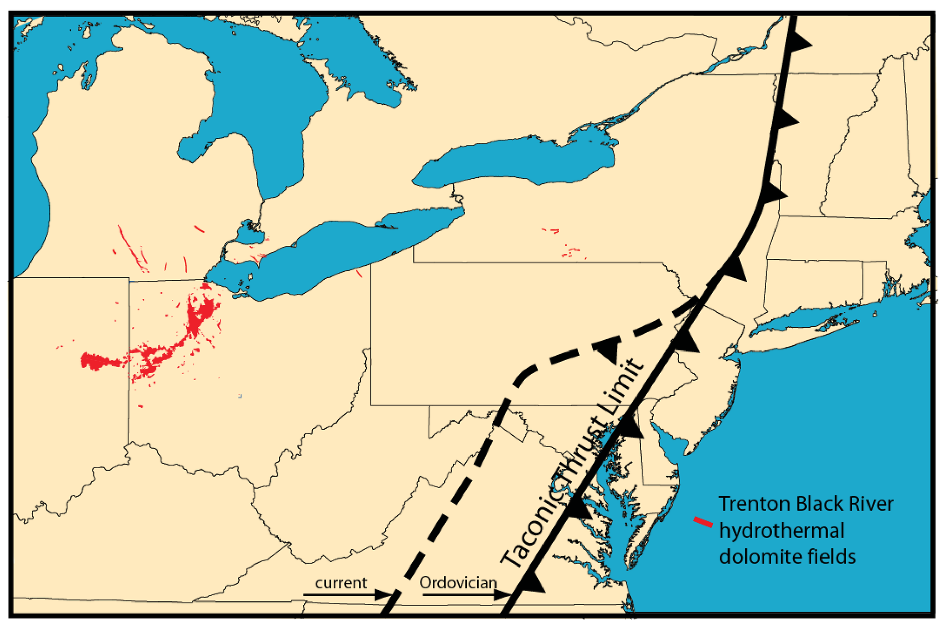
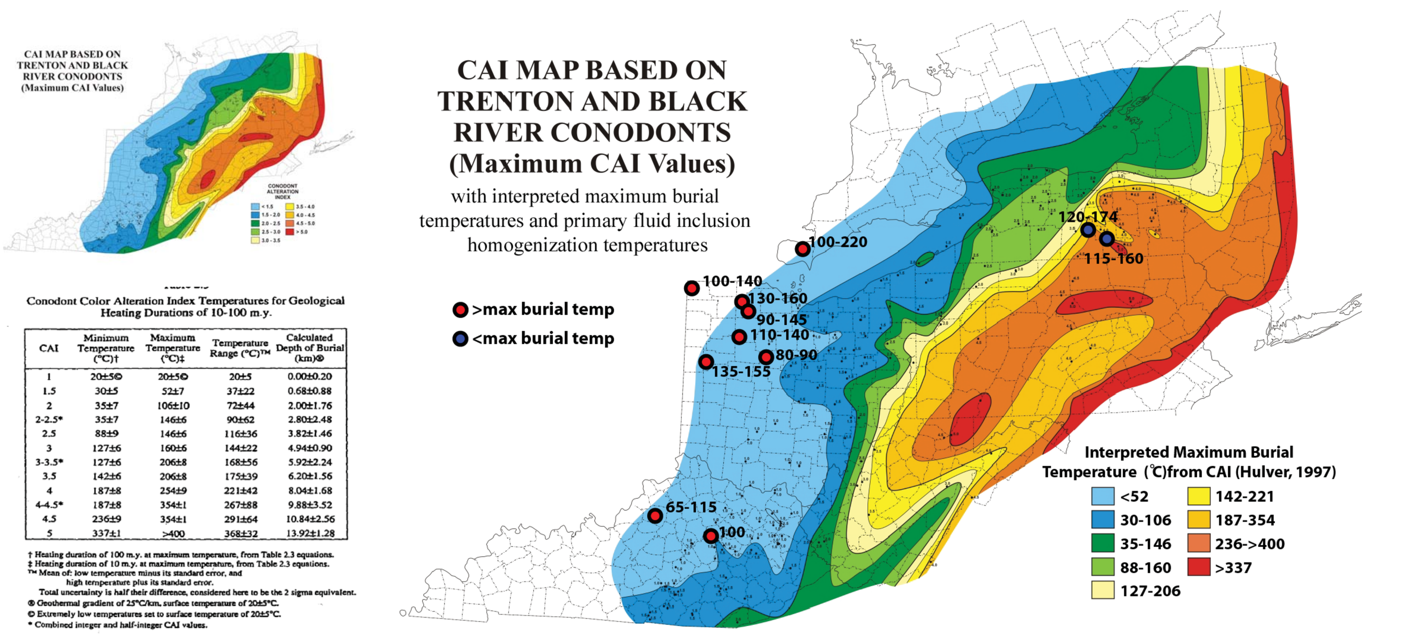
Regional Dolomitization

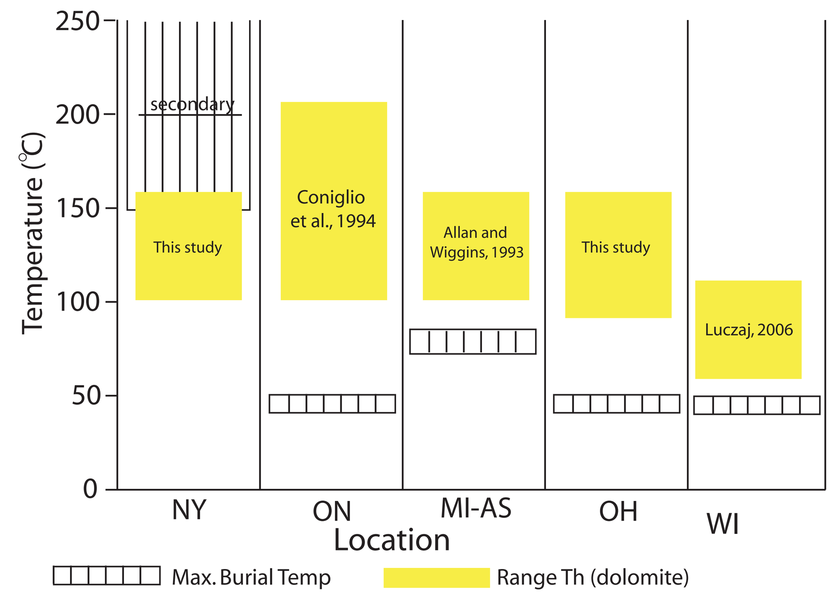
Many consider hydrothermal dolomite to only occur in small patches around faults: but its occurrence can be widespread and should be considered as a possible model for regional dolomitization



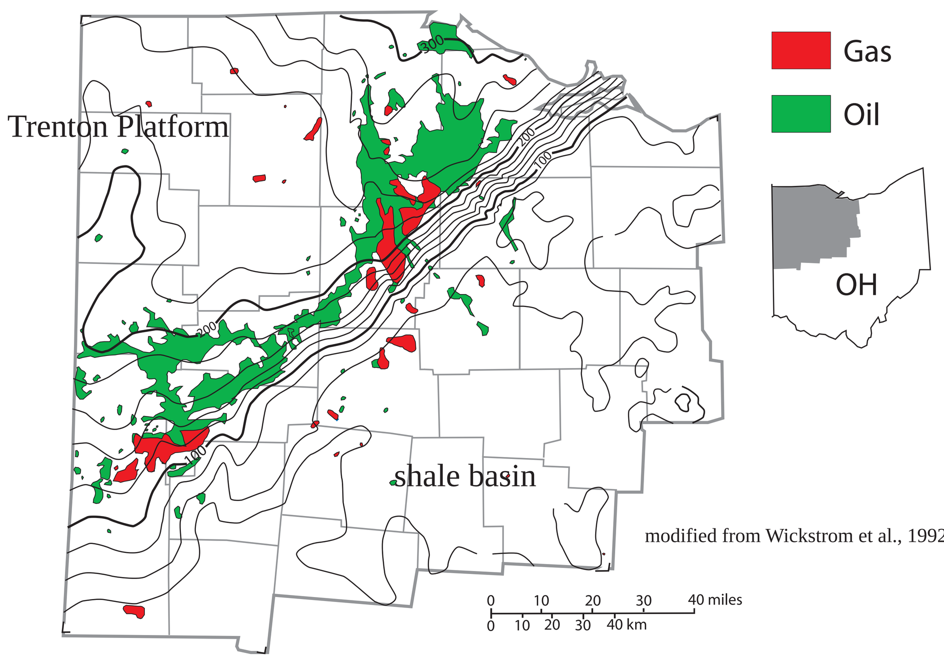
Map showing Upper Ordovician Trenton and Black River hydrothermal dolomite Fields.



Upper left shows CAI values from USGS (map by J. Harper). CAI values can be converted to maximum burial temps using Hulver (1997). Primary fluid inclusion homogenization temps from matrix and saddle dolomite plotted on the map show that most Trenton Black River dolomites are unequivocally hydrothermal



Primary fluid inclusion homogenization temperatures and maximum burial temperatures shows that most TBR dolomites are unequivocally hydrothermal.

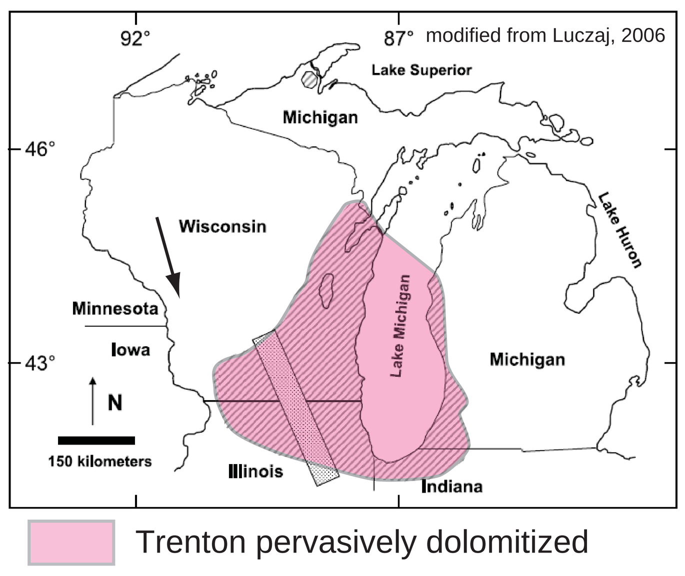


Dolomitized Trenton Black River oil and gas reservoirs, NW Ohio - there is a lot of dolomite not included that is tight (cap dolomite, etc)


Facies dolomite

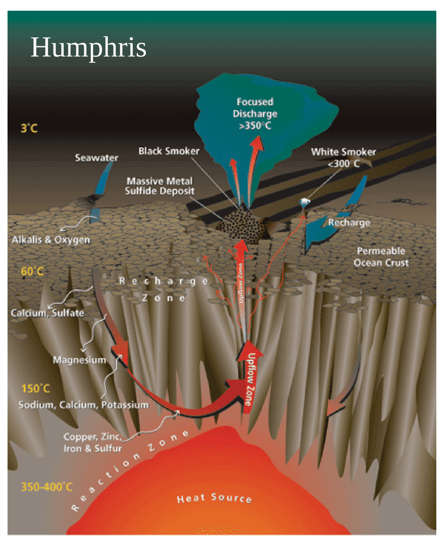

Fracture dolomite

• ~40 km³ in Ohio if facies dolomite and fracture related dolomite average of 50 feet thick (not including cap dolomite), ~65 km³ including 10 foot thick cap
• Assuming 30 volumes of saline brine at 100C to make on volume of dolomite (Machel and Mountjoy, 1987), 1.2 trillion m³ or 7.5 trillion barrels of water for facies and fracture dolomites, 12.2 trillion barrels of brine with cap dolomite just for mapped dolomite in Ohio
•That is enough to fill a sandstone 100 meters thick with 20% porosity that blanketed the state - this is about 5-10 times more porosity than exists- fluids must be recycled or added to system

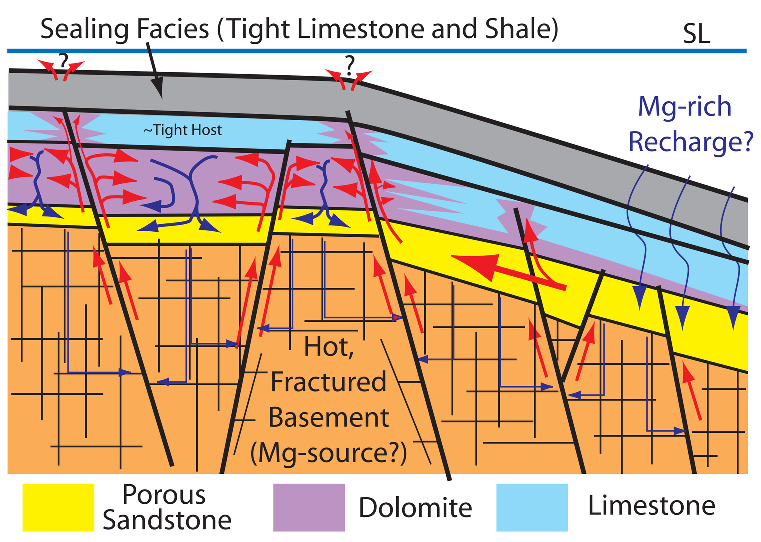


The Trenton Group is pervasively dolomitized along the southern and western margins of the Michigan Basin . The Trenton dolomite in Wisconsin is the type section for the mixing zone dolomite model of Badiozamani, 1973. Primary fluid inclusion homogenization teperaptures in this dolomite range from 60-120C - formation never buried more than 1 km (~45C) - all this dolomite likely to be hydrothermal (Luczaj, 2006). Many dolomites previously attributed to mixing zone may be hydrothermal. This volume of dolomite would probably require 100s of trillion barrels of fluid. This is far more than could be stored in the Michigan, Appalachian, and Illinois Basins.

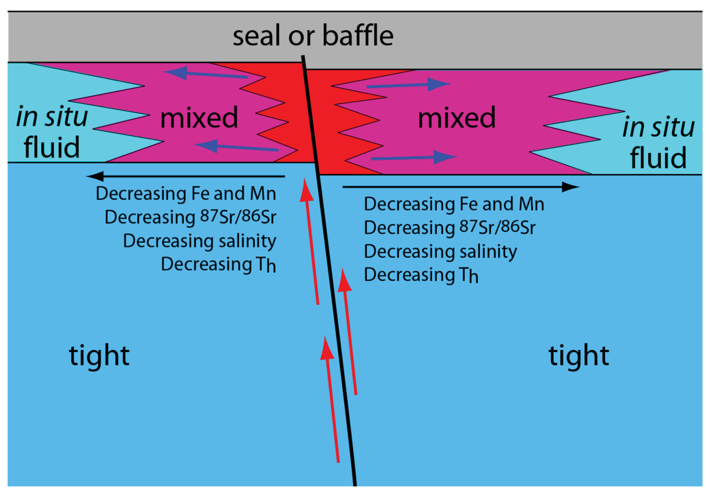
Possible Fluid Flow Models



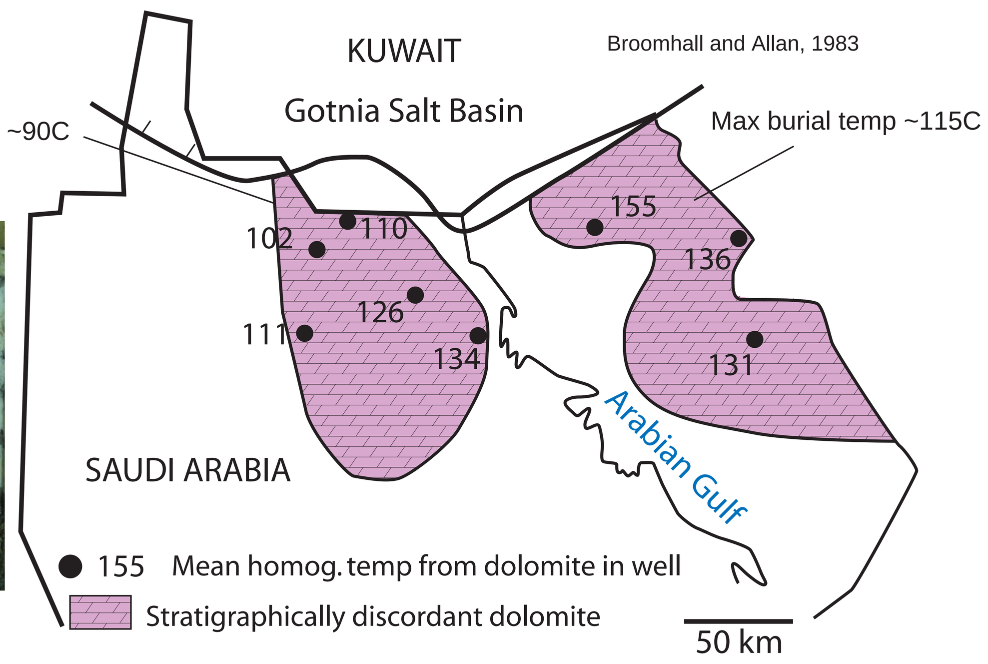
Fluids could convect downward across a wide area and be focused back upward in fault zones as occurs at mid-oceanic ridges



"Forced episodic convection" - Faulting could drive convection cycle between altered formation and deeper zones where heat and possibly Mg are acquired

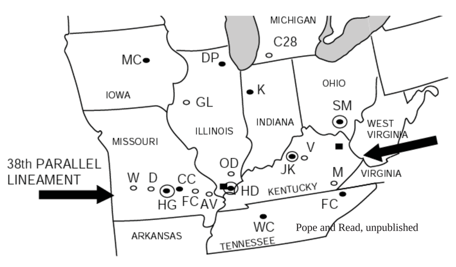


Some mixing may occur between the fault-derived fluids and in situ fluids (seawater?). The in situ fluids could provide magnesium, rising fluids provide heat.



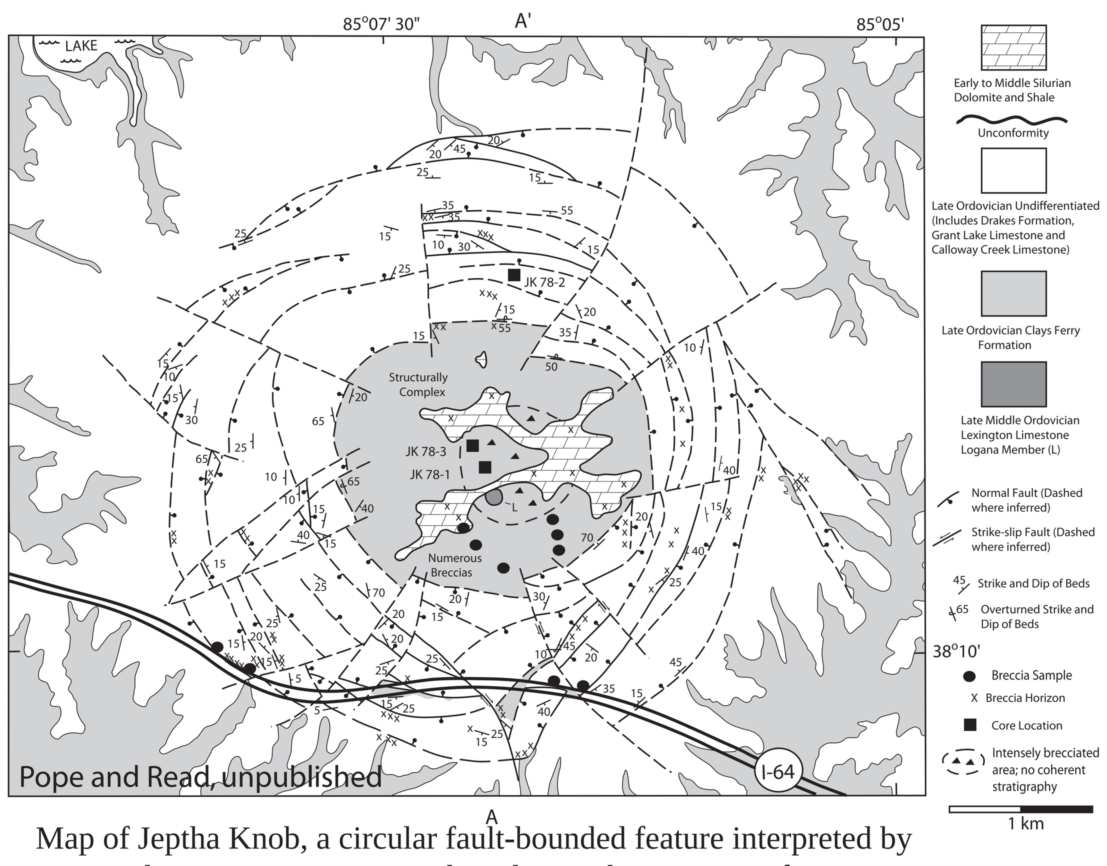
Not just the Trenton Black River- Occurrence of laterally extensive hydrothermal dolomite in Jurassic and Cretaceous strata near the margin of the Gotnia Salt Basin (modified from Broomhall and Allan, 1983). Fluid inclusion homogenization temperatures exceed maximum burial temperatures by up to 30 or 40C. There are many other examples as well including Devonian of WCSB, Carboniferous of Ireland, etc.

Impact Structure or Hydrothermally Altered Positive Flower Structure?

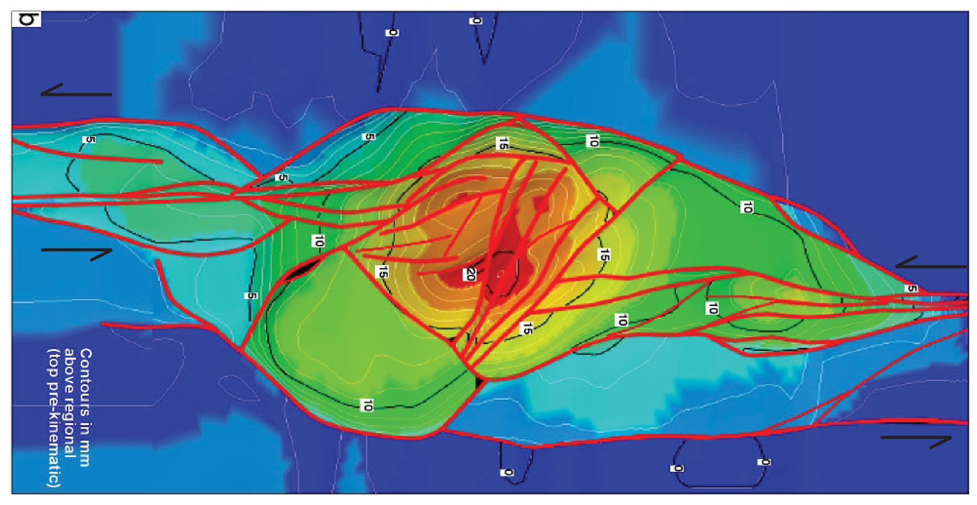


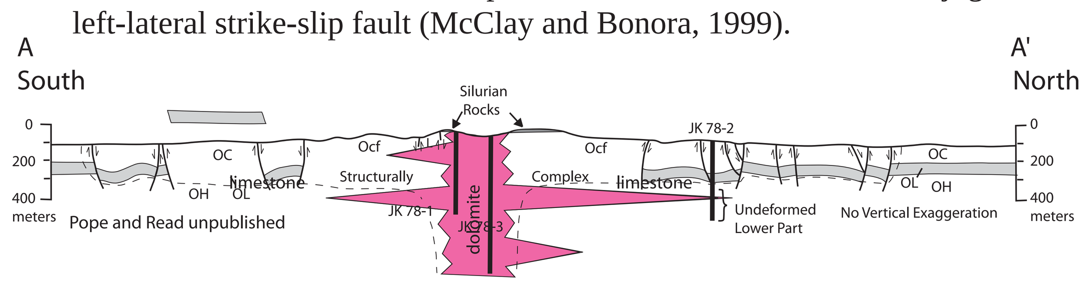
Map showing Jeptha Knob and other subcircular features.


Cores showing porous and permeable dolomite from Jeptha Knob

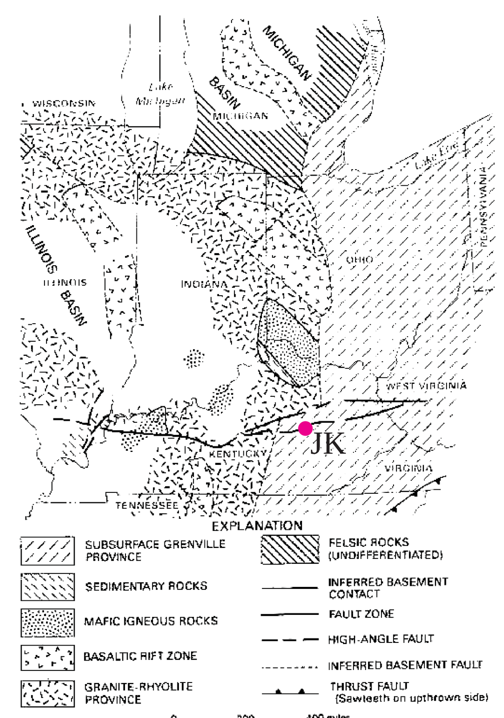


Map of Jeptha Knob, a circular fault-bounded feature interpreted by some to be an impact structure, by others to be a tectonic feature Silurian strata not affected by faulting


Sandbox model of sub-rounded positive flower structure formed at jog on left-lateral strike-slip fault (McClay and Bonora, 1999).



Cross section through Jeptha Knob -Core of structure is dolomitized, flanks are limestone. Multiple breccia beds occur in off structure well that are interbedded with the stratigraphy and could not be a single event.



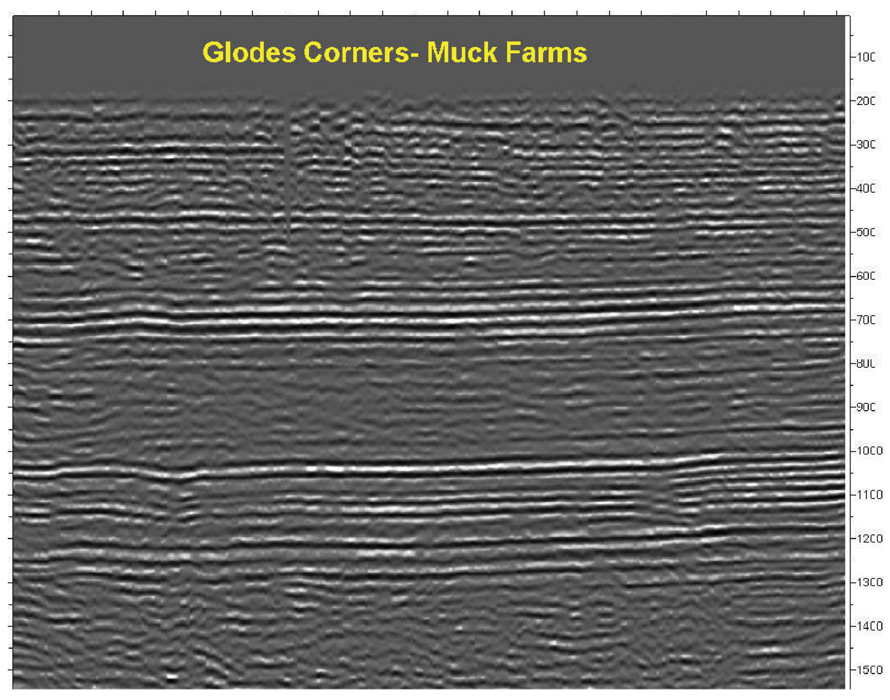
Jeptha Knob is very near the 38th parallel lineament which is a major right-lateral strike slip fault in the basement. Jeptha Knob may be related to this fault system (Wickstrom et al., 1992).

Changing Paradigms

Structurally controlled hydrothermal alteration is far more common than previously thought and is an important model for carbonate diagenesis on par with meteoric, reflux or any other model.

Paradigms on burial diagenesis, the origin of leached limestone, microporosity and leached dolomite, brecciated carbonate reservoirs and regional dolomitization should be reexamined. Some diagenesis previously attributed to those models may in fact be of a structurally controlled hydrothermal origin.

At the very least structurally controlled hydrothermal alteration should be considered as a possible model that needs to be ruled in or out whenever burial diagenesis, leached limestone and dolomite, brecciated carbonates or regional dolomitization is encountered.



Recognition of very subtle wrench faults active during or soon after deposition is the key - Many might pass over these features as bad data

Acknowledgements

We would like to thank John Martin and NYSERDA, the US Department of Energy, Talisman Energy and all of the supporters of Grahamd Davies multi-client study on hydrothermal dolomitization for their financial support of this research. We would also like to thanks Rich Nyahay and the rest of the Reservoir Characterization Group at the New York State Museum for their tireless efforts.

Thanks also to Talisman Energy, Ardent Resources, Encana, and others for allowing us to use their seismic and other data.