Update on Trenton Black River Playbook Study-New York State Museum

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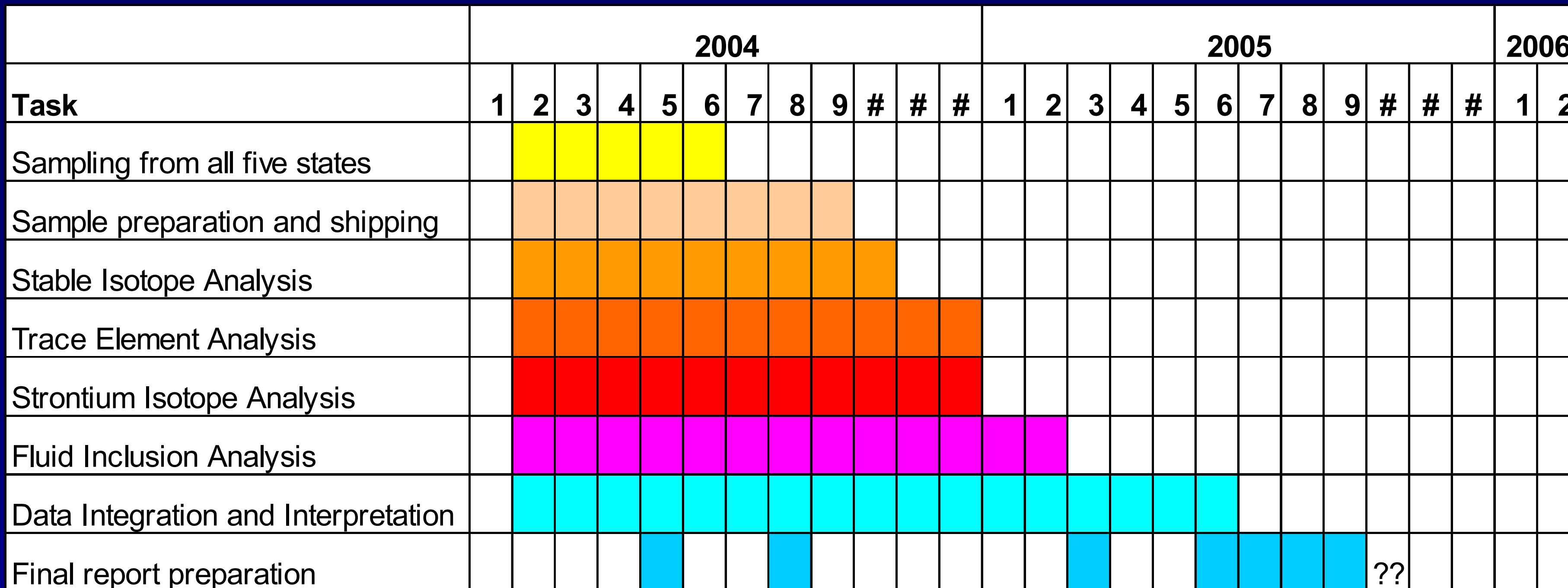
New York State Museum

Reservoir Characterization Group at the New York State Museum

NETL

Task 4: Geochemistry



Have sampled NY and Ohio, will ample WV tomorrow. Plan to sample KY and PA in the next two month

Have prepared all NY and Ohio samples

Have sent NY samples for all analyses and received results for stable isotopes and strontium isotopes

Accomplishments to Date

- All surveys given access to New York subsurface database – this includes tops, scanned logs, completion reports, core photos, more
- Over 150 TBR wells digitized – hope to have 350 more done in the next two months
- Have constructed isopach maps in of Ordovician intervals
- Have done extensive sampling for geochemistry in Ohio and NY

Sampling for Geochemistry

- Visited Ohio and met with members of Ohio and PA Surveys – Thanks Mark and Ron for your hospitality and great intro and organization
- Took 428 samples for stable isotope analysis – for both dolomite and ^{13}C stratigraphy
- Will analyze approximately 25 samples for strontium isotopes and 150 samples for trace elements
- Also took approximately 25 samples for fluid inclusion analysis

Sampling for Geochemistry

- Have also taken about 150 samples from three cores in New York, sent them out and received some results
- Should receive all data from NY geochemistry and fluid inclusions in next month

Sampling for Geochemistry

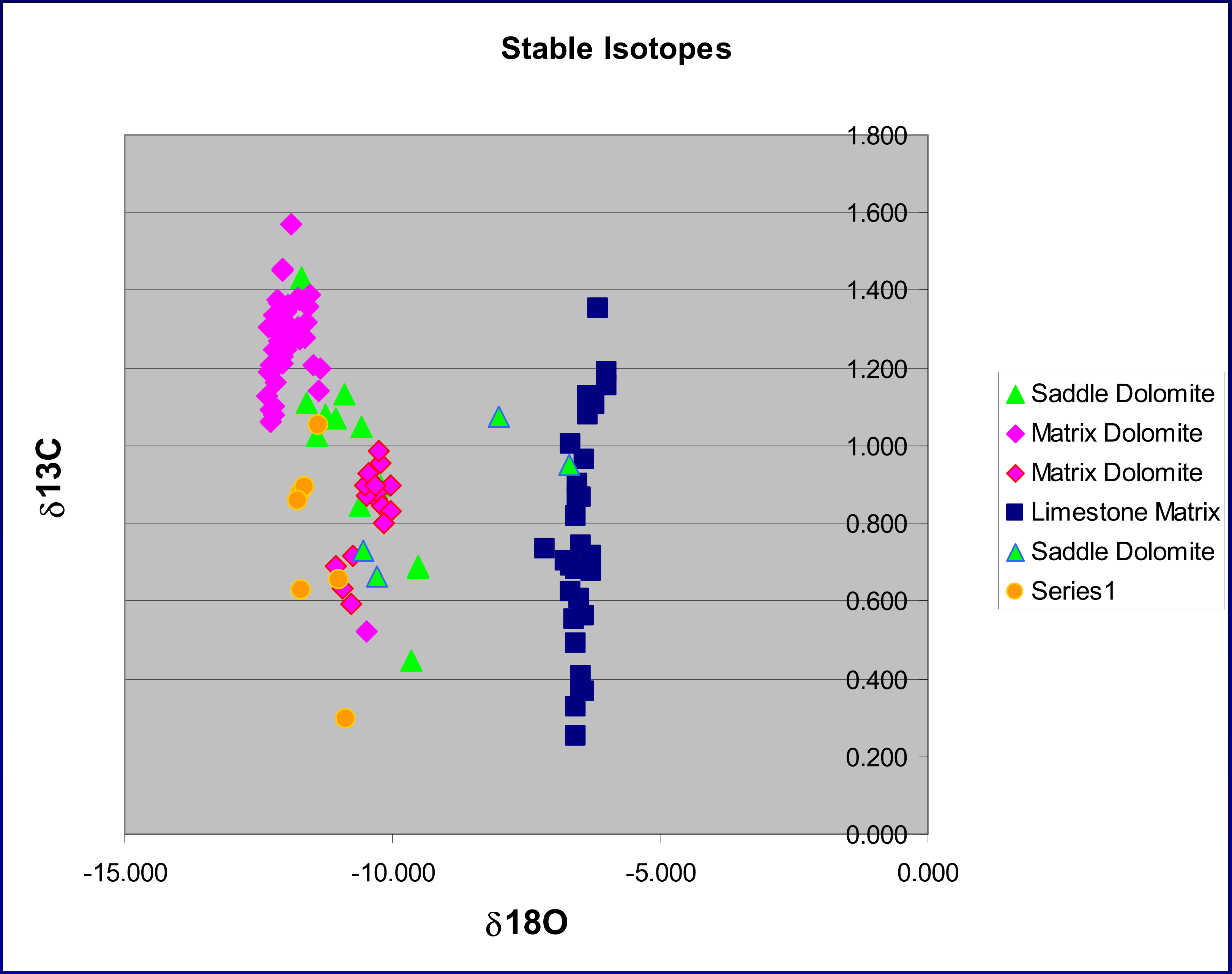
- Going to try to sample cuttings from some OH wells for 13C
- If this works, I encourage other surveys to send cuttings from wells where T-BR contact is hard to pick

Carbon and Oxygen Isotopic Composition of Saddle Dolomite: selected examples

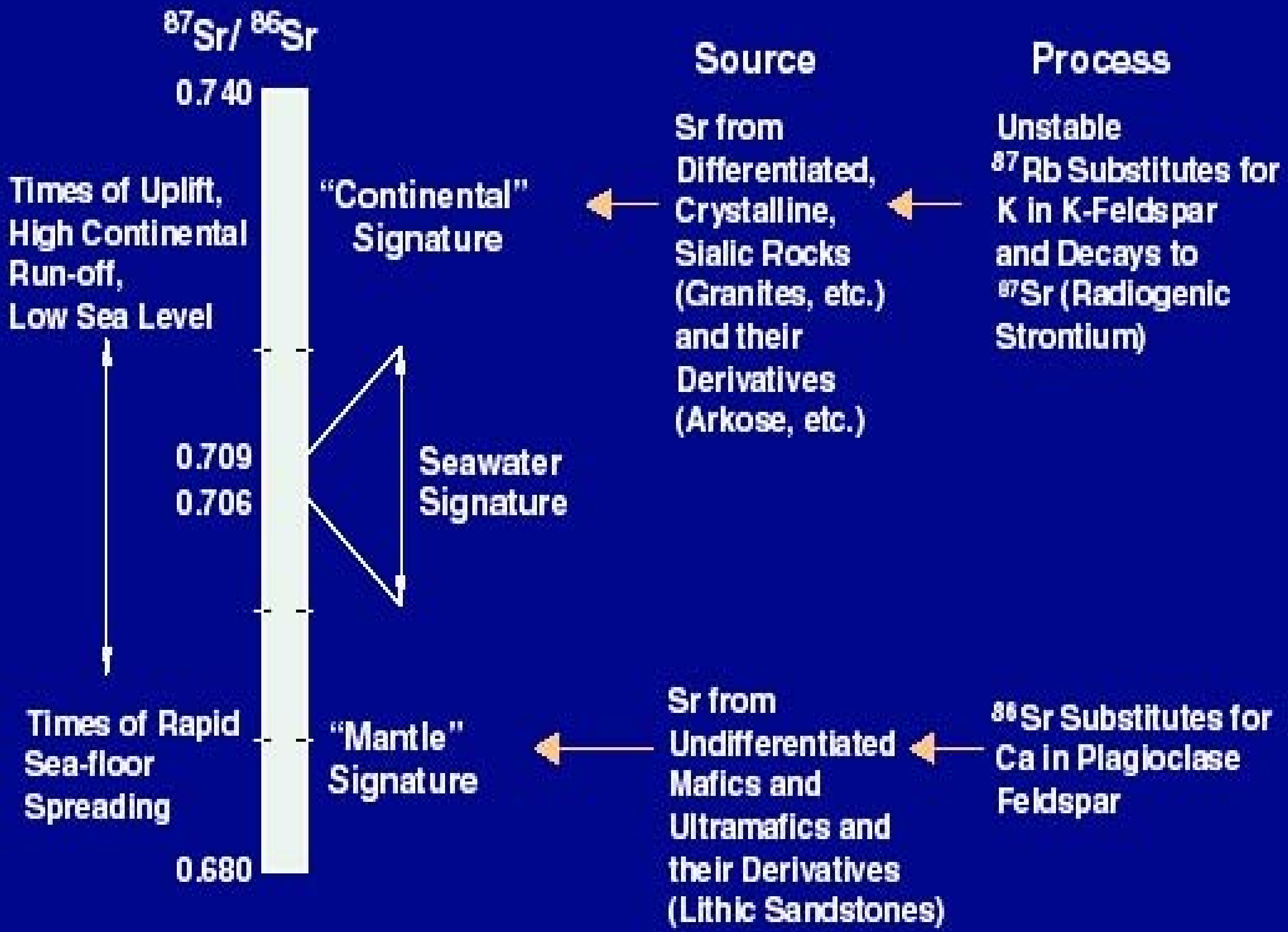
Source	δ^{18}C‰ PDB	δ^{13}C‰ PDB	Reference
Camb., Cathedral, SE BC	-18.4 to -17.3	-3.2 to -1.9	Yang et al, 1990
Ord., Trenton, Mich.	-11.3 to -7.5	-0.5 to +1.9	Allan and Wiggins, 1993
M. Dev., Manatoe, NWT	-17.33 to -6.25	-5.5 to -1.45	Morrow et al, 1990
M. Dev., Elk Point, N. Alb.	-12 to -14	-1.0 to +2.0	Dravis and Muir, 1992
M. Dev., Pine Point, NWT	-16.0 to -7.0	-3.8 to +1.7	Qing and Mountjoy, 1994
Dev., Sidang-Budan, China	-9.58 to -6.78	-3.08 to -0.78	Schneider et al, 1991
U. Dev., Wabaman, Alb.	-8.99 to -5.71	-0.69 to +0.12	Mountjoy and Dihardja, 1991
U. Dev., Wabaman, Alb.	-6.7 +/- 0.7	0.55 +/- 0.5	Packard et al, 1989
Cret., Saudi Arabia	-7.2 to -4.0	-0.7 to +3.0	Broomhall and Allan, 1987

Davies, 2000

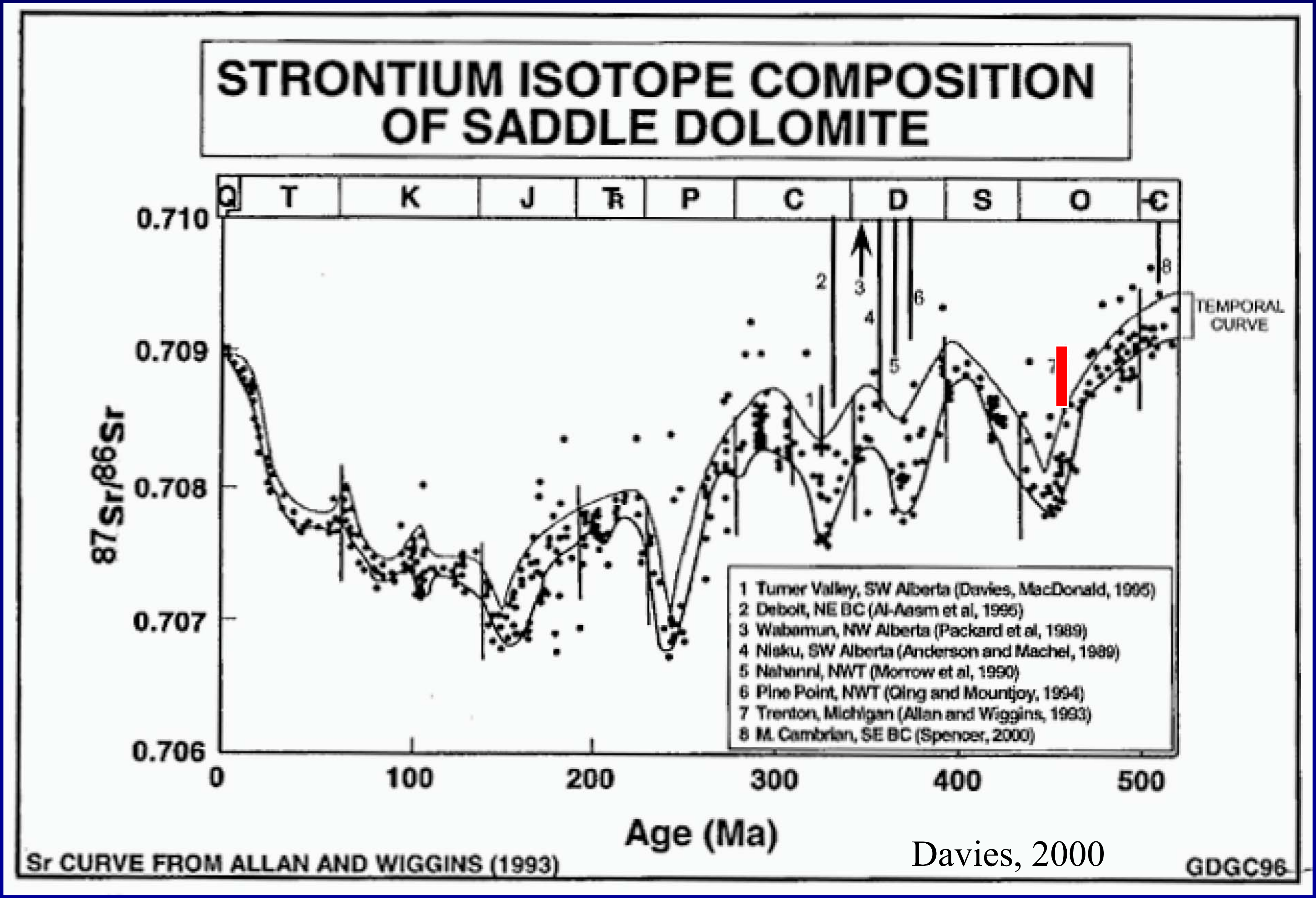
Oxygen isotopes are generally light (negative) in hydrothermal dolomites


Stable Isotopes
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
δ13C
-15.000
-10.000
-5.000
0.000
δ18O
Saddle Dolomite
Matrix Dolomite
Matrix Dolomite
Limestone Matrix
Saddle Dolomite
Series1

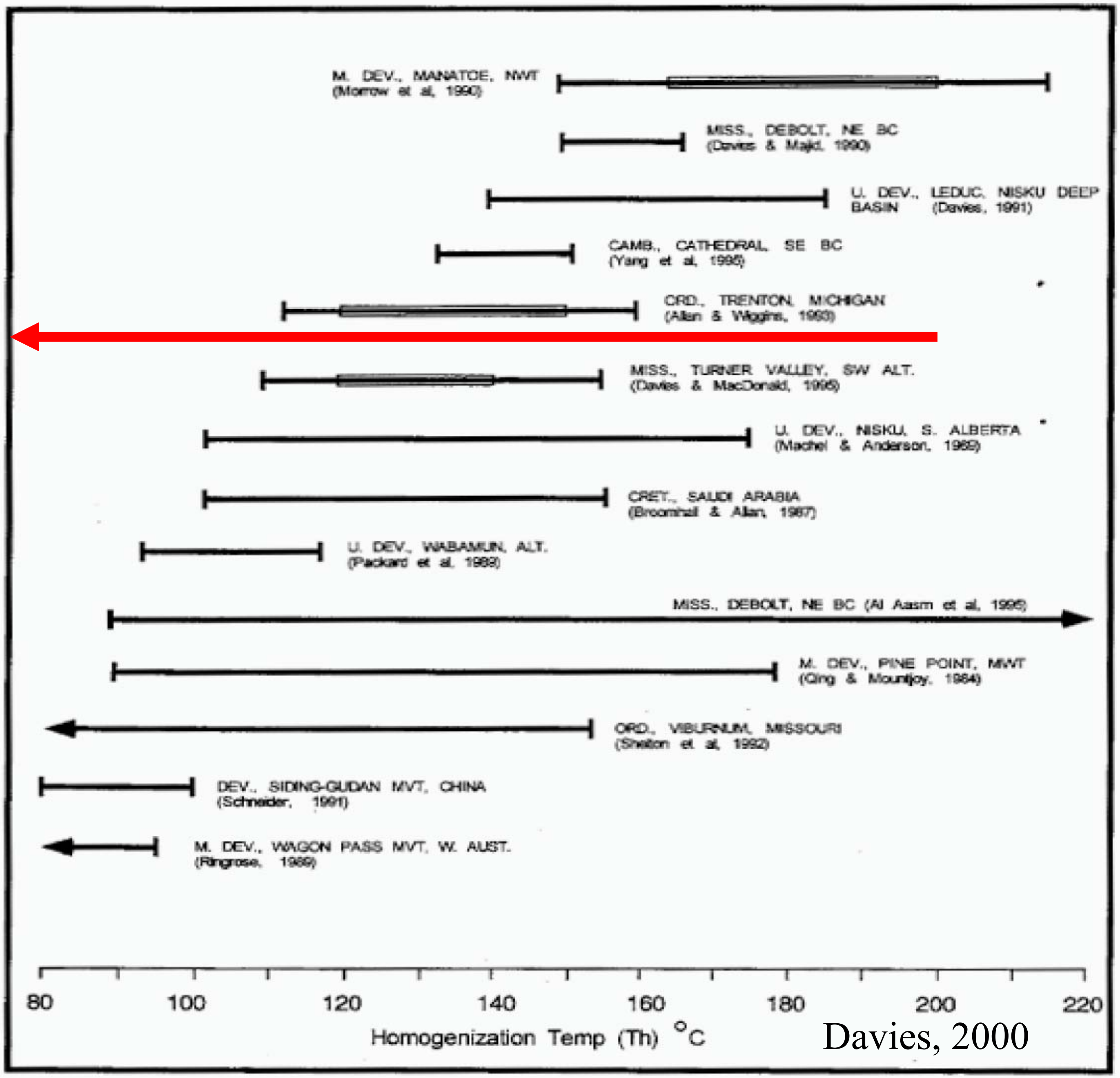
Sources of ^{87}Sr and ^{86}Sr and Paths Which Influence Sr Isotopic Composition of Paleo-Oceans



Allan and Wiggins (1993)

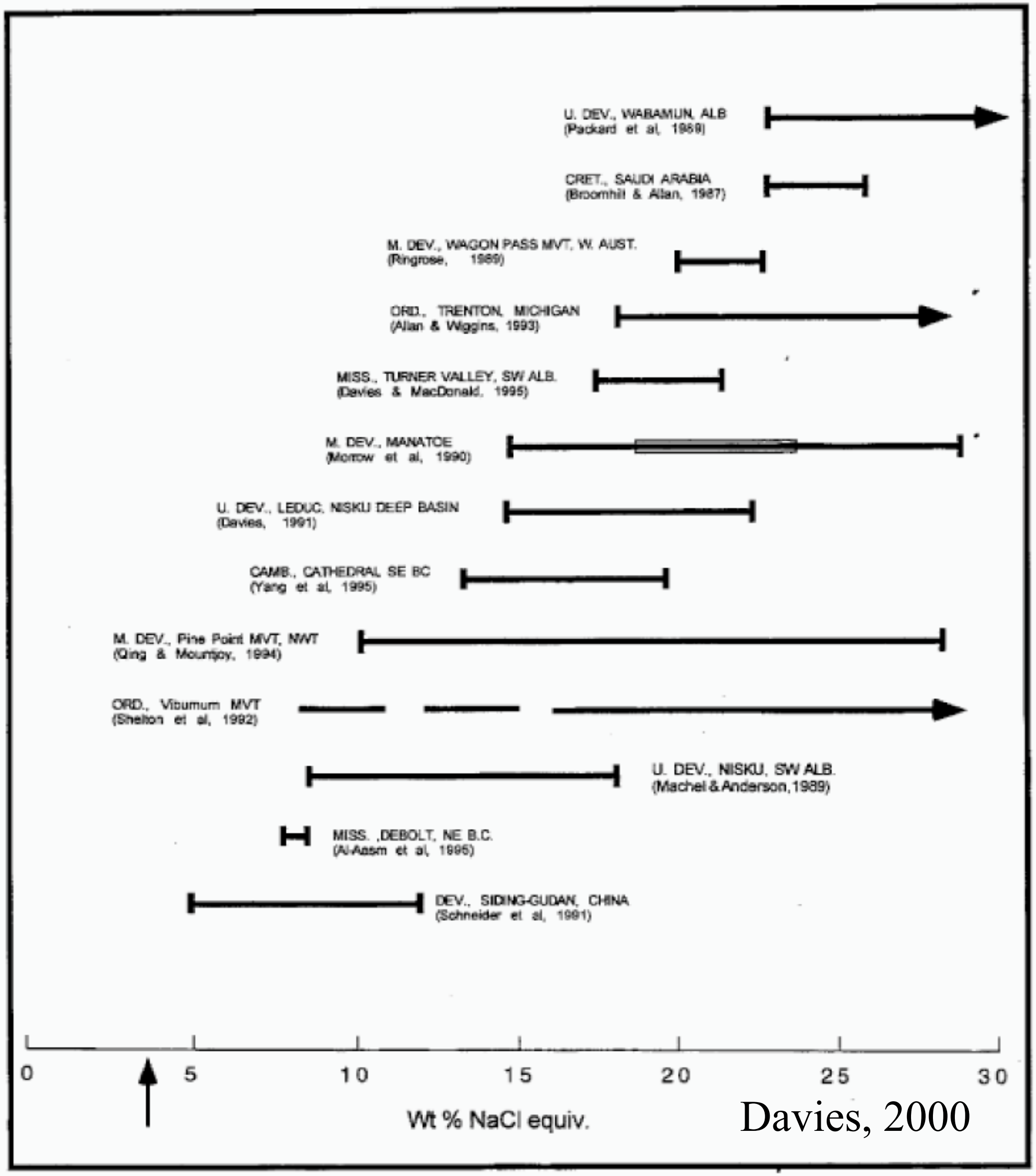


Hydrothermal dolomites typically plot as more radiogenic than seawater for the time the rocks were deposited – True for TBR (barely)


M. DEV., MANATOE, NWT (Morrow et al, 1990)
MISS., DEBOLT, NE BC (Davies & Majid, 1990)
U. DEV., LEDUC, NISKU DEEP BASIN (Davies, 1991)
CAMB., CATHEDRAL, SE BC (Yang et al, 1995)
ORD., TRENTON, MICHIGAN (Allan & Wiggins, 1993)
MISS., TURNER VALLEY, SW ALT. (Davies & MacDonald, 1995)
U. DEV., NISKU, S. ALBERTA (Machel & Anderson, 1989)
CRET., SAUDI ARABIA (Broomhall & Allan, 1987)
U. DEV., WABAMUN, ALT. (Packard et al, 1989)
MISS., DEBOLT, NE BC (Al Aasm et al, 1995)
M. DEV., PINE POINT, NWT (Qing & Mountjoy, 1984)
ORD., VIBURNUM, MISSOURI (Shelton et al, 1992)
DEV., SIDING-GUDAN MVT, CHINA (Schneider, 1991)
M. DEV., WAGON PASS MVT, W. AUST. (Ringrose, 1989)
80
100
120
140
160
180
200
220
Homogenization Temp (Th) °C

Davies, 2000

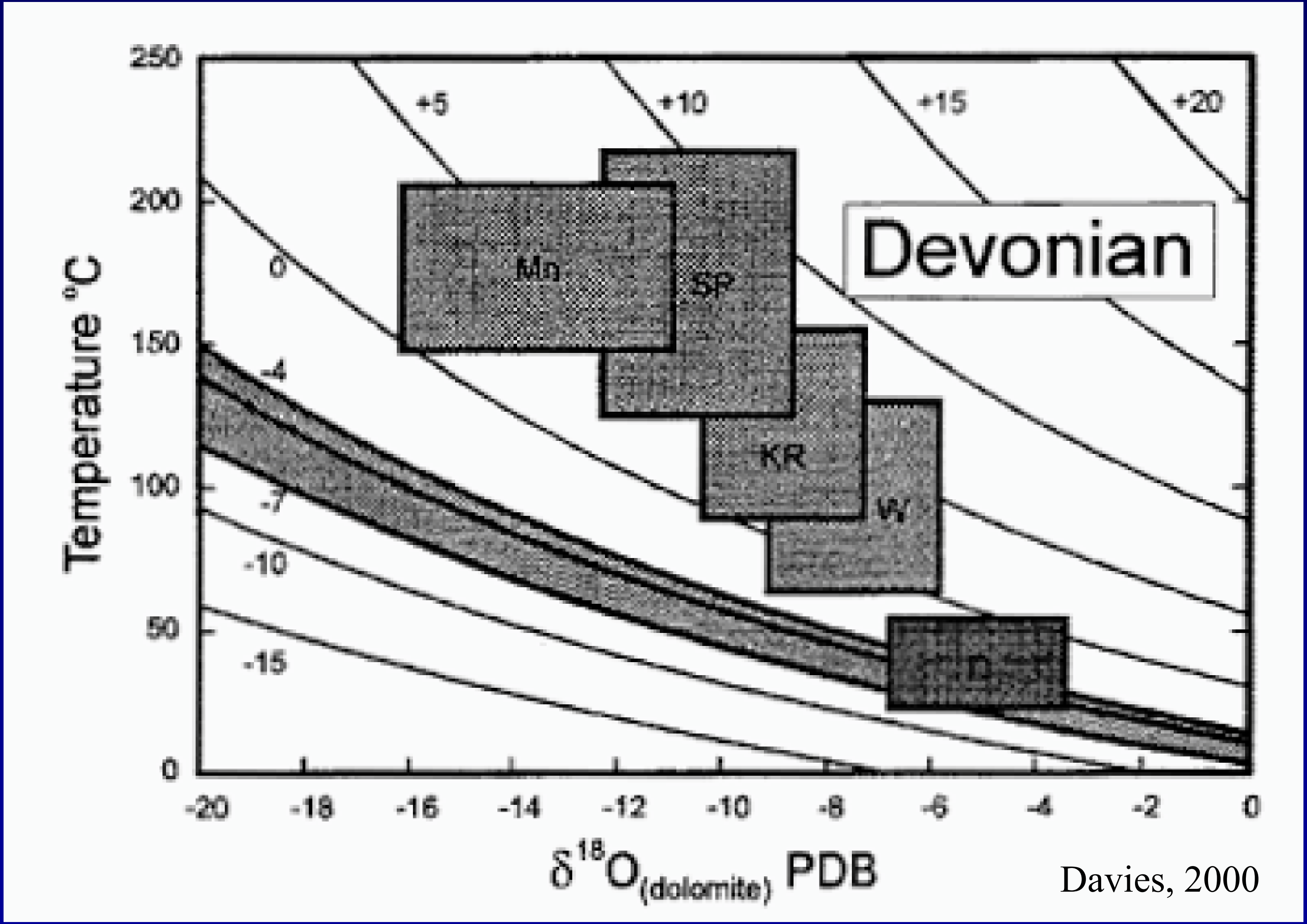
Table 2 Salinity of Fluid Inclusions from Melting Temperature (Tm) for Saddle Dolomite: Selected Sources



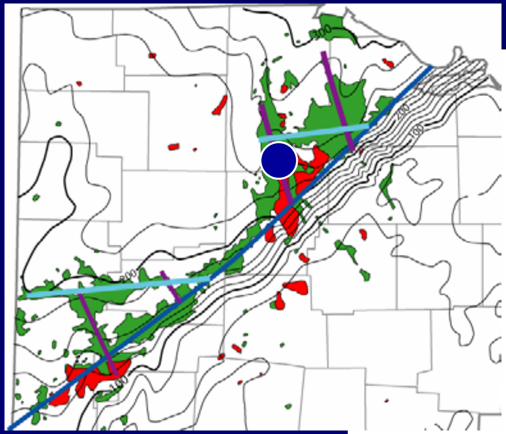
Davies, 2000

Salinity of the fluid that made the dolomite can be determined from fluid inclusions

TBR dolomite averages around 20 wt% (6 times normal seawater)

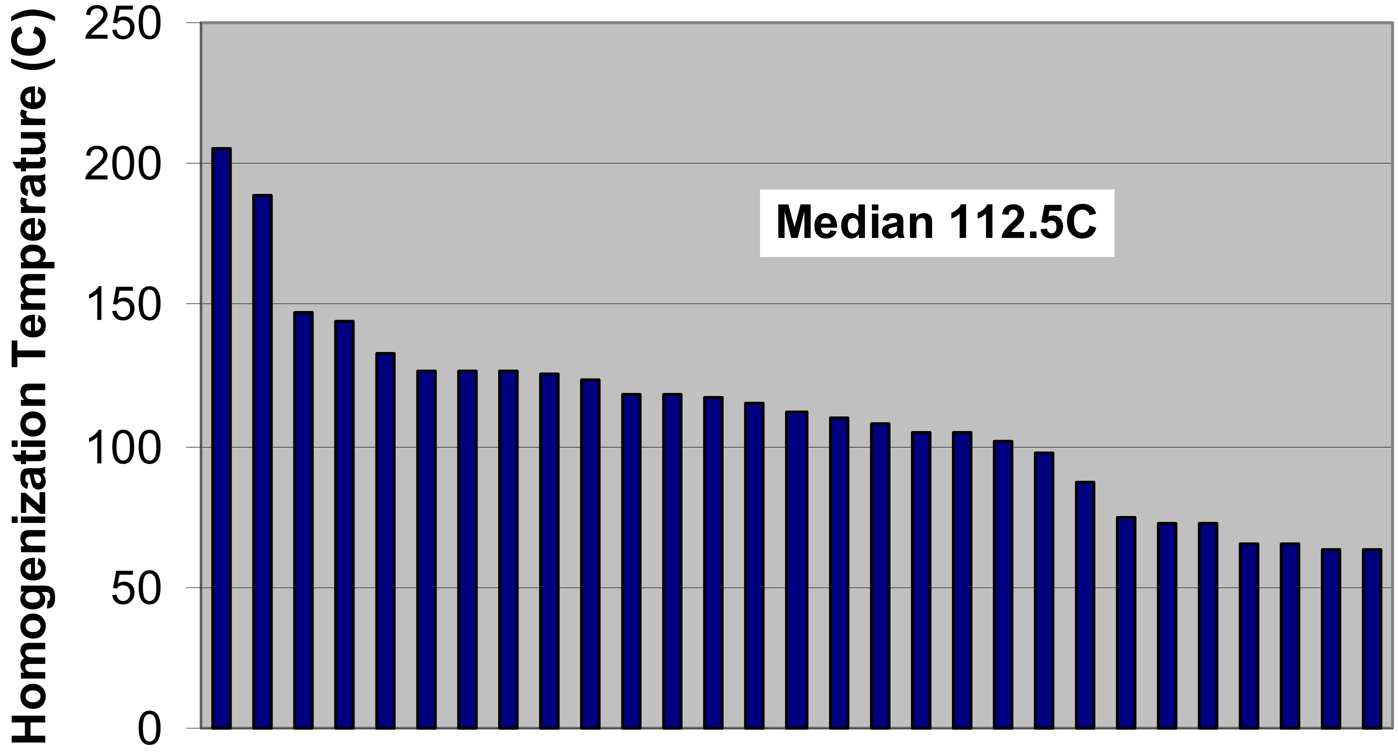


With fluid inclusion data and stable isotopes, it is possible to determine the composition of the fluid which then makes direct interpretation of temperature from stable isotopes possible

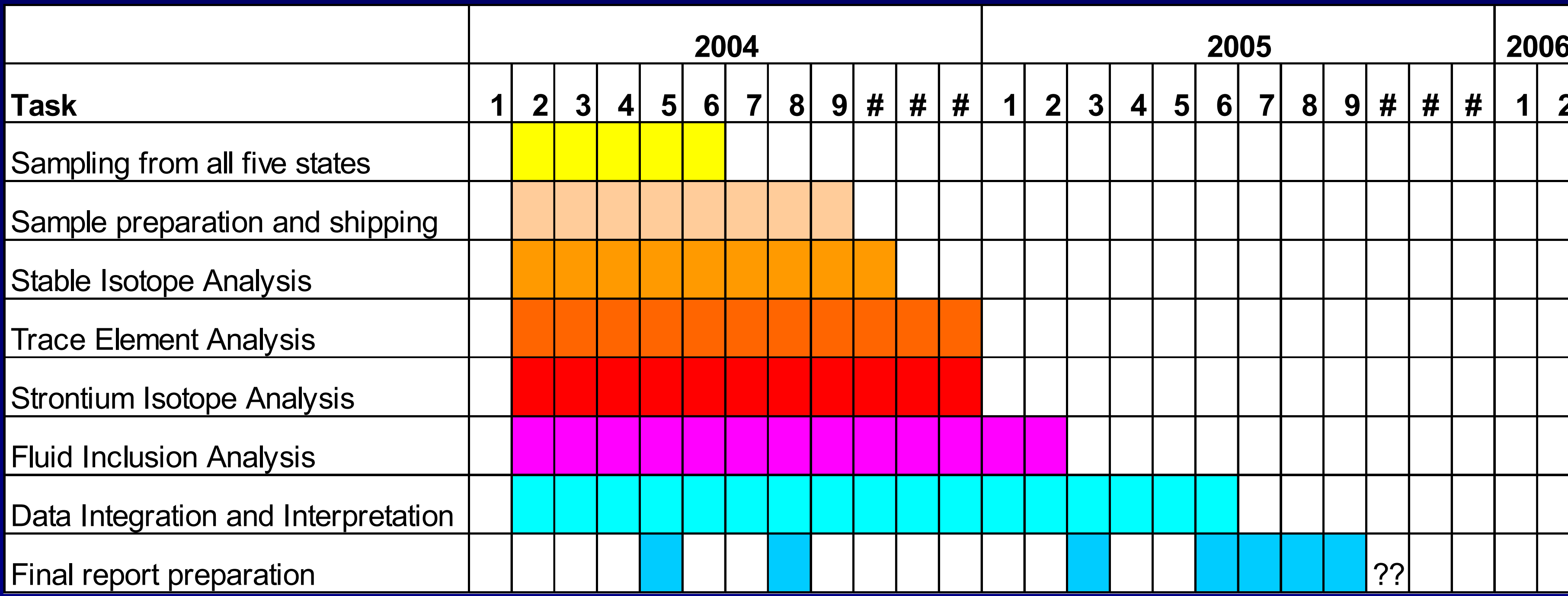


Homogenization Temperatures, Saddle Dolomite, Bowling Green Fault Zone (around 350 meters, probably never buried more than 1Km)

Trenton (currently at 1200 ft) *probably* never buried more than 1 km on Findlay Arch (50ºC)



These temperatures suggest that TBR is truly hydrothermal, Homogenization temps>ambient temperature ever was



Sampling all matrix and saddle dolomites and also taking samples at regular intervals for carbon isotope stratigraphy

A little behind schedule, but we should be able to catch up now that we are (hopefully) getting paid

Dolomitized Grainstone

"Facies" dolomite from near margin in SW Ohio

Fault zone in Black River. Interval arou
fault is dolomitized and massive calcite
occurs in actual fault zone (Prudential V

Saddle dolomite cemented breccia, Spitler well, Trenton Formation, Bowling Green fault Zone

Post saddle dolomite blocky , calcite, Spitler well

Saddle dolomite in horizontal clay seam; horizontal vugs also very common

"Cap" dolomite, Top Trenton, near bowling Green Fault zone – Fe stained

Dolomite- and Fe-sulfide-cemented breccia (First published in Wickstrom et al., 1992)

Note geopetal distribution of sulfides to base of voids and saddle dolomite to tops- this was seen throughout – not sure what it means

Breccia is within Trenton and is thought (by me) to be a hydraulic or fault-related breccia, not a karst breccia

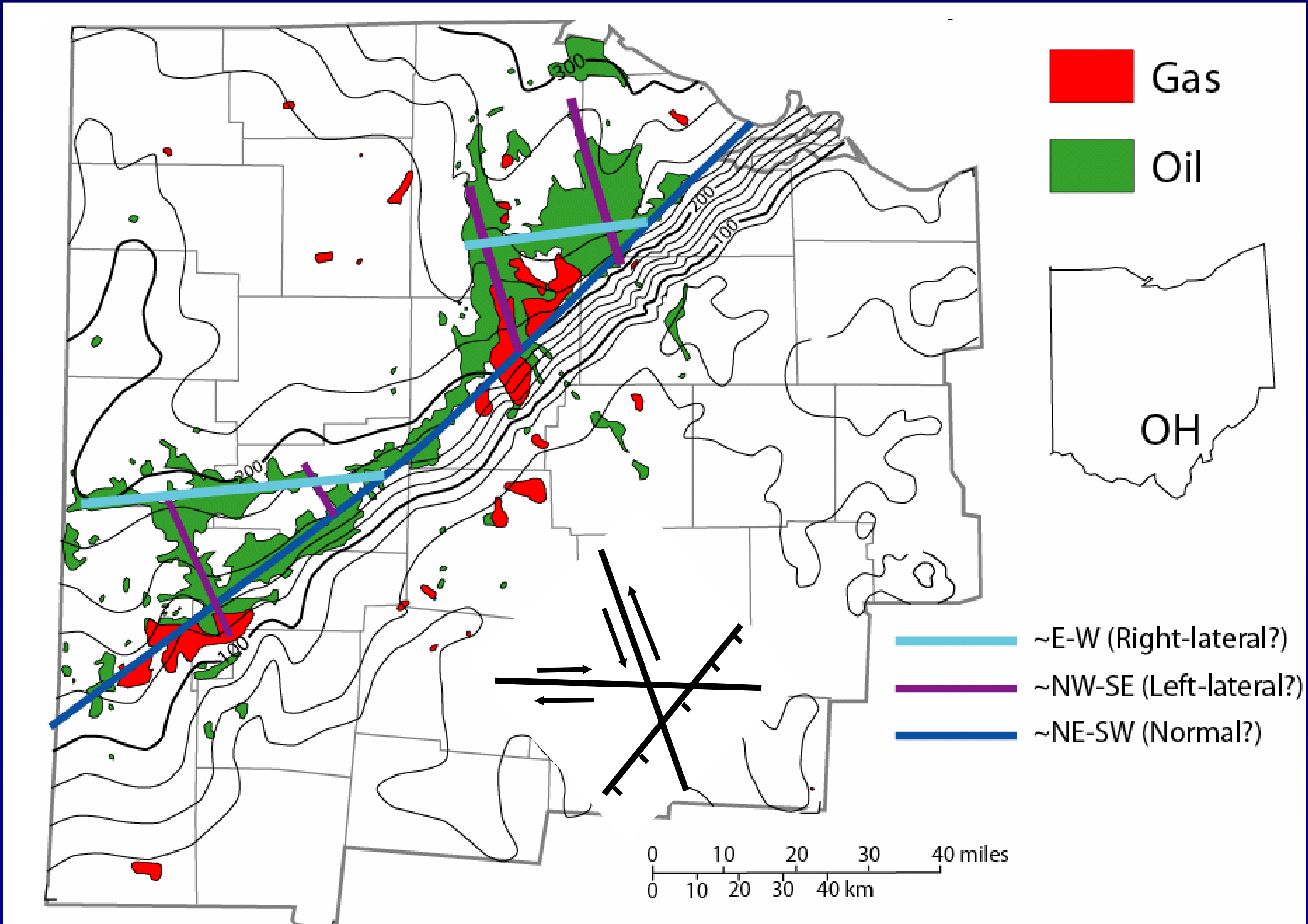
GB well, Bowling Green Fault Zone

Piper, margin southwest of BG fault, Black River, looks like fracture propogating through soft sediment in shallow marine facies

This suggests that the rock was not lithified and therefore pretty shallowly buried at the time of fracturing

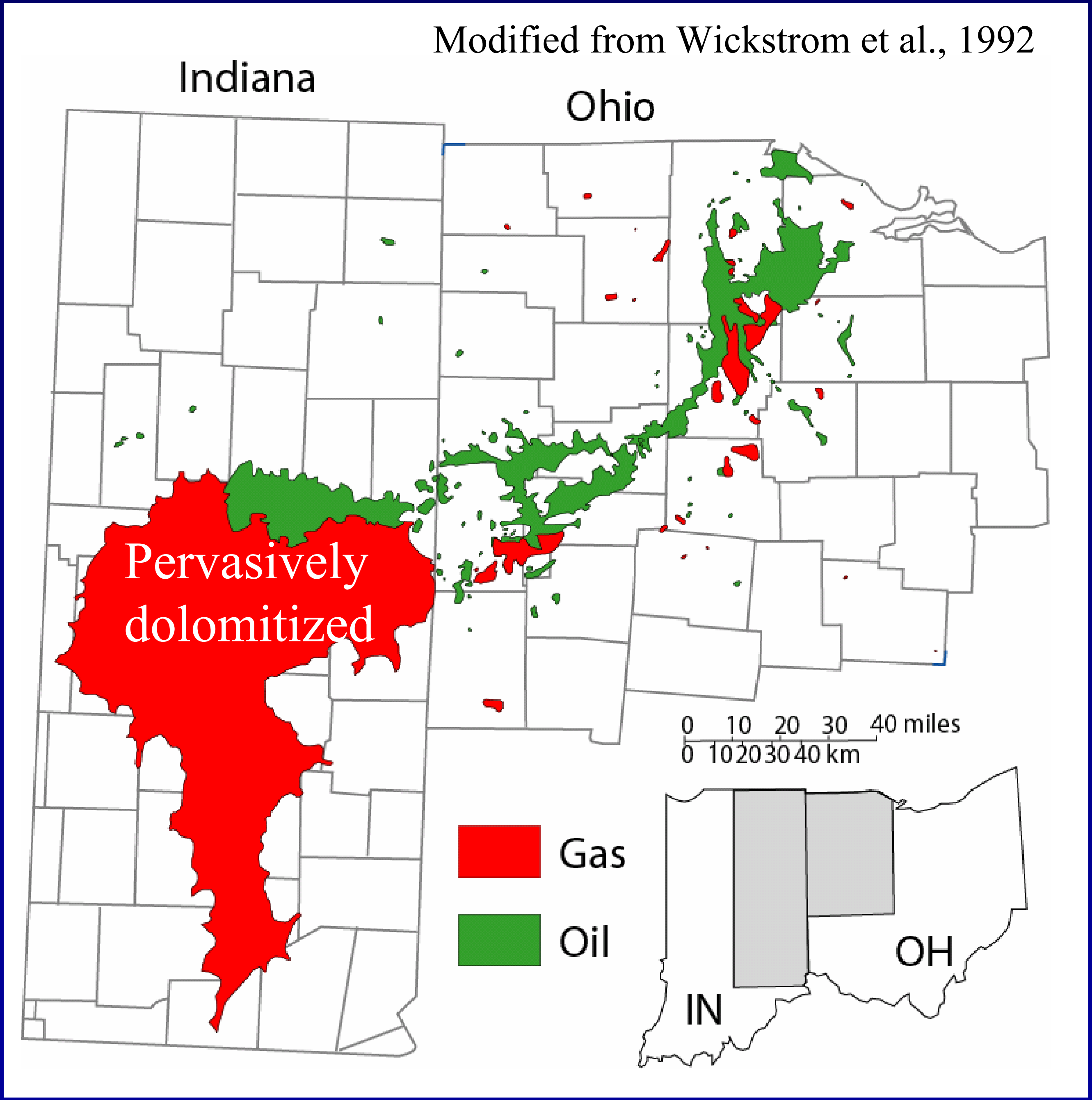
Evidence for Shallow Burial at the Time of Alteration

- What are the implications of horizontal vugs and fractures? Horizontal fractures common from surface down to about 1500 feet, then vertical fractures take over
- Seismic shows faults dying out in Trenton or Utica in many cases
- Seismites abundant in Trenton
- Soft sediment deformation around fractures and faults
- Findlay Arch area probably never buried more than 1 km yet everything looks the same there



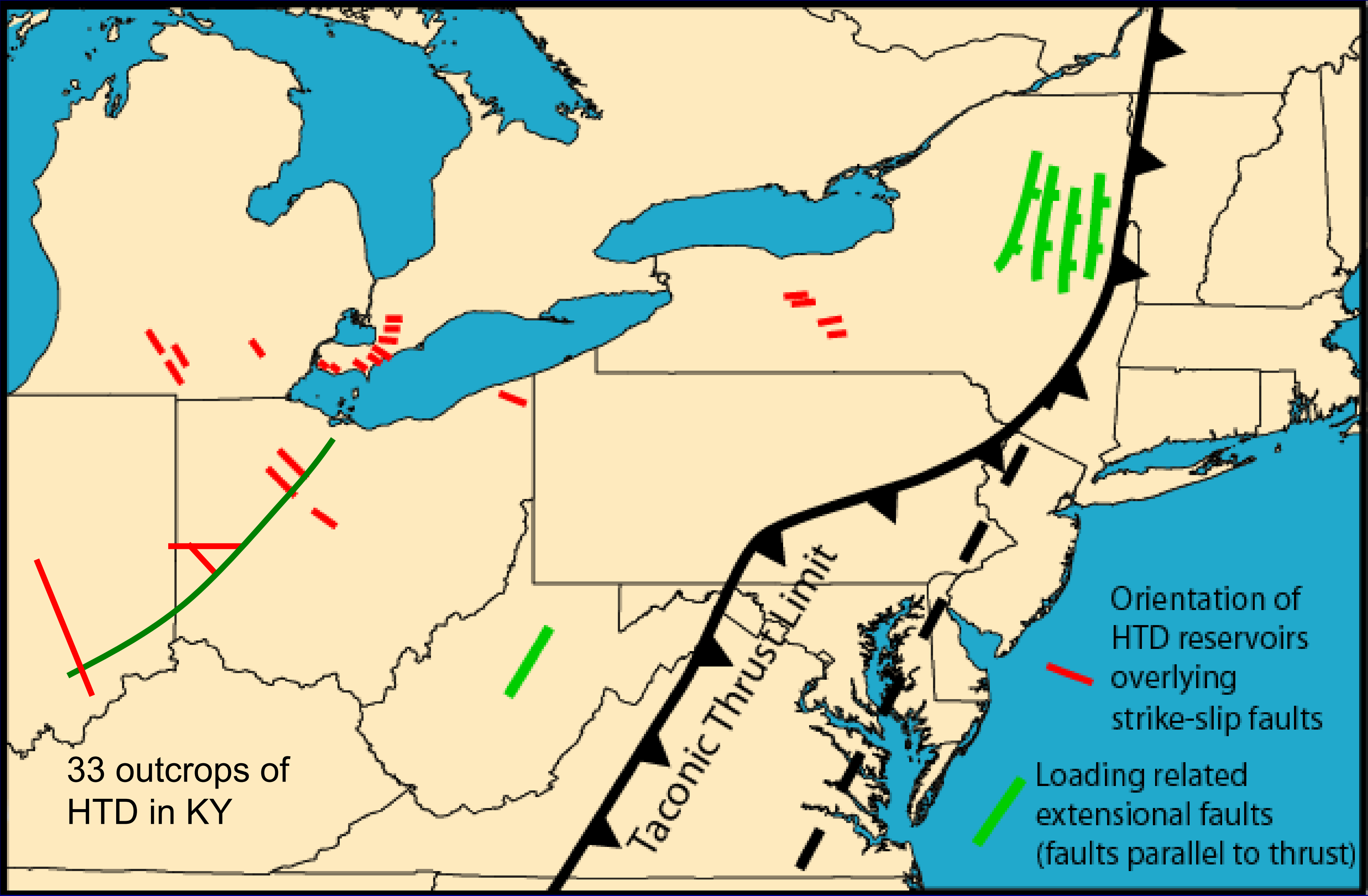
Modified from Wickstrom et al., 1992

Dolomitization in Trenton occurs along margin with shale basin, around intraplatform wrench faults and at fault intersections

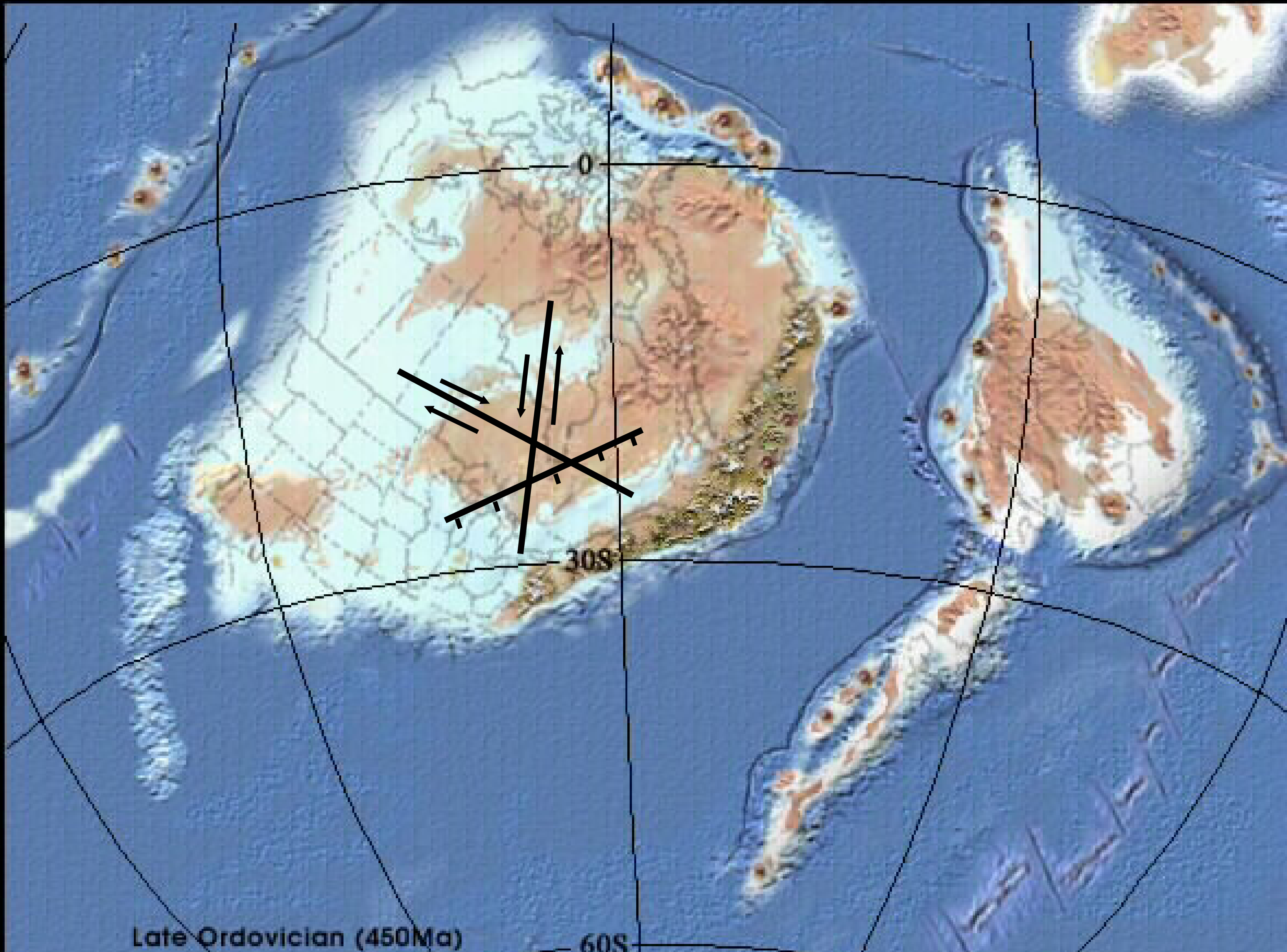


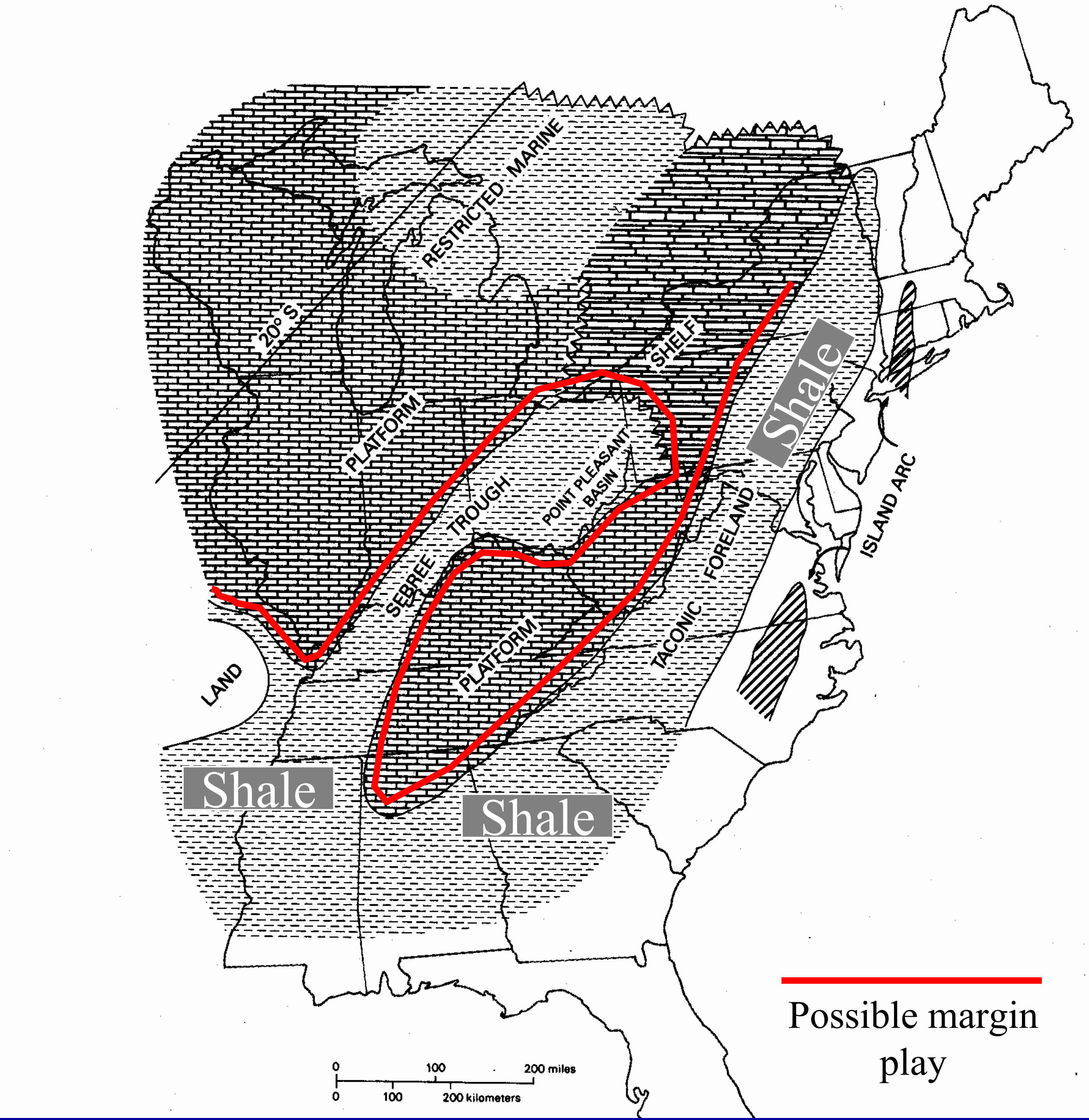
Trenton Black River "Facies Dolomite" Reservoirs in Indiana and Ohio – Pervasively dolomitized over large area but is probably all fault-controlled hydrothermal dolomite

Q: Can pervasive dolomitization be hydrothermal in origin?



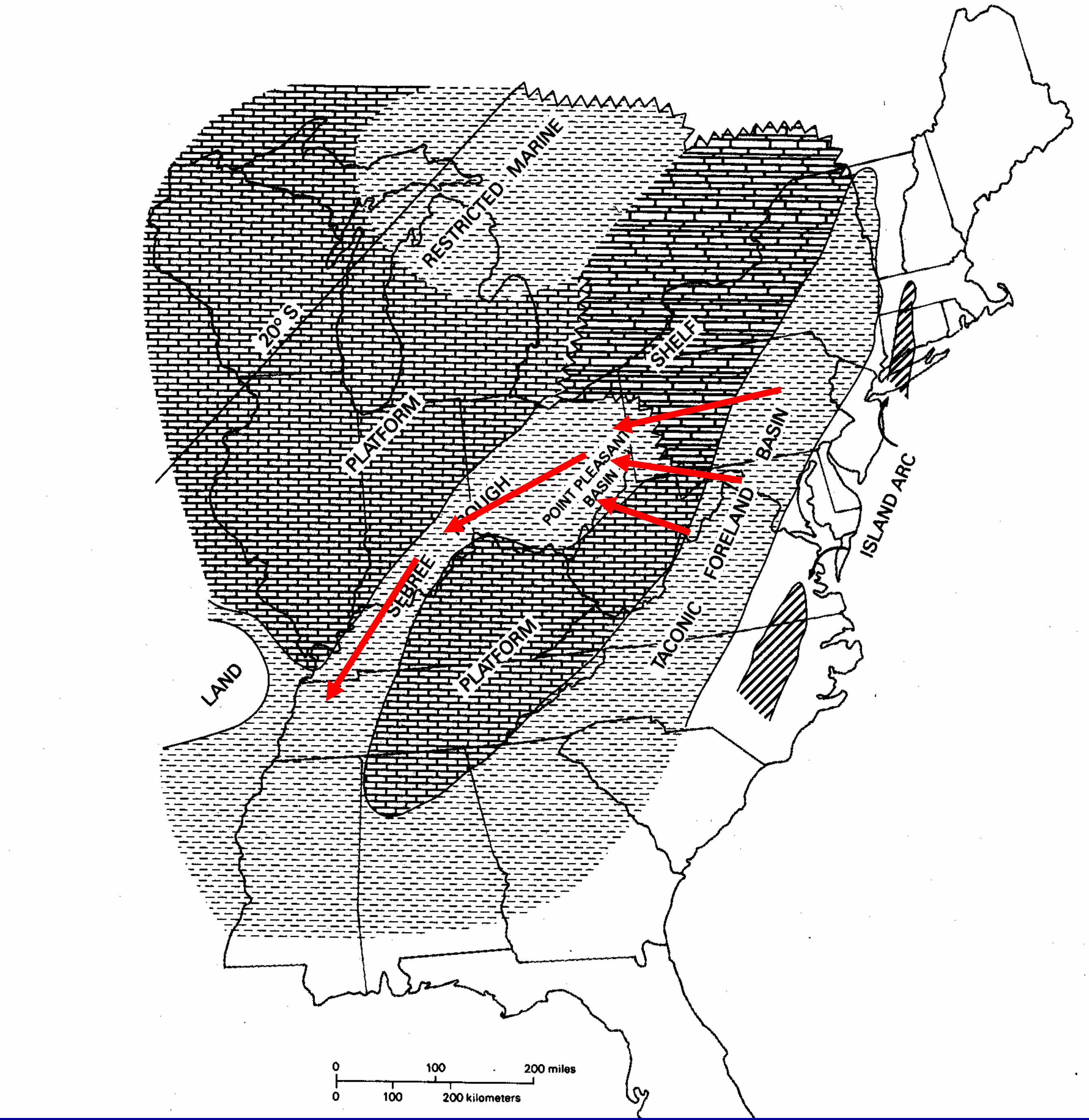
Orientation of hydrothermal dolomite reservoirs and some Mid-Late Ordovician structures, Eastern US


0
30S
60S
Late Ordovician (450Ma)



Trenton time Facies Map from Wickstrom et al., 1992

This may explain the "facies" dolomite of Keith, 1985 in NW Ohio and Indiana (which is probably also hydrothermal in origin)

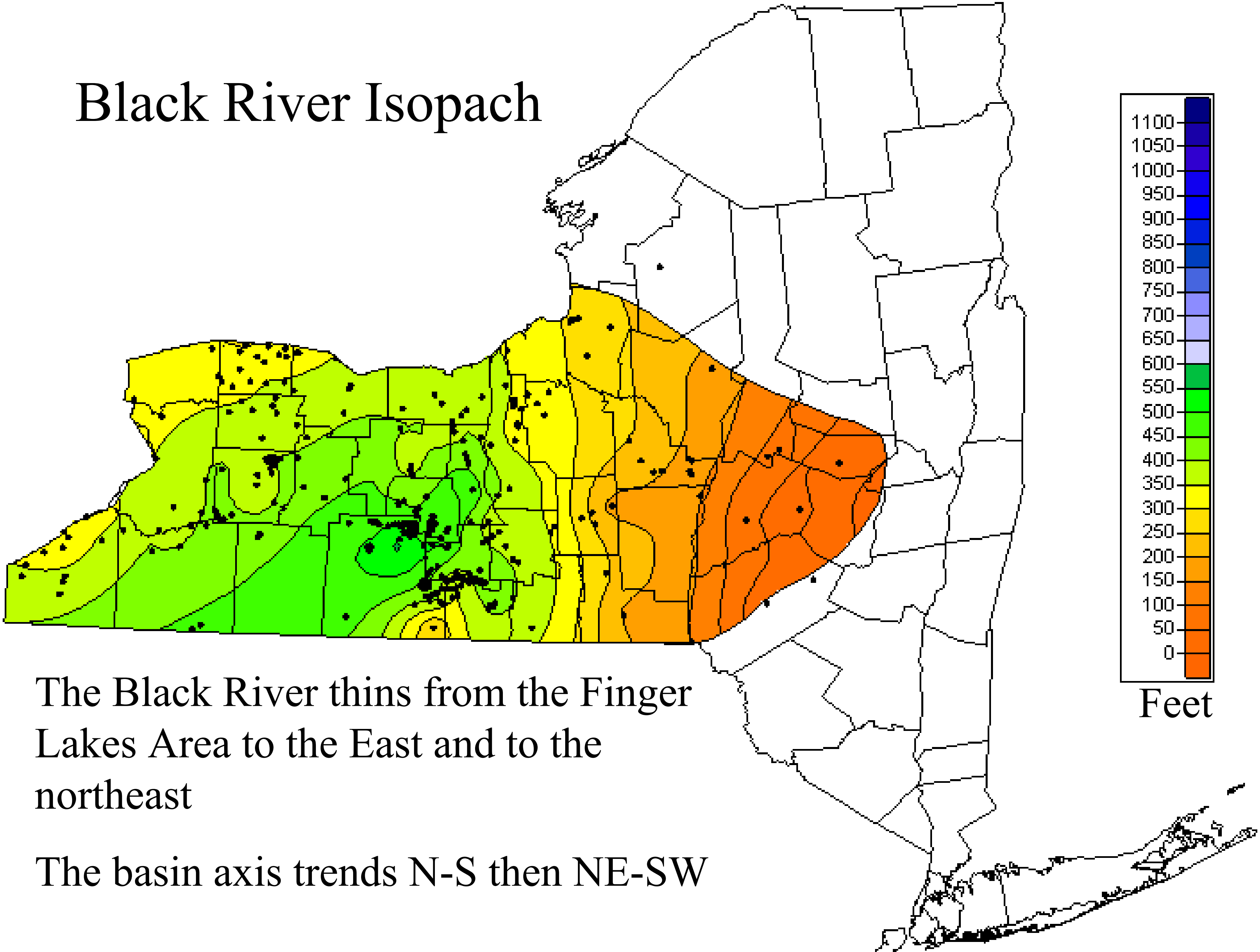


Could the Sebree Trough be a clay filled channel discharging from mountains?

Channel may have formed in subtle low and suppressed or halted carbonate production

Where else would clay come from?

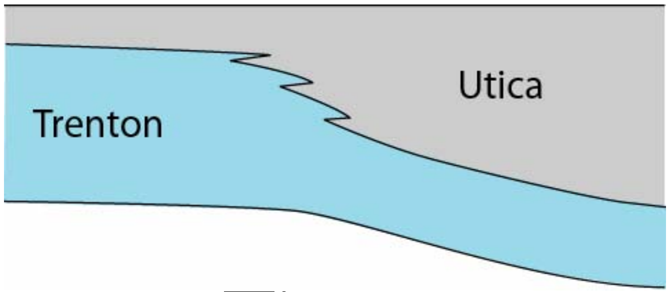
Black River Isopach

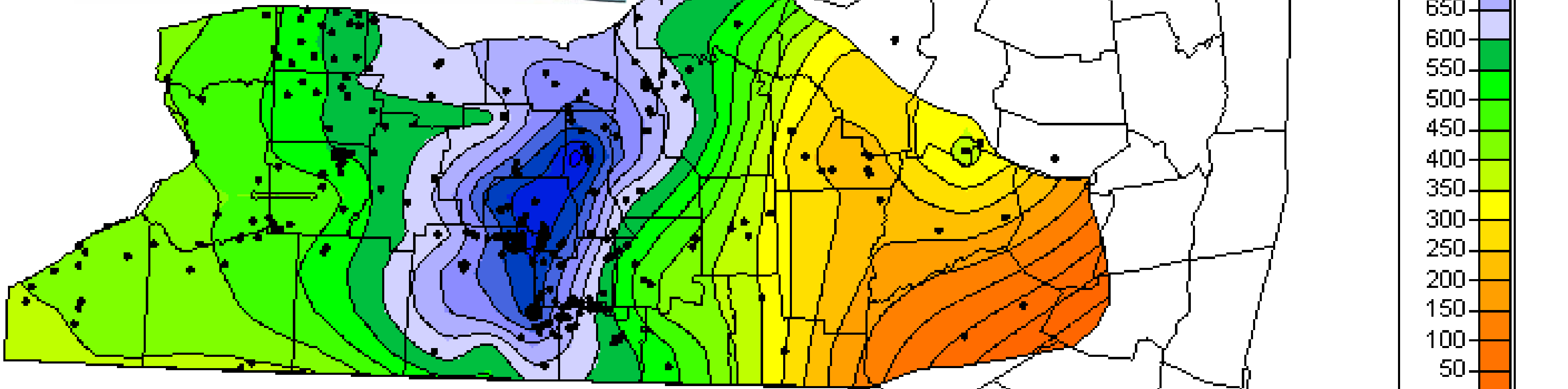


The Black River thins from the Finger Lakes Area to the East and to the northeast

The basin axis trends N-S then NE-SW

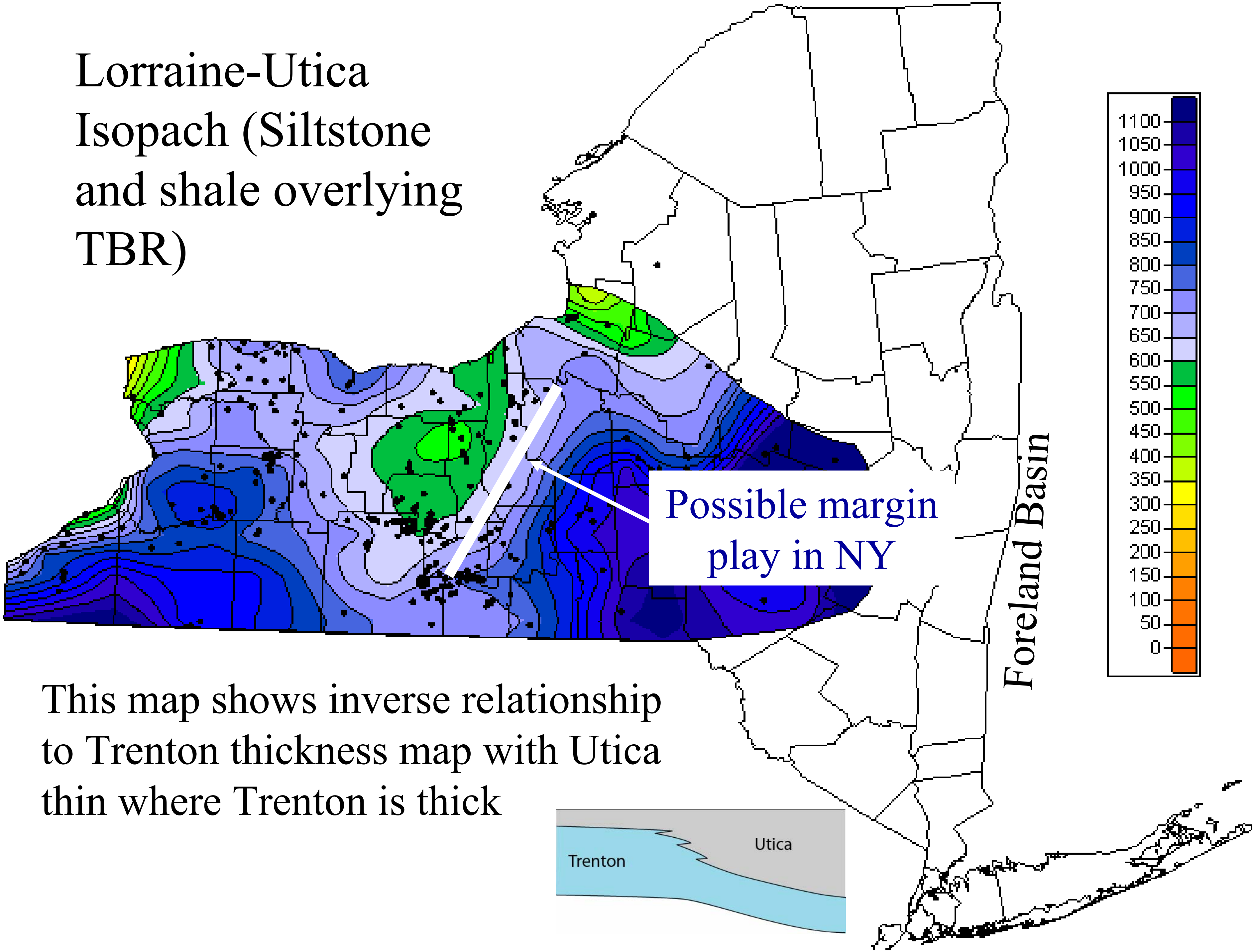
Trenton Isopach





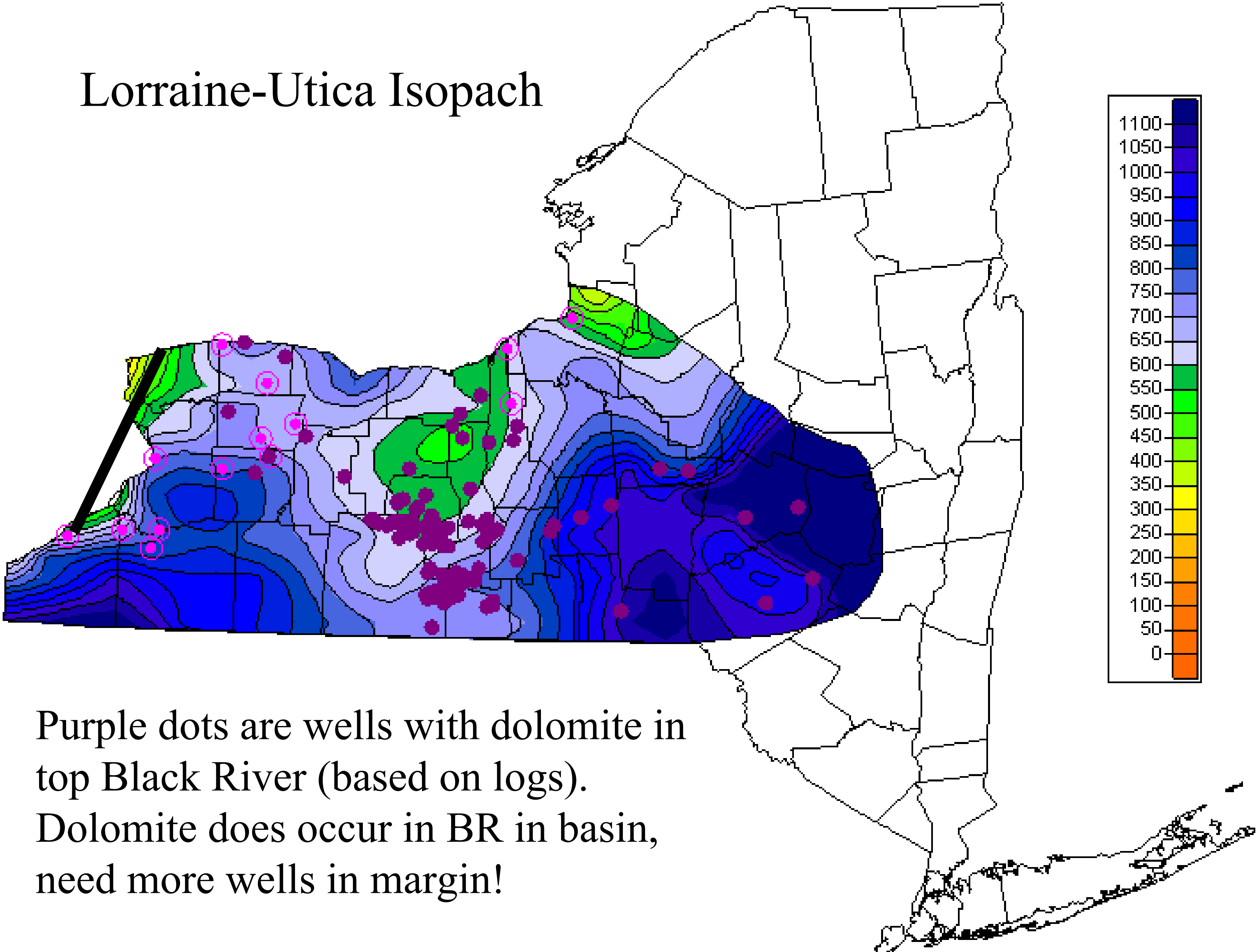
Onset of tectonic activity related to Taconic Orogeny leads to great thickness differences in Trenton – Top Trenton in thickest area is laterally equivalent to Utica

Lorraine-Utica Isopach (Siltstone and shale overlying TBR)

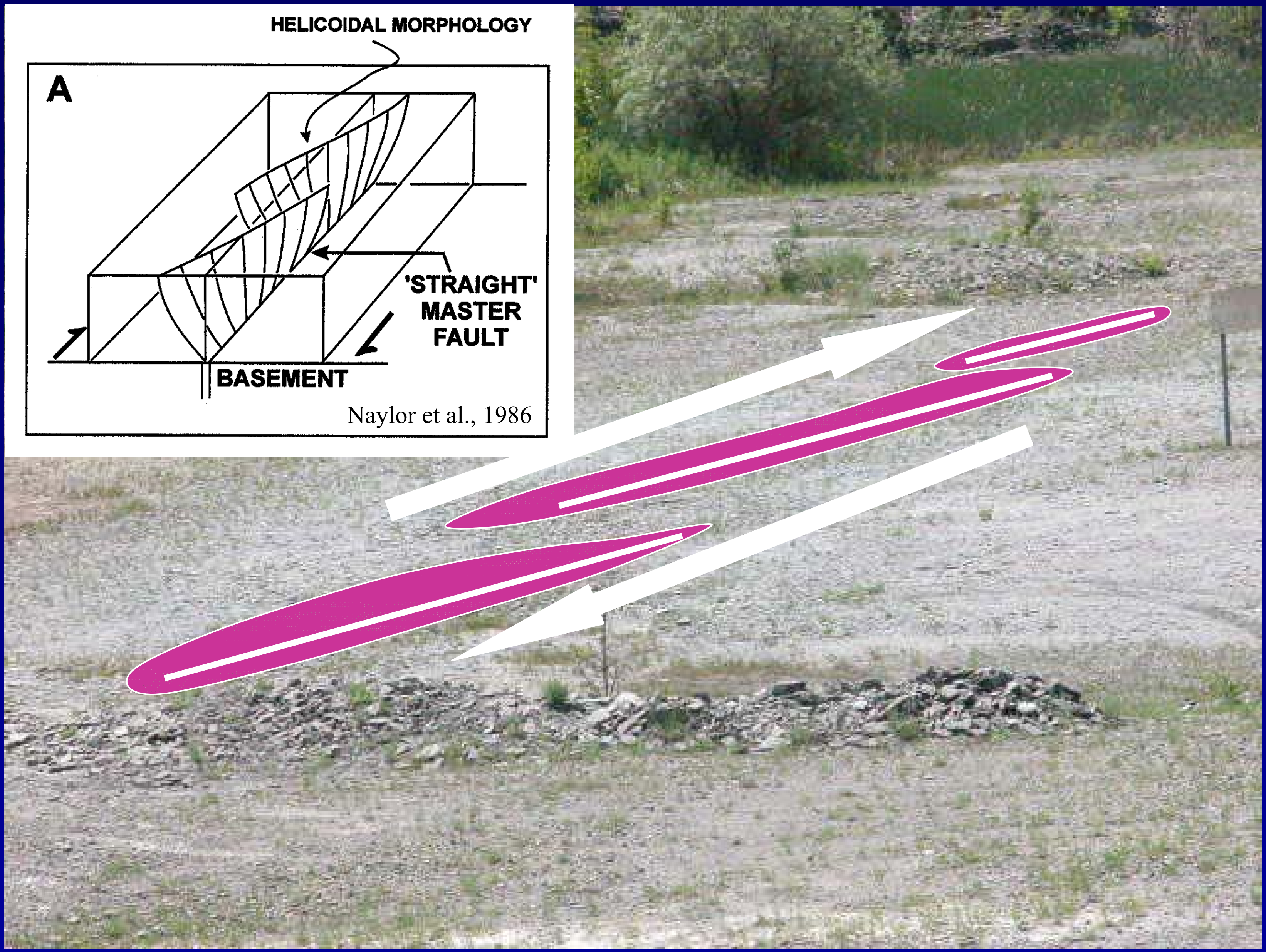


This map shows inverse relationship to Trenton thickness map with Utica thin where Trenton is thick

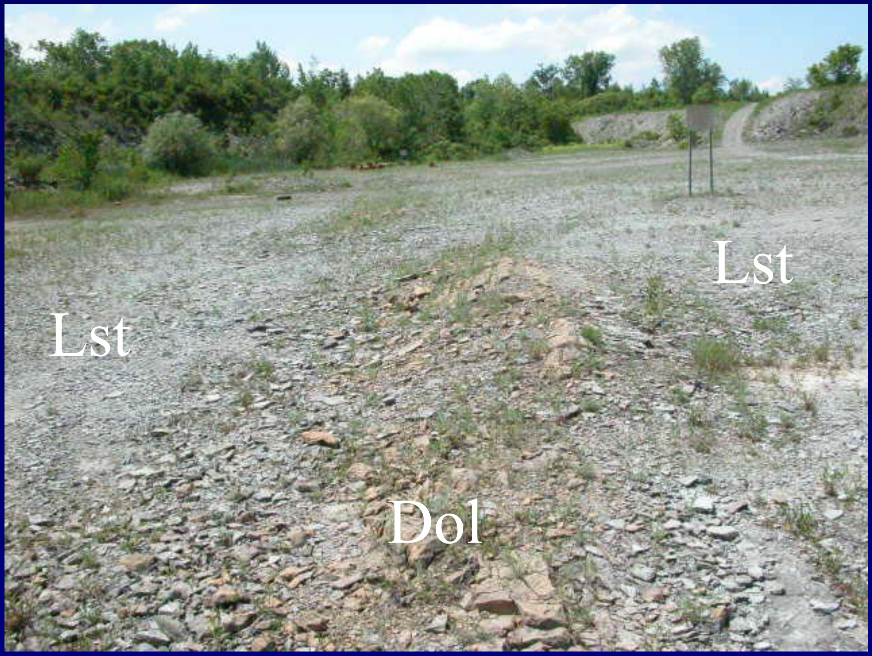
Lorraine-Utica Isopach

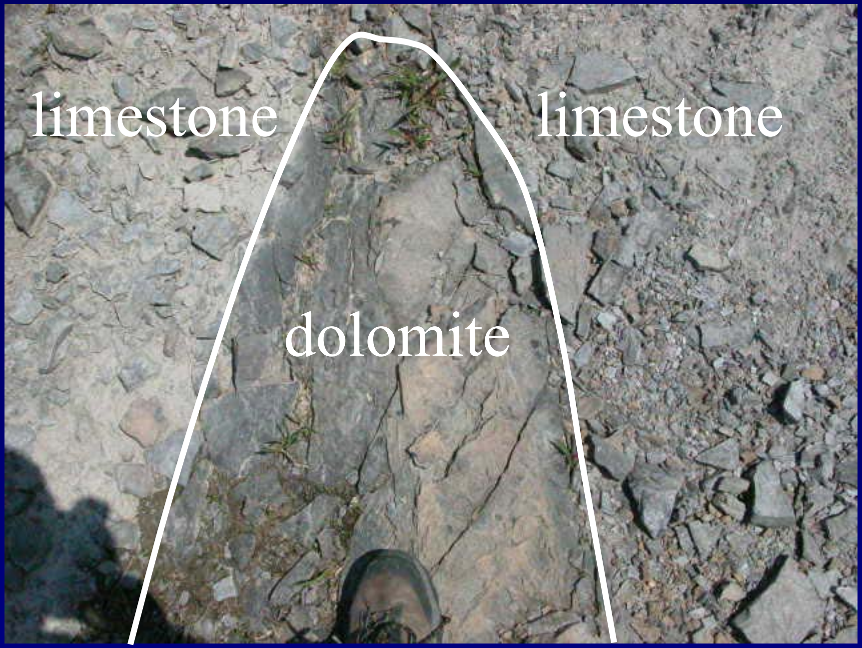


Purple dots are wells with dolomite in top Black River (based on logs). Dolomite does occur in BR in basin, need more wells in margin!



Dolomitization around Reidel Shears over right lateral strike-slip fault in Ordovician of New York





Ordovician Tribes Hill Formation outcrop, Mohawk Valley, New York