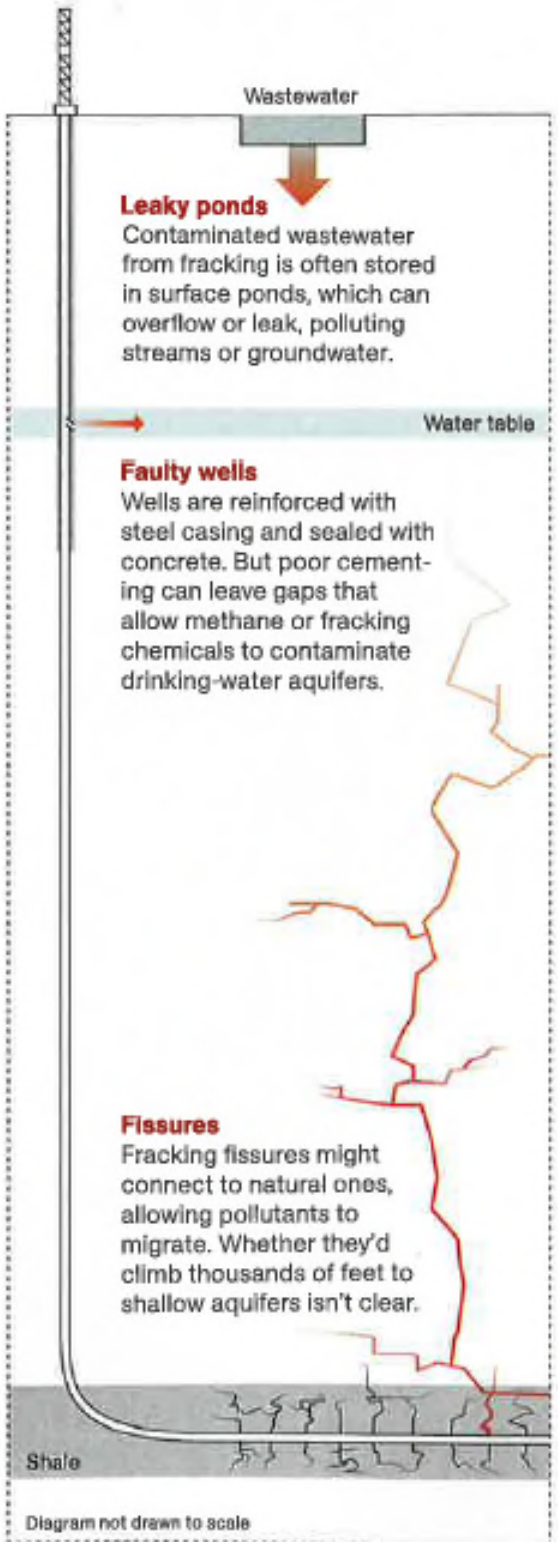
Shale basin (potential gas resource)



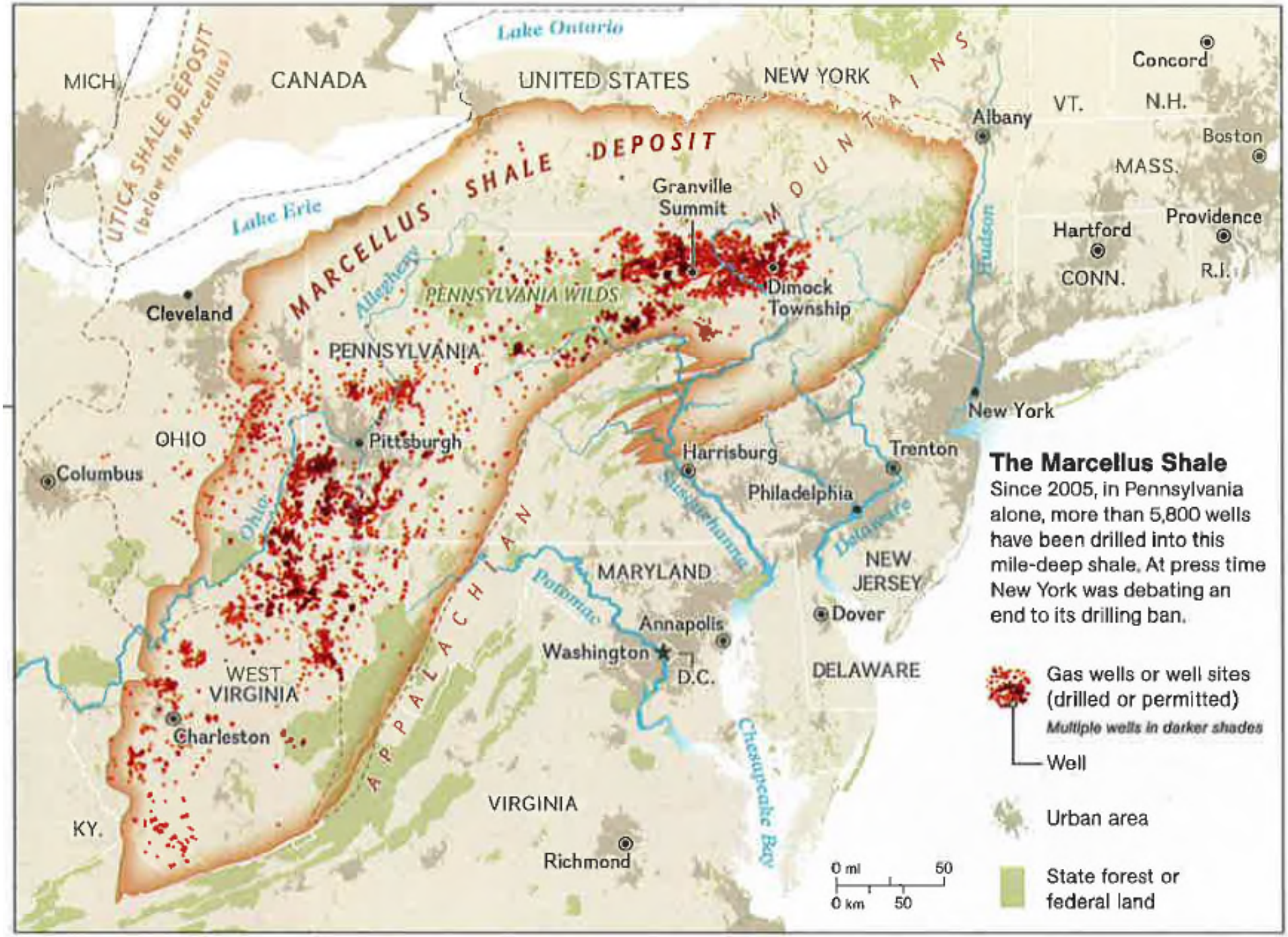
From: National Geographic Magazine

FEAR OF FRACKING

A key technique in shale drilling is hydraulic fracturing, aka fracking. A fluid mix of water, sand, and chemicals is pumped down the well at high pressure, creating fissures in the shale that let gas flow into the well. But the whole drilling process may also create pathways that allow gas or chemicals to pollute drinking water.



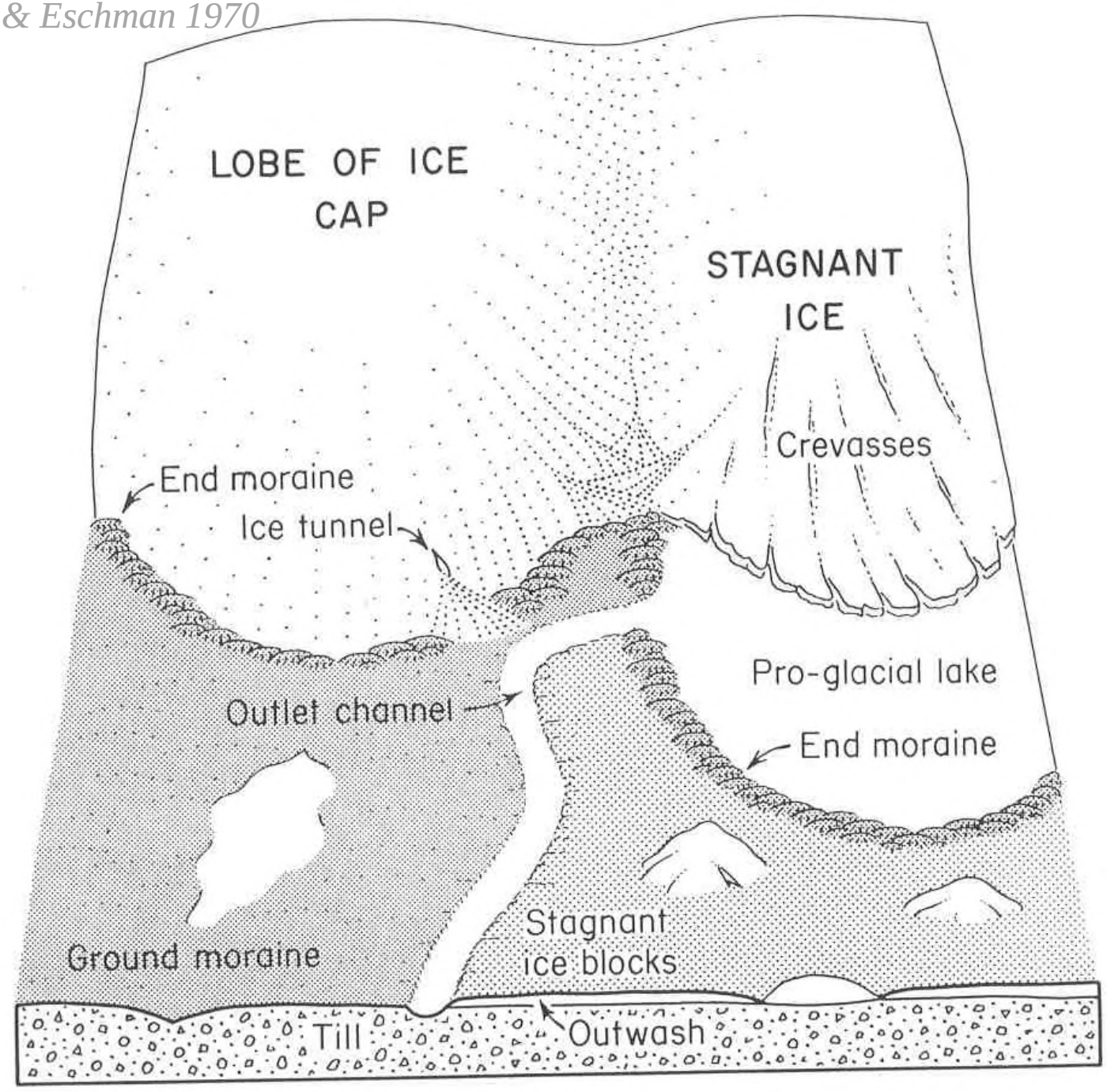
From: National Geographic Magazine



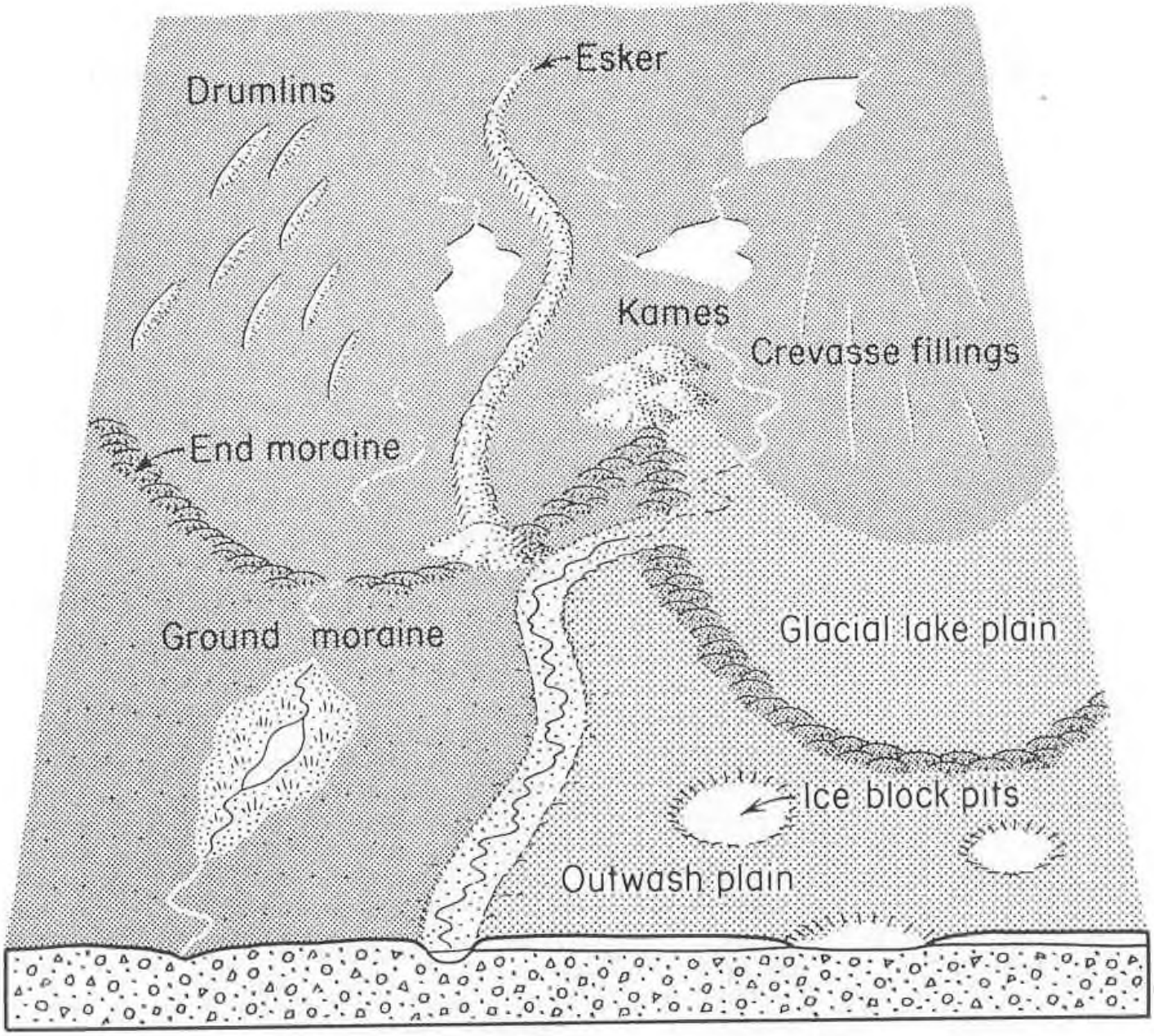
From: National Geographic Magazine

Glacial Geology

from Dorr & Eschman 1970

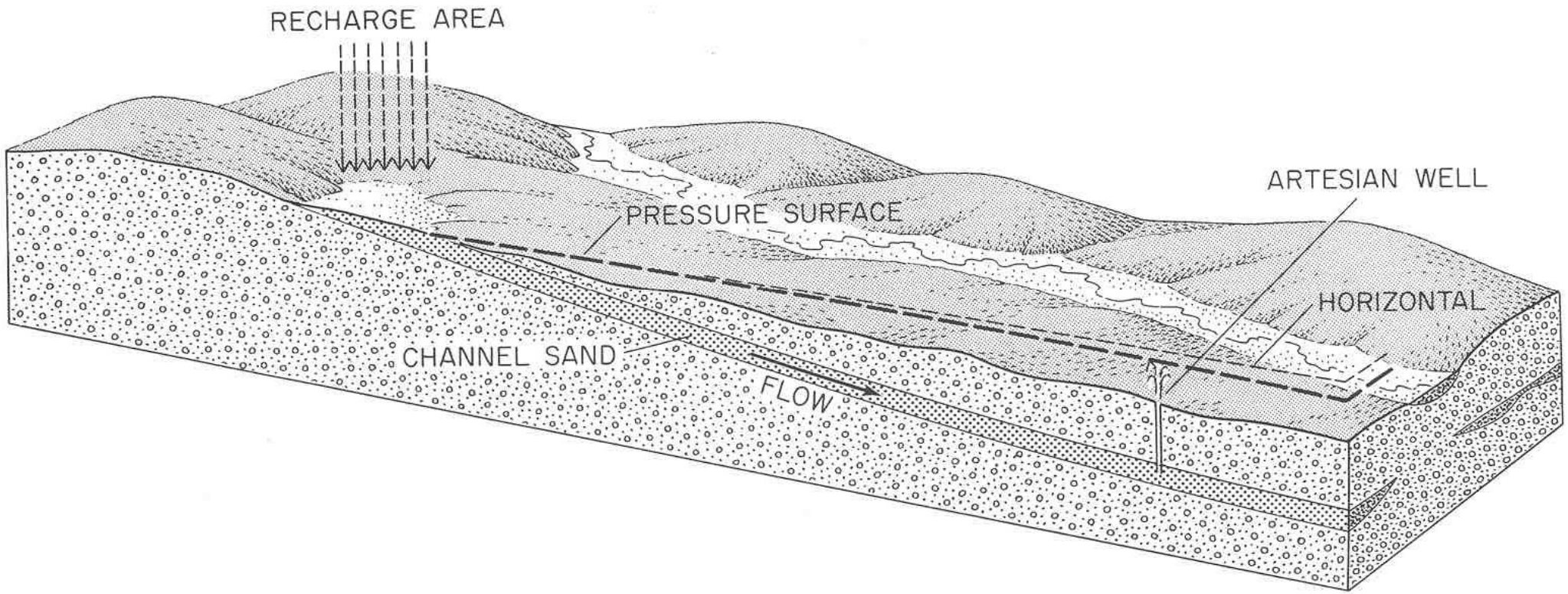


from Dorr & Eschman 1970



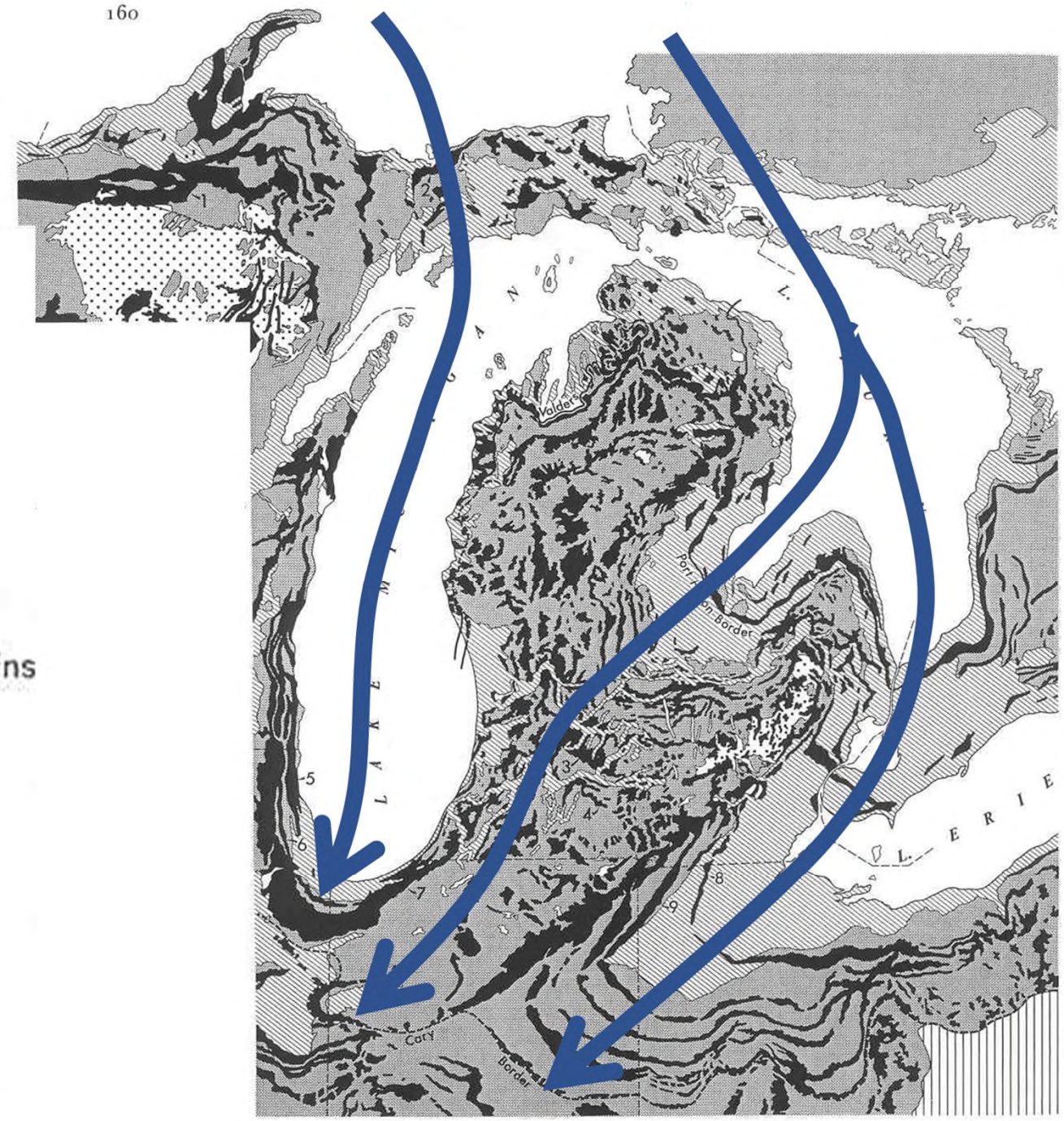
from Dorr & Eschman 1970

Formation of Artesian Conditions



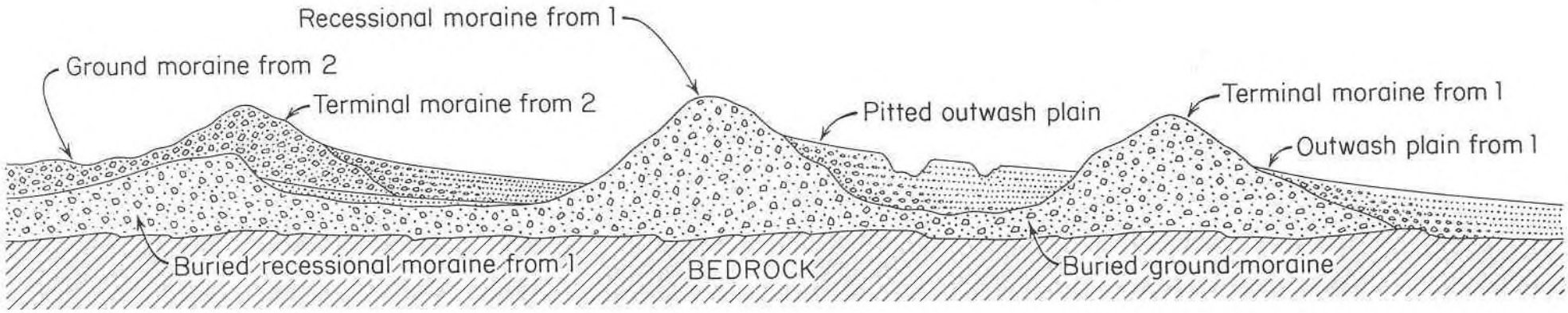
from Dorr & Eschman 1970

General Paths of Glacial Advance

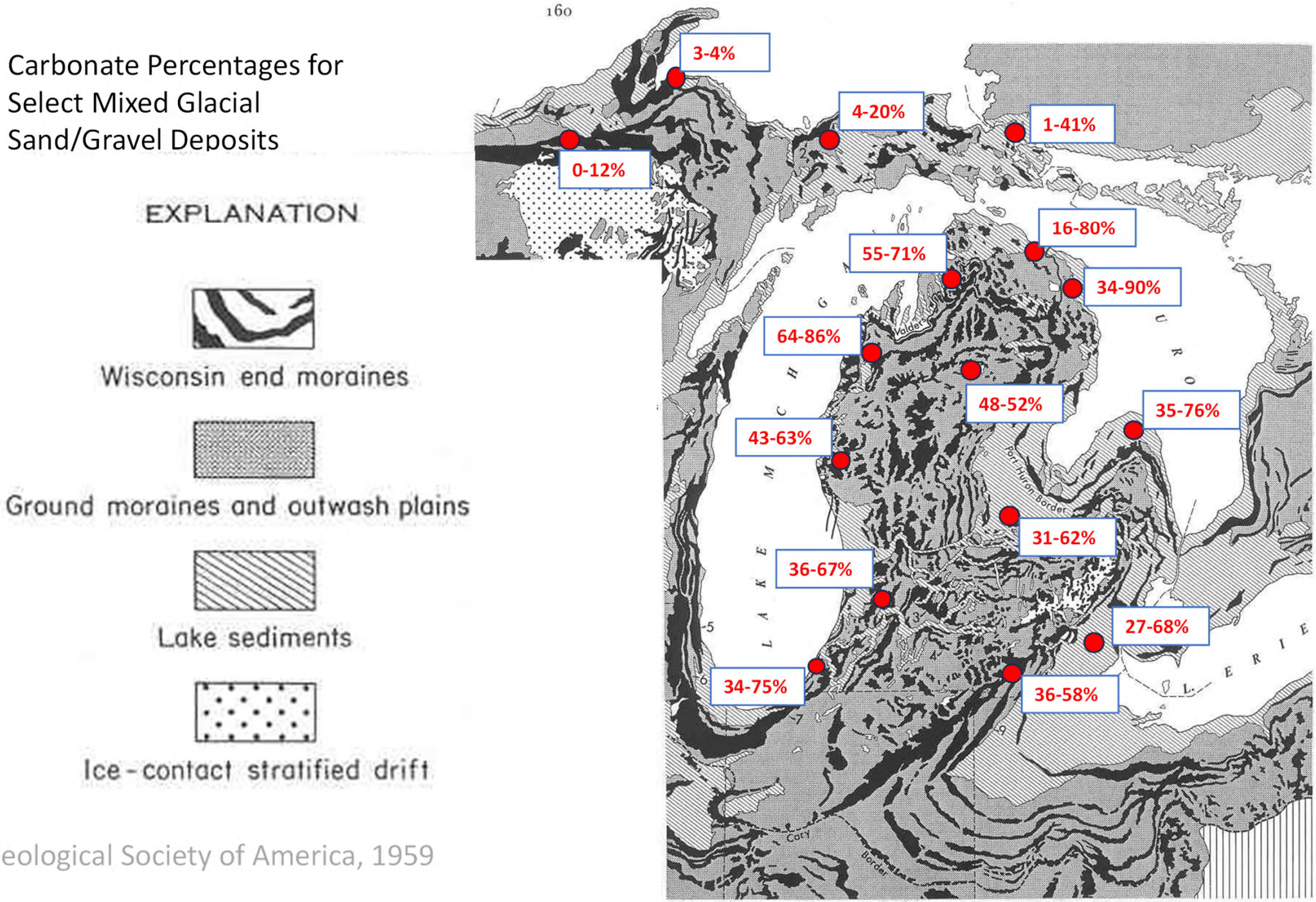


Geological Society of America, 1959

from Dorr & Eschman 1970

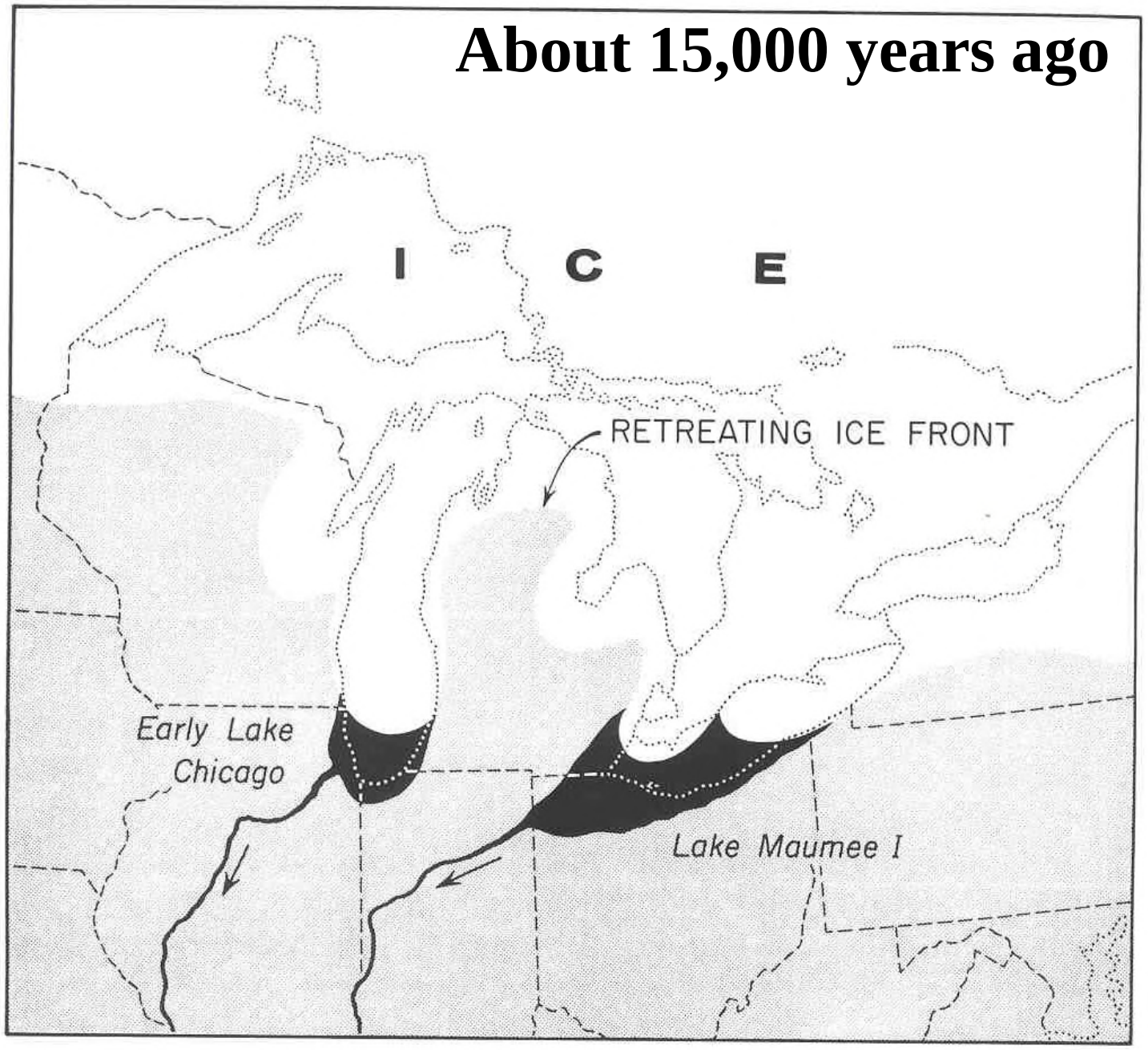


Carbonate Percentages for Select Mixed Glacial Sand/Gravel Deposits

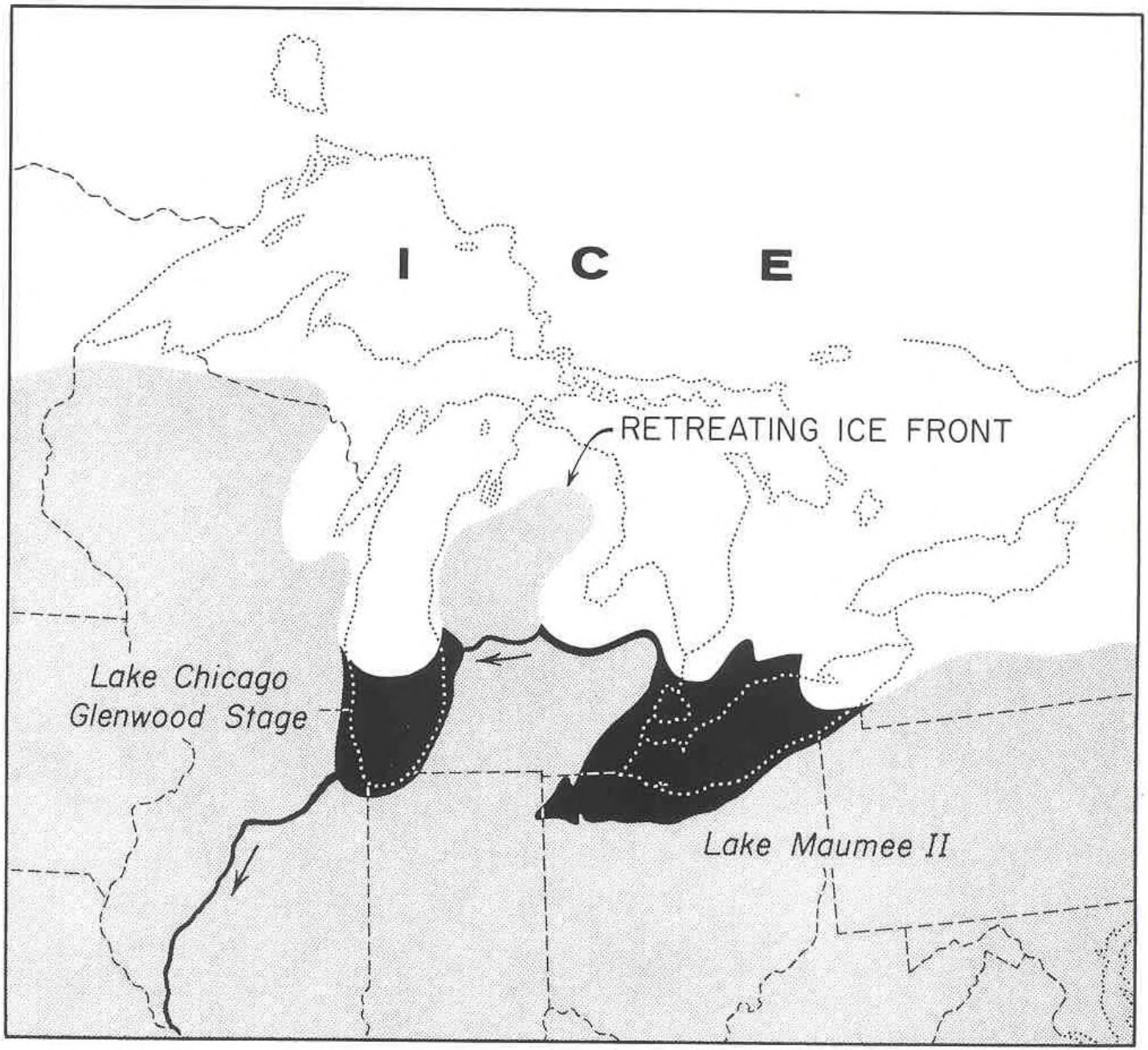


Geological Society of America, 1959

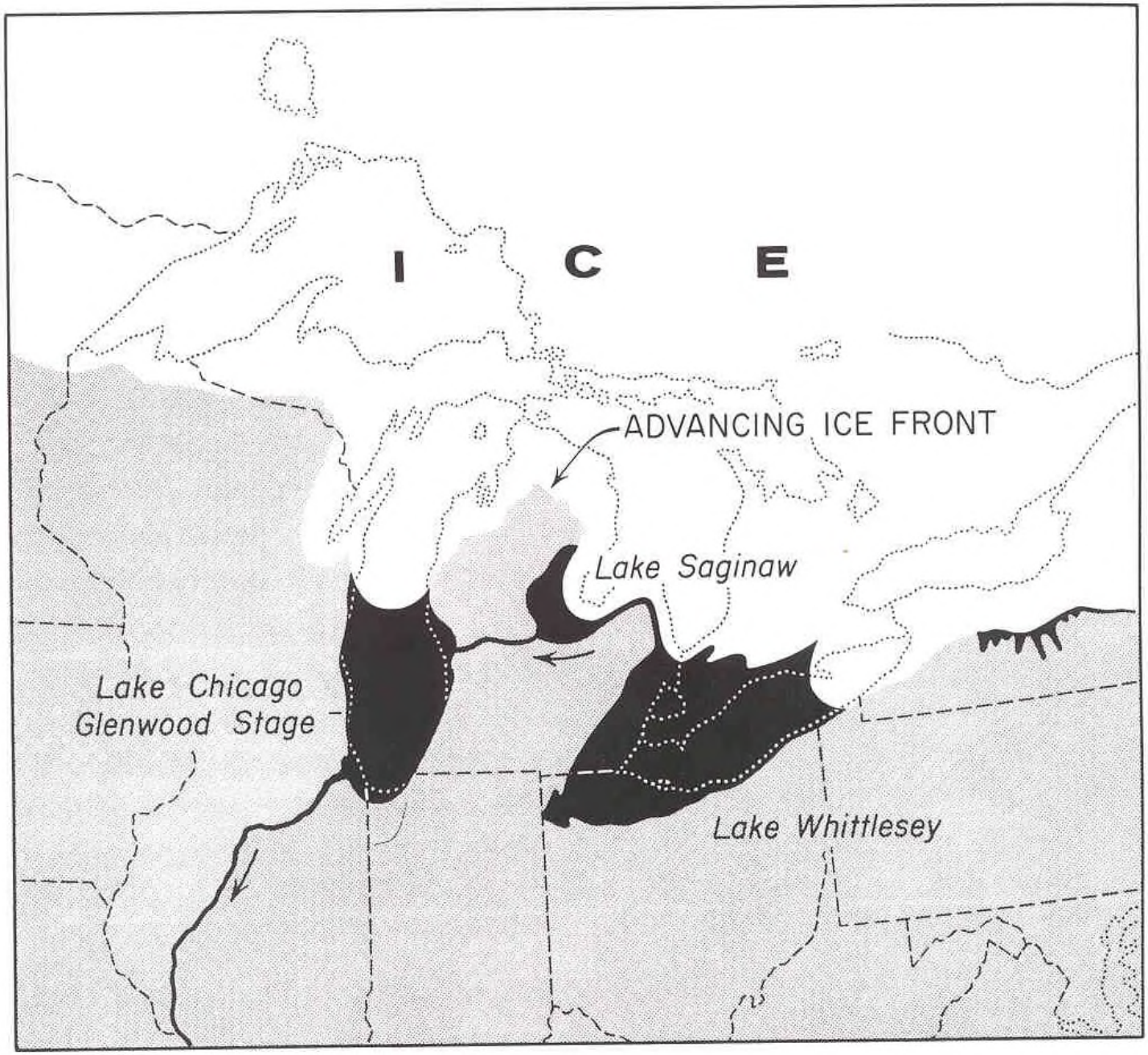
from Dorr & Eschman 1970



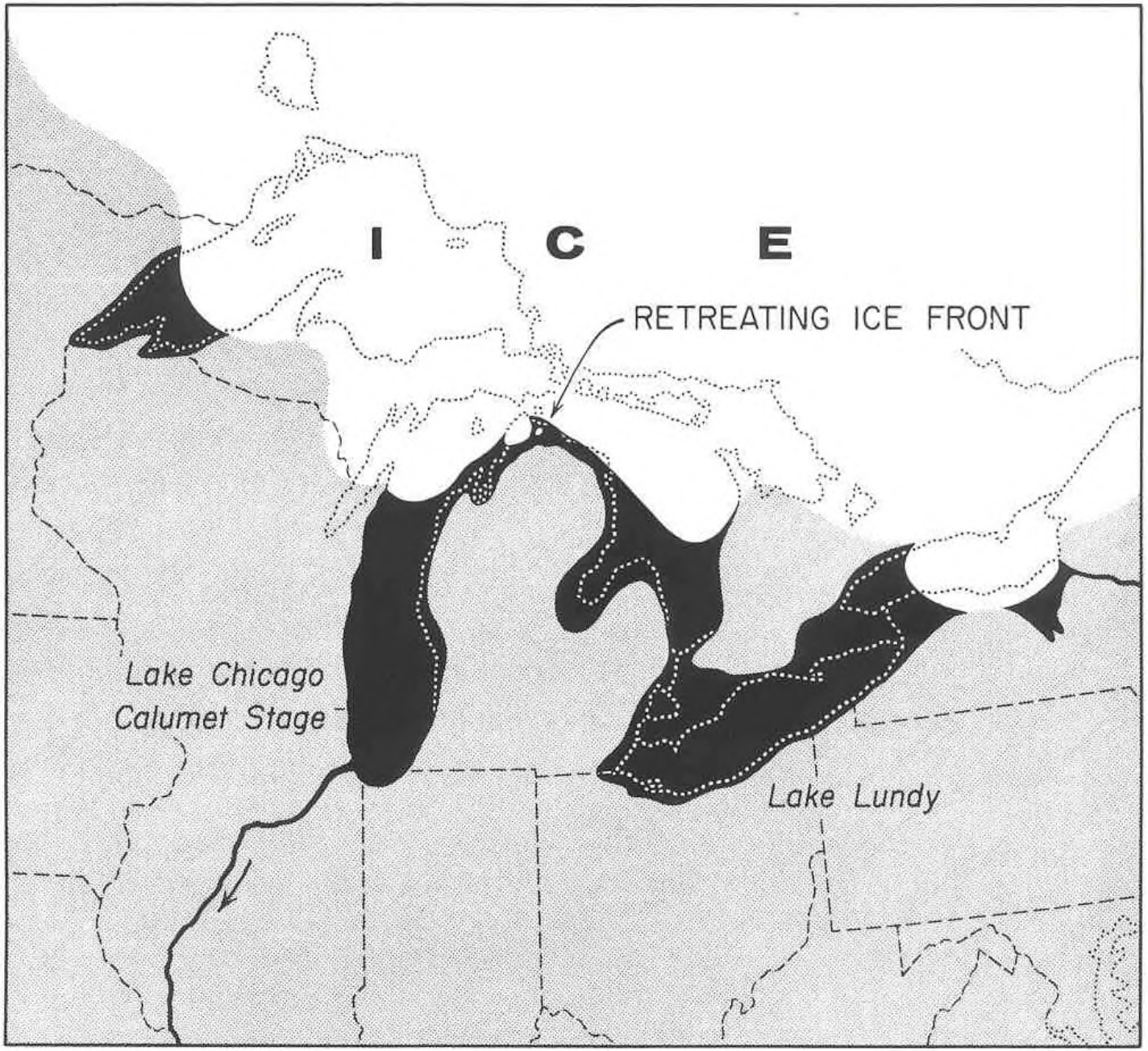
from Dorr & Eschman 1970



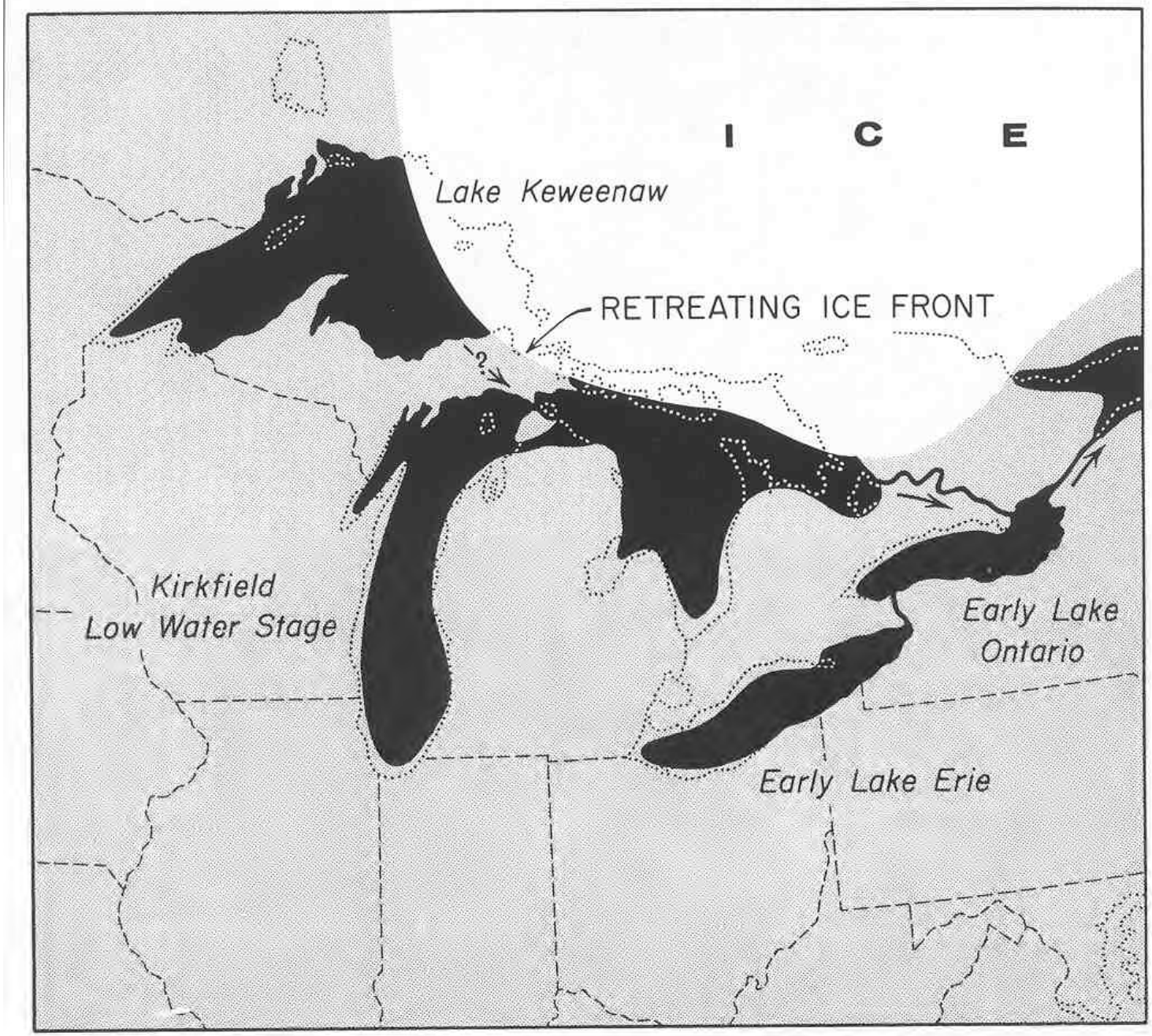
from Dorr & Eschman 1970



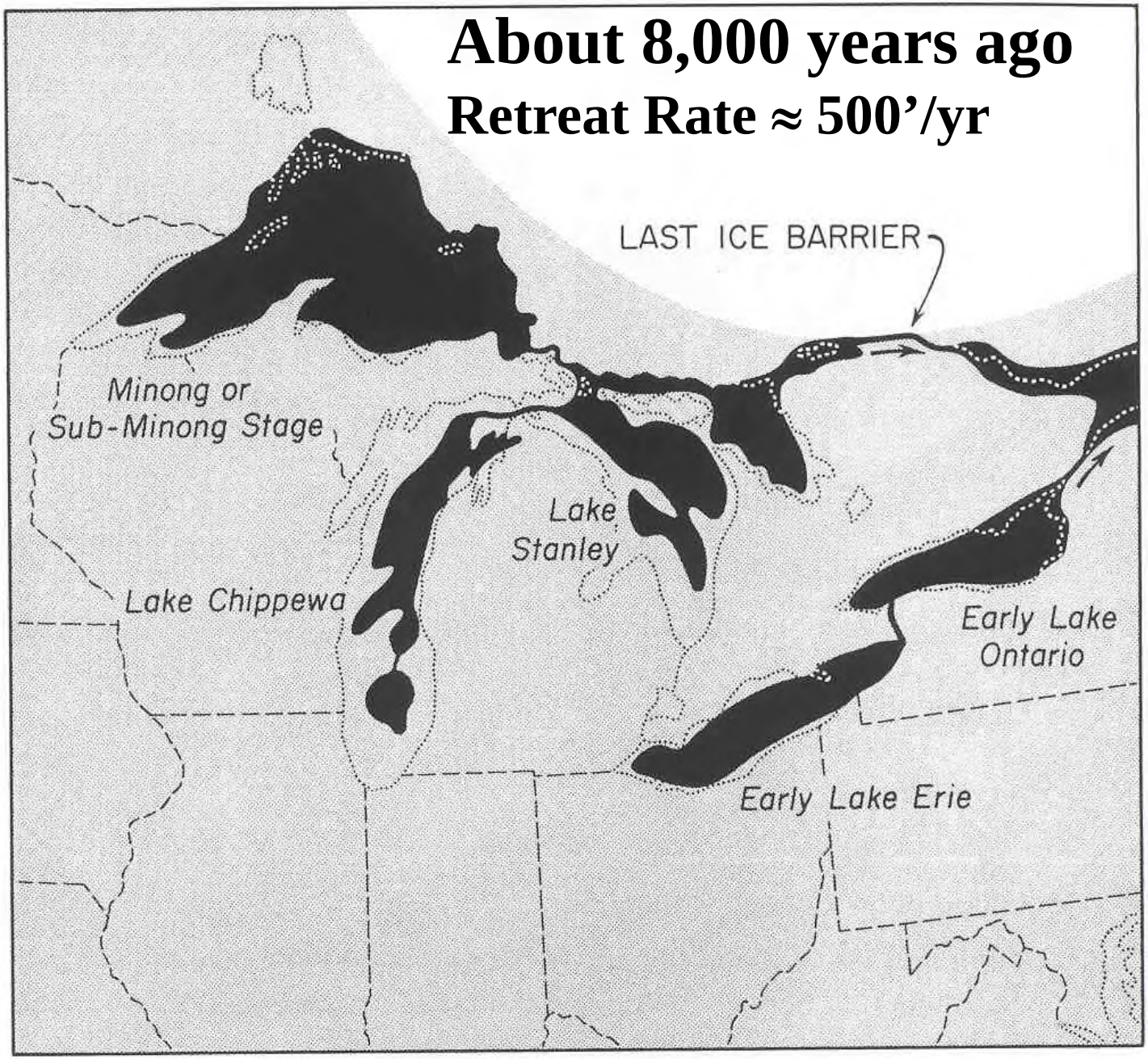
from Dorr & Eschman 1970



from Dorr & Eschman 1970

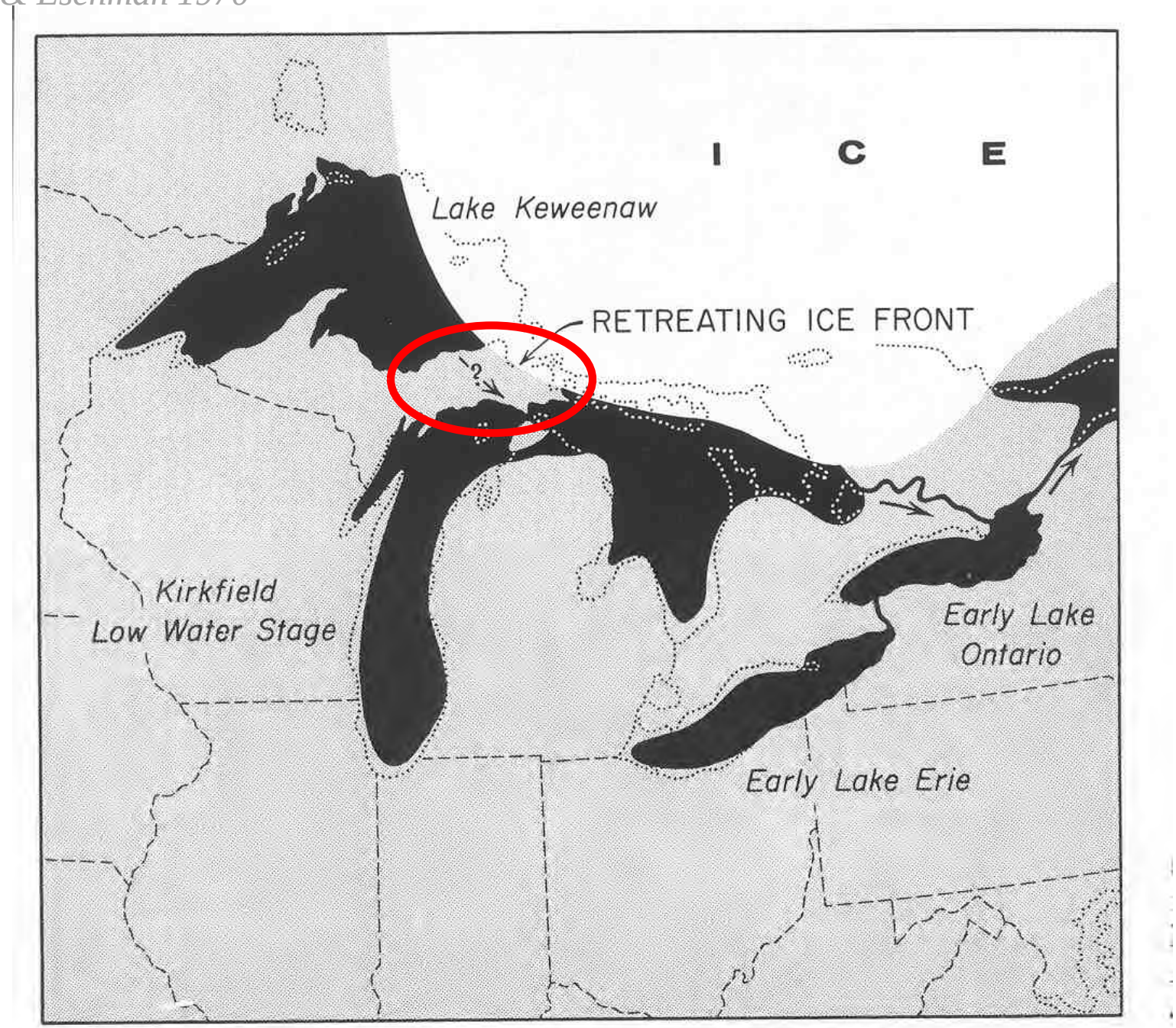


from Dorr & Eschman 1970



from Dorr & Eschman 1970

from Dorr & Eschman 1970



from Dorr & Eschman 1970

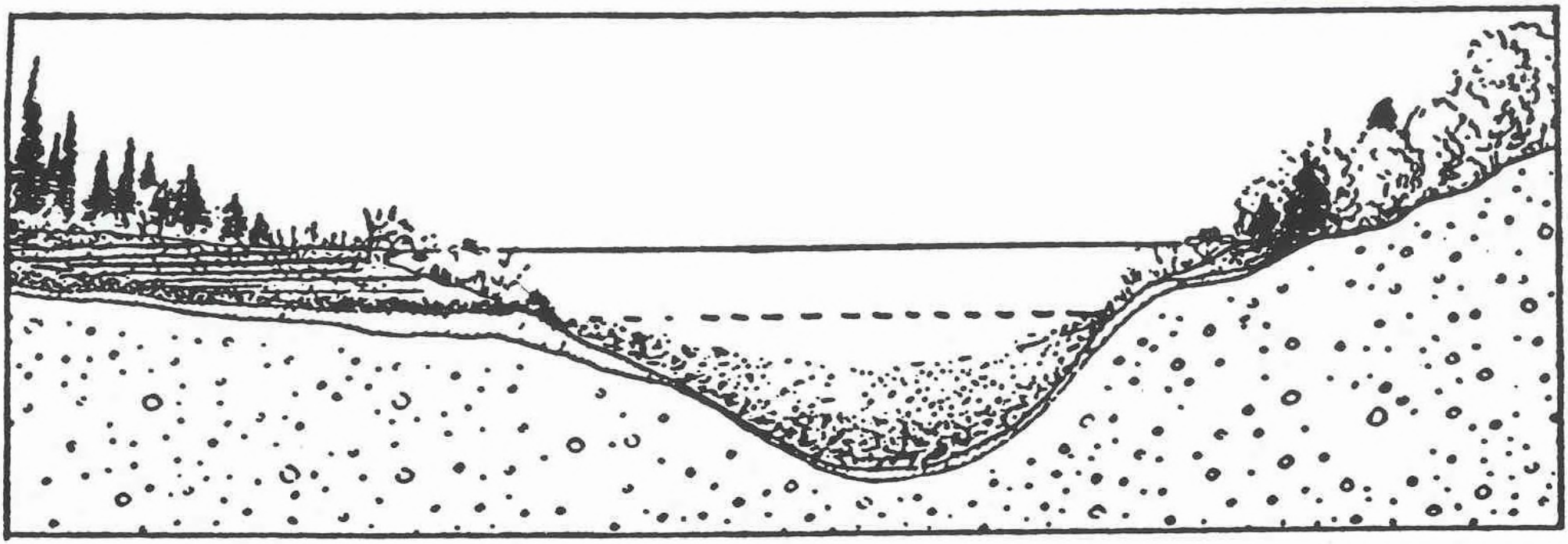


Fig. 2.10—The Formation of Sedimentary Peat.

from Dorr & Eschman 1970

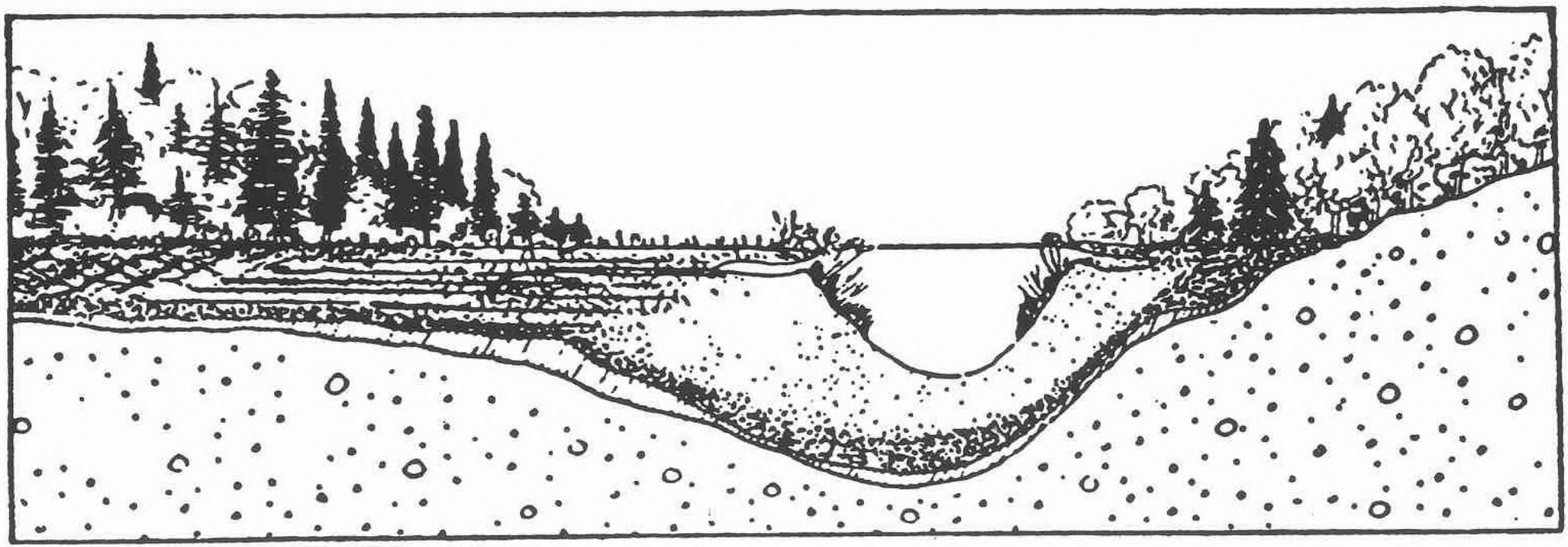


Fig. 2.11—The Formation of Fibrous Peat.

from Dorr & Eschman 1970

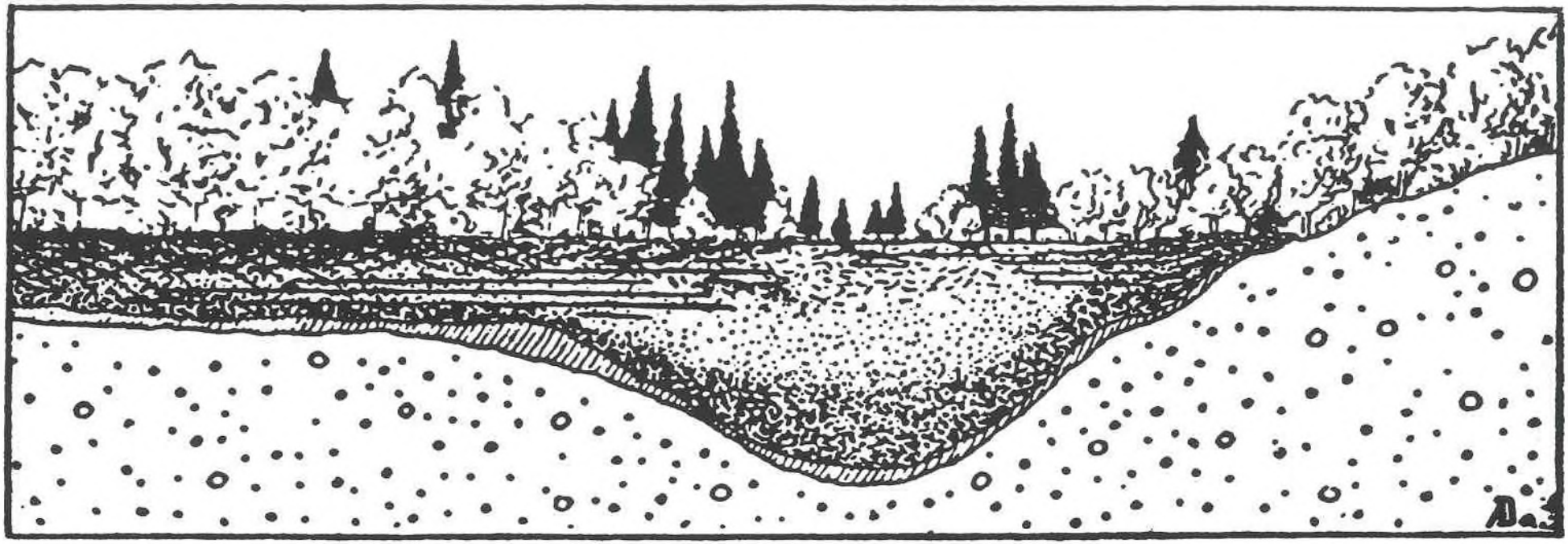
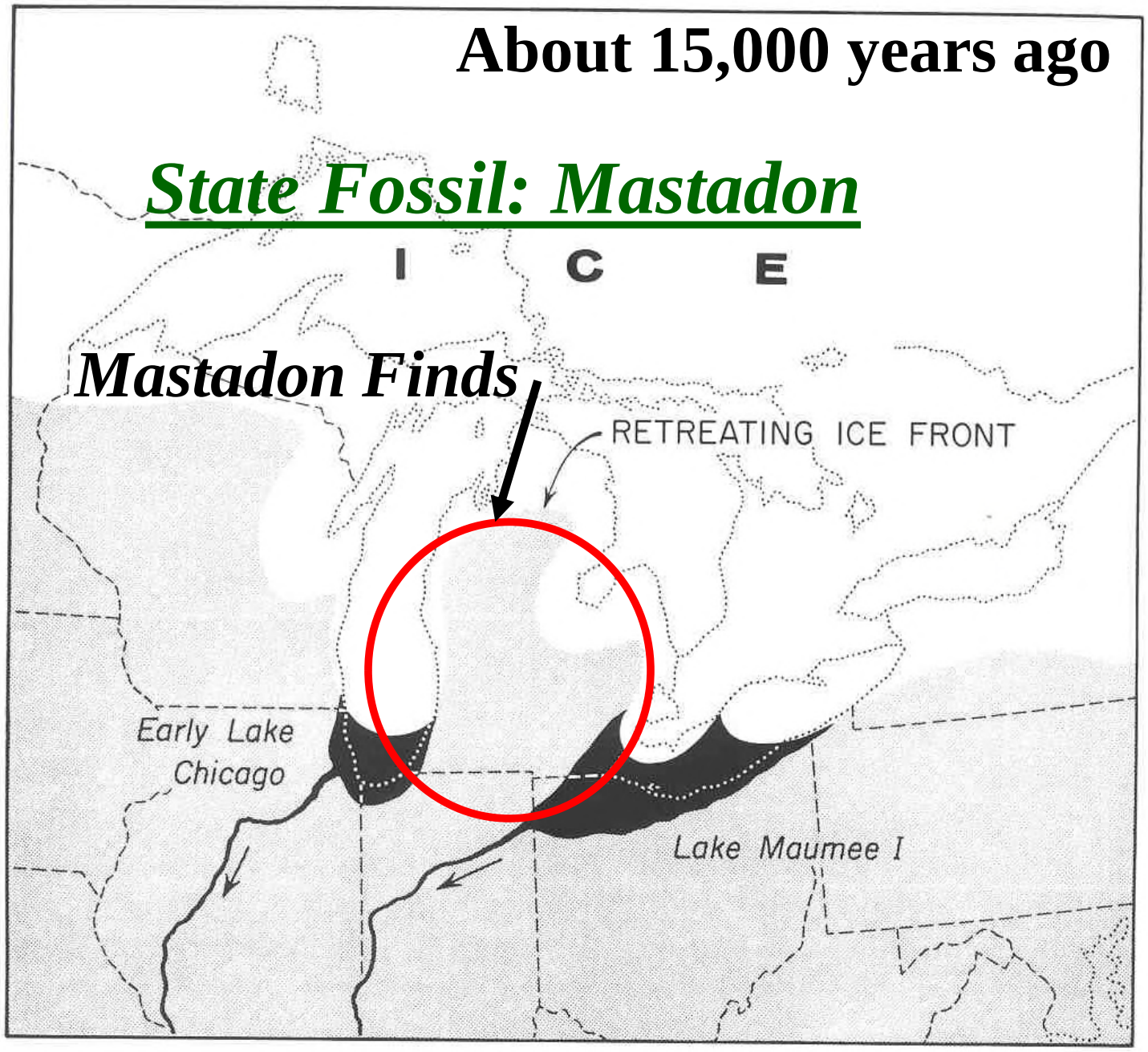


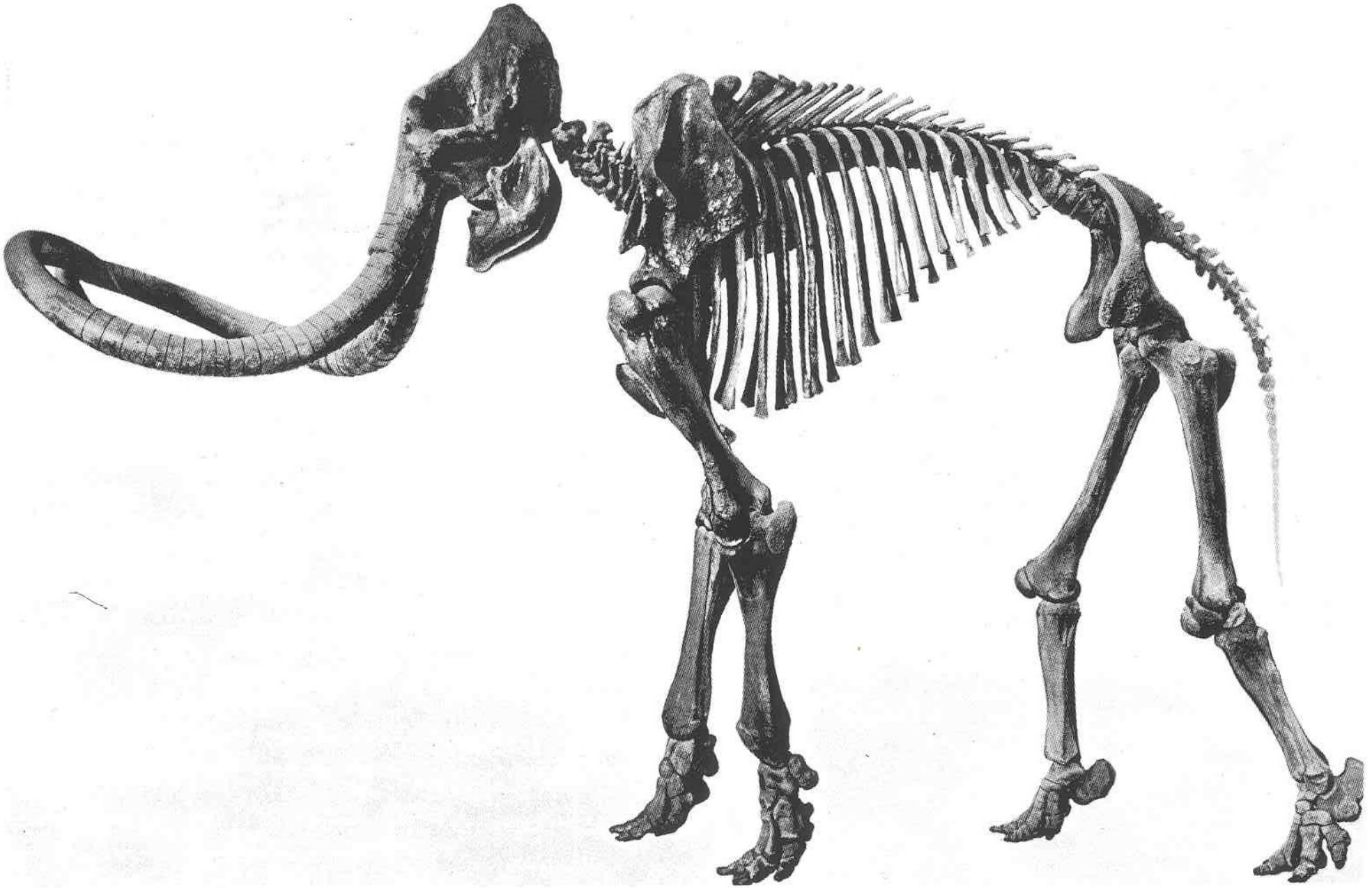
Fig. 2.12—The Formation of Woody Peat.

from Dorr & Eschman 1970

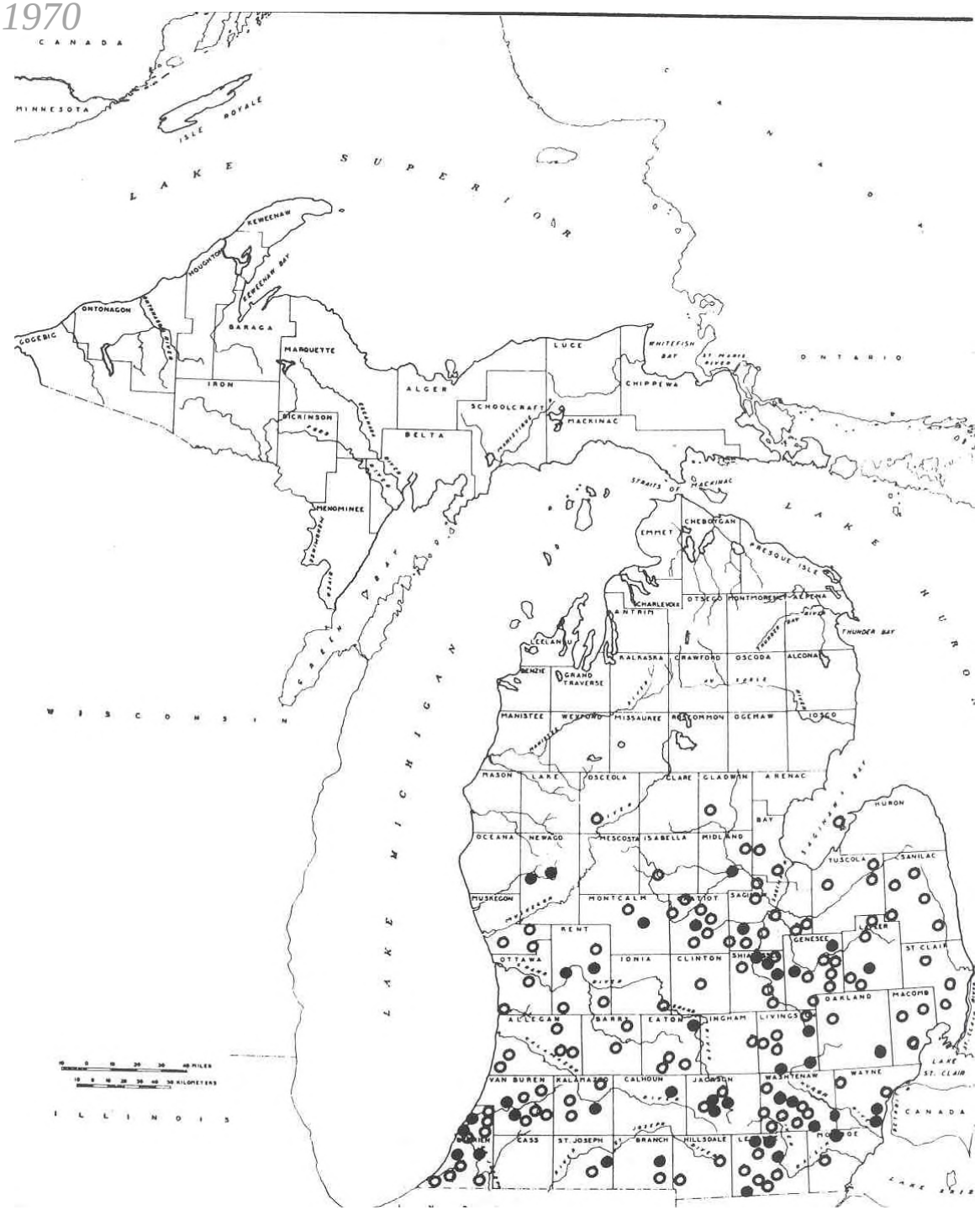
C. Byrum



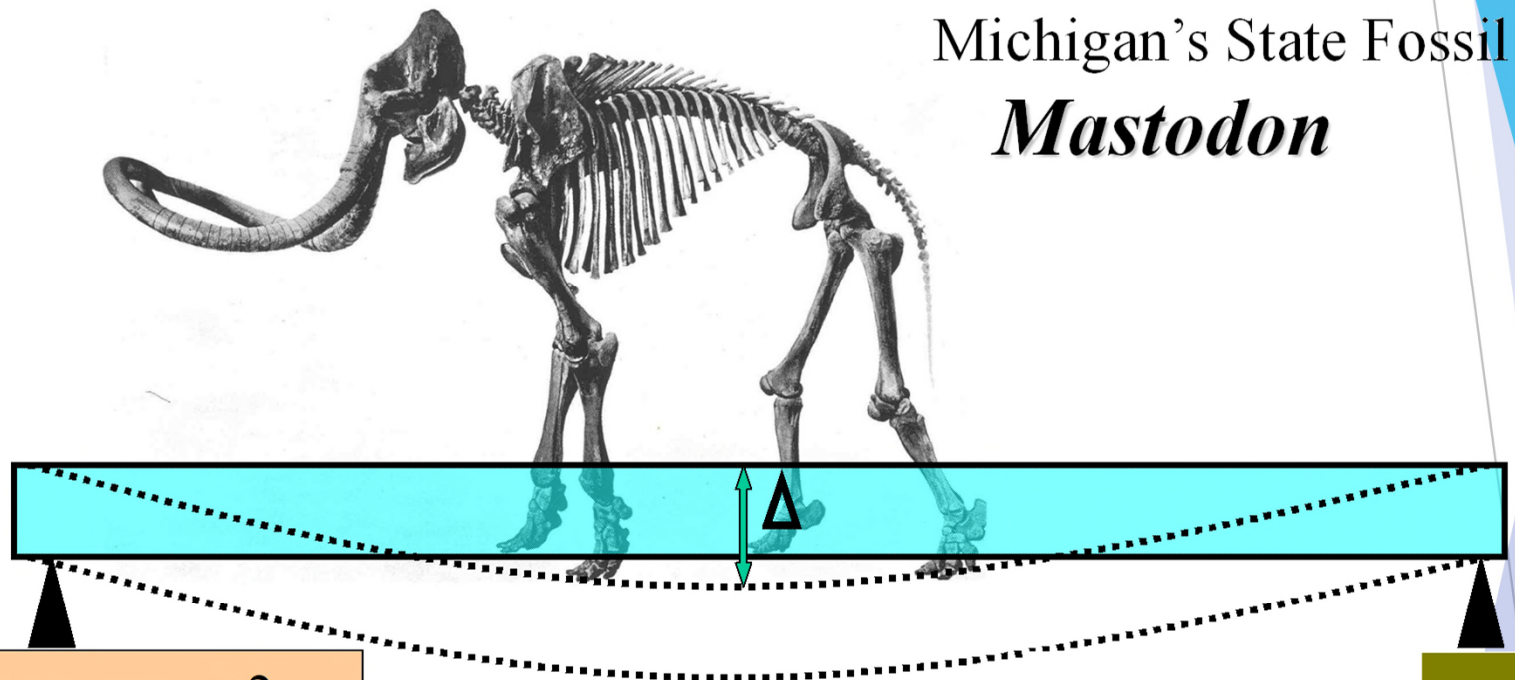
from Dorr & Eschman 1970



from Dorr & Eschman 1970



Open Discussion



$$M = EI\frac{d^2z}{dx^2}$$