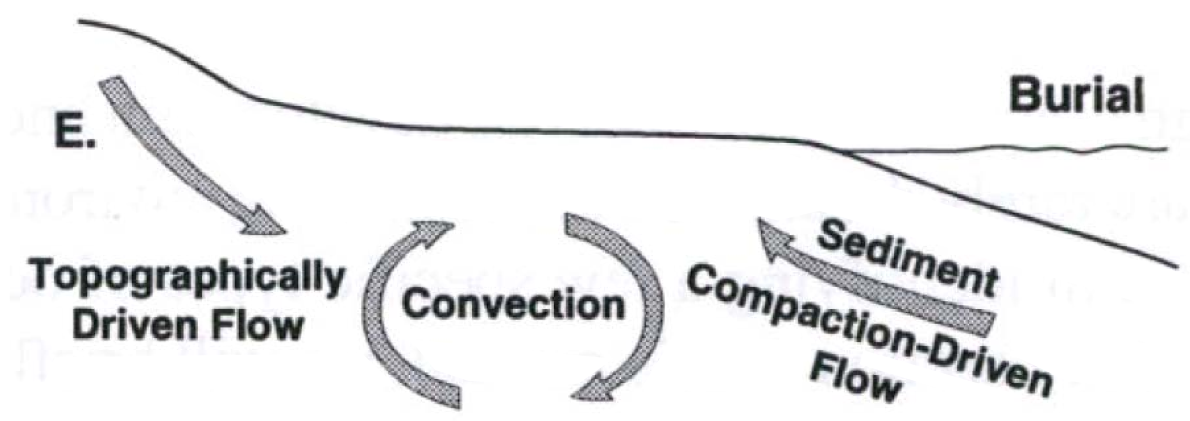
“Deep Burial” Diagenesis vs. Hydrothermal Diagenesis

Main Points: Hydrothermal diagenesis commonly occurs at relatively high pressures and temperatures but at shallow depths (<1km)
Much diagenesis previously interpreted to occur at depths of several kilometers may occur at much shallower depths

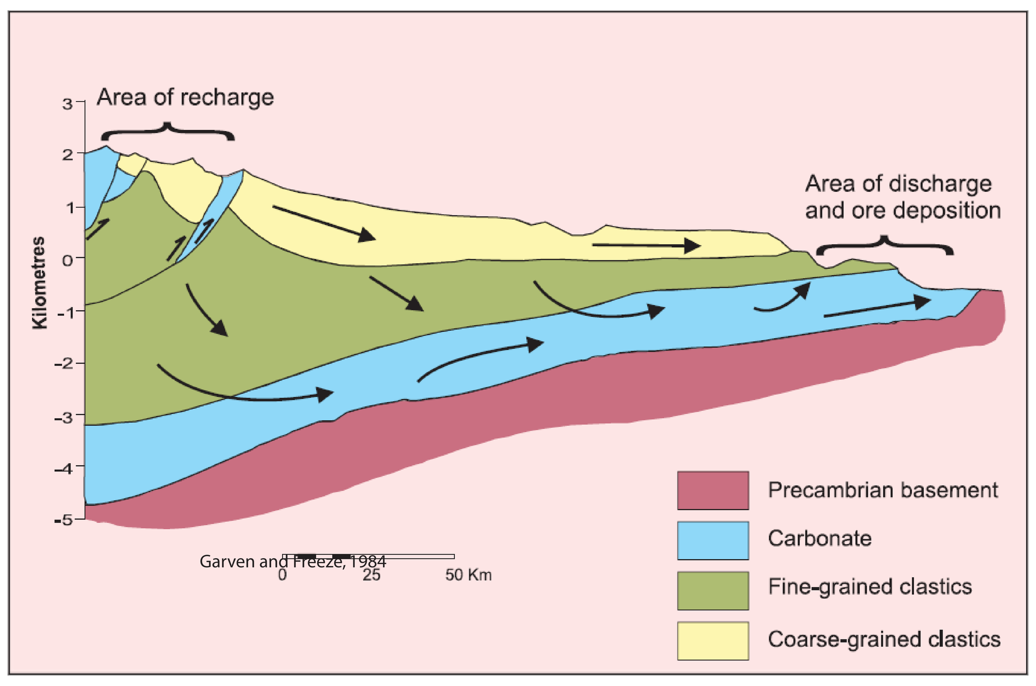


Commonly applied models for “burial” dolomitization from Allan and Wiggins (1993). Even though they use an example from the Trenton Black River, hydrothermal dolomitization is not listed as a model. They are not alone in minimizing the importance of fault-related fluid flow.

Stylolites -Not Necessarily That Deep!

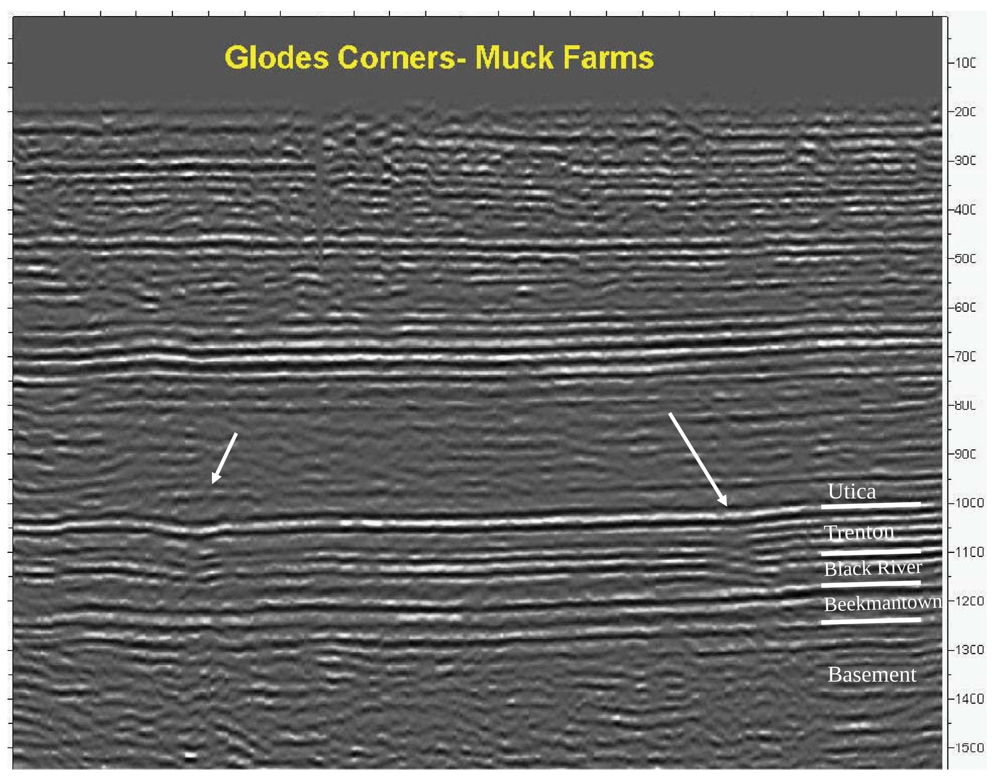
Many workers see evidence for minor pressure solution occurring prior to matrix dolomitization. Many workers then use a depth of >800-1000 meters for onset of pressure solution and interpret the dolomitization to have occurred at that depth or greater. Incipient pressure solution can actually start within a few tens of meters of burial (30 meters - Railsback, 1993).

Core sample from Ellenburger Formation, Marble Falls, TX, shows well developed stylolites in dolomite but formation was never buried more than 350m at this location (Kupecz and Land, 1991). Major stylolites can therefore form at depths <350 meters. Hydrothermal alteration may promote early onset of stylolitization.



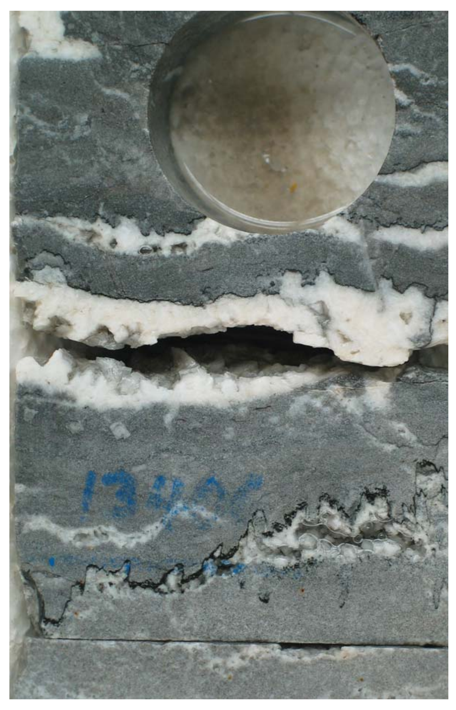
Topographically-induced fluid flow model. Fluid Flow rates 1-10m/yr, water is fresh, not hypersaline brine, will precipitate calcite as it is warmed - hard to see how this could make hot dolomite.

Evidence for Shallow Emplacement



Sags formed by faulting are filled shortly after deposition of the Black River during Trenton and Utica time. This suggests that alteration occurred soon after deposition when the Black River was buried to a depth of <350m.

Many hydrothermally altered reservoirs have an abundance of sub-horizontal fractures suggesting relatively shallow burial depth at the time of alteration (principal compressive stress horizontal, not vertical).



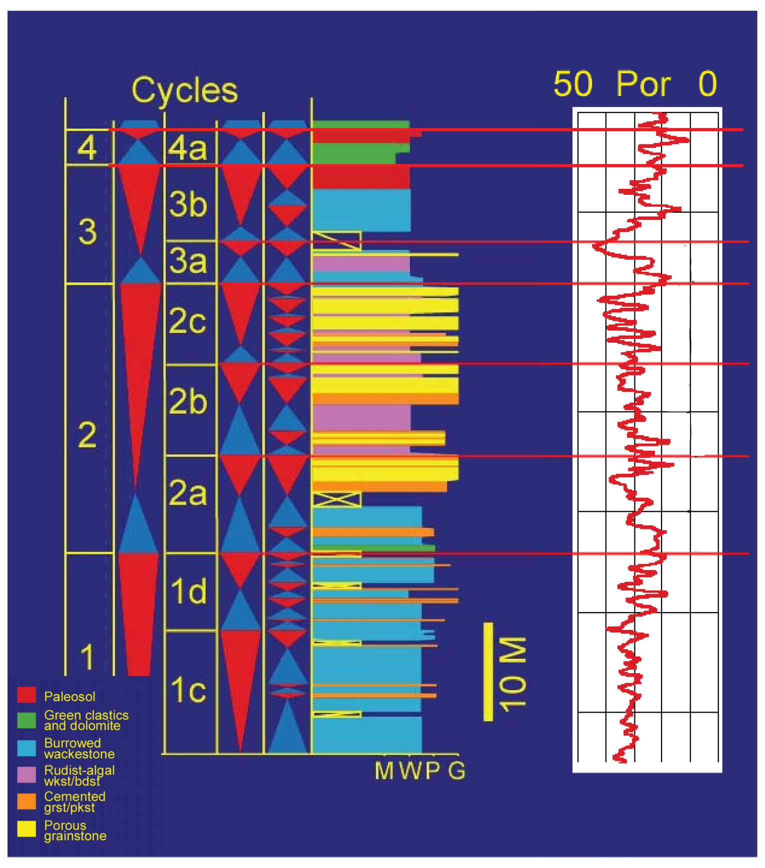
Major stylolites almost always postdate fracturing and dolomitization. Minor pressure solution may precede dolomitization.

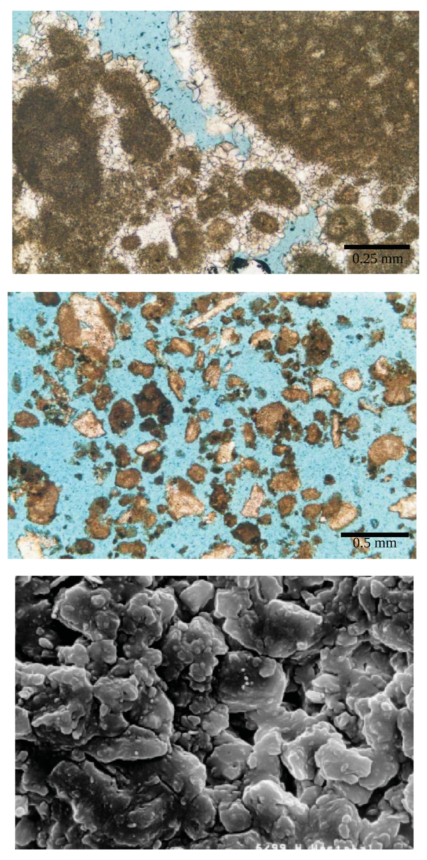
Model	Potential Volume	Salinity	Temperature	Pressure	Continuity	Rate (m/yr)
Topographic Recharge	High	Low (meteoric)	~Ambient	~Ambient	~Continuous (seasonal?)	.1-100
Sediment Compaction	Low	Low-High	~Ambient	~Ambient	Waning	.1-100
Free Convection (no faults)	Low(?) (perm barriers)	Low-High	~Ambient	~Ambient	Continuous (when occurring)	.001-1 (?)
Fault-Related Hydrothermal	High	Low-High	>>Ambient	>>Ambient	Episodic	Up to 100,000,000 (6 m/s)

Hydrothermal fluids can better overcome rock buffering because they have different pressure, temperature and composition than ambient and are introduced at very high rates

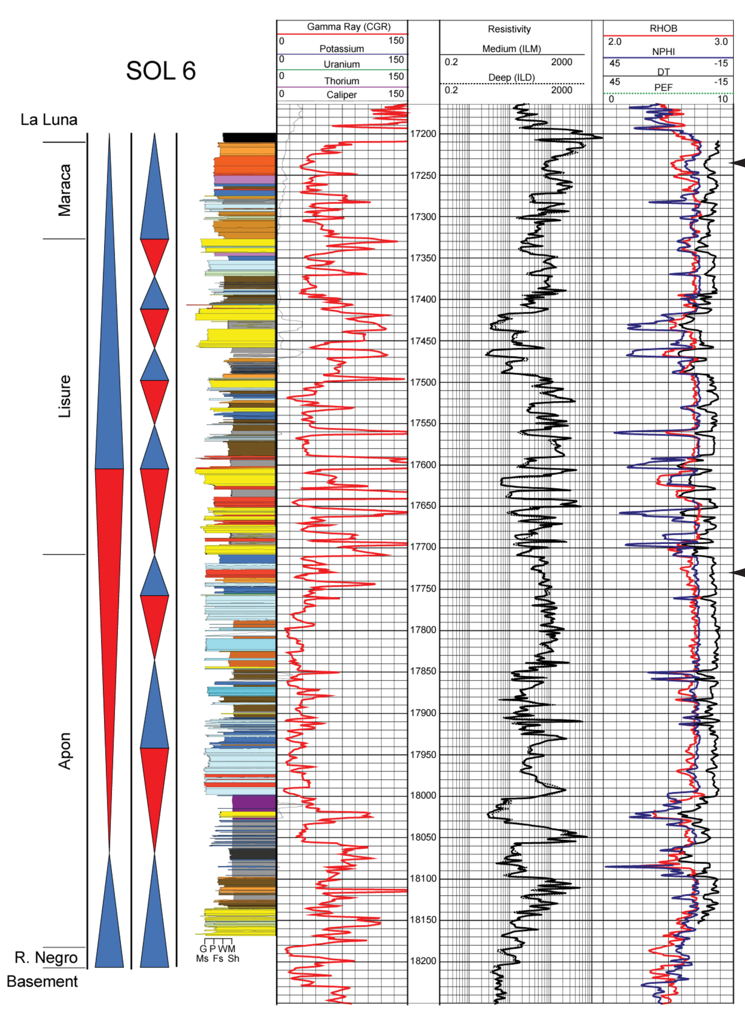
Meteoric vs. Fault-Sourced Fluid Leaching and Development of Microporosity

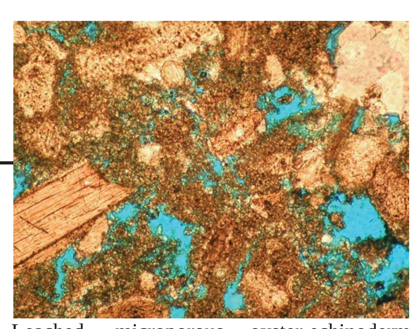
Main Points: Leaching of limestone matrix and development of microporosity may be occur due to acidic fluids flowing up faults and then laterally rather than by meteoric fluids which might only affect matrix within a few meters of unconformities



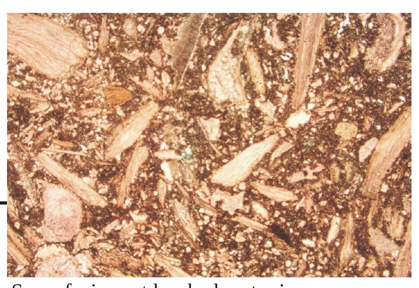


Core description from Cretaceous Natih E reservoir, Al Ghubar Field, Oman. Strata generally tighter beneath sequence boundaries. Meteoric diagenesis probably mainly resulted in cementation (A). Reservoir is incredibly leached in some places (B) and microporous throughout (C). The leaching is here thought be fault-related - many fields in Oman overlie strike-slip faults.



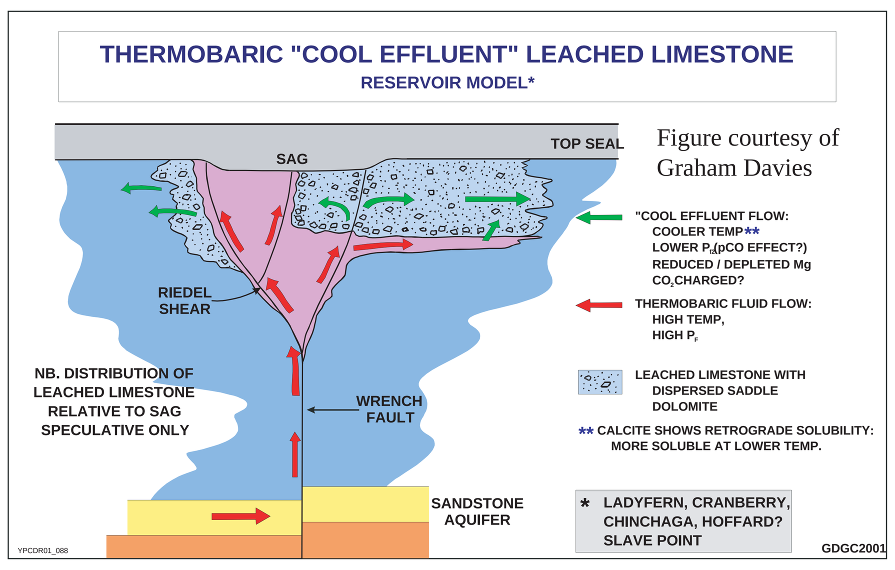


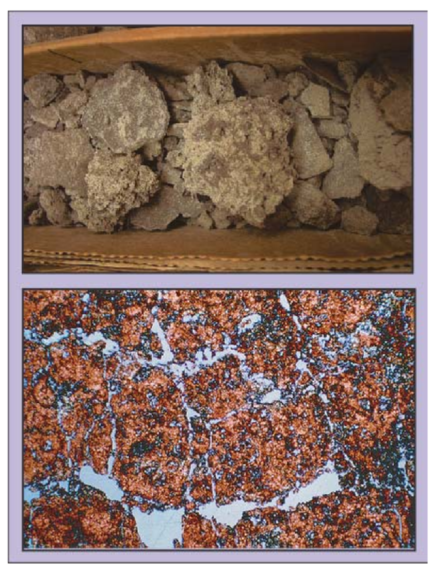
Leached, microporous oyster-echinoderm pelecypod packstone



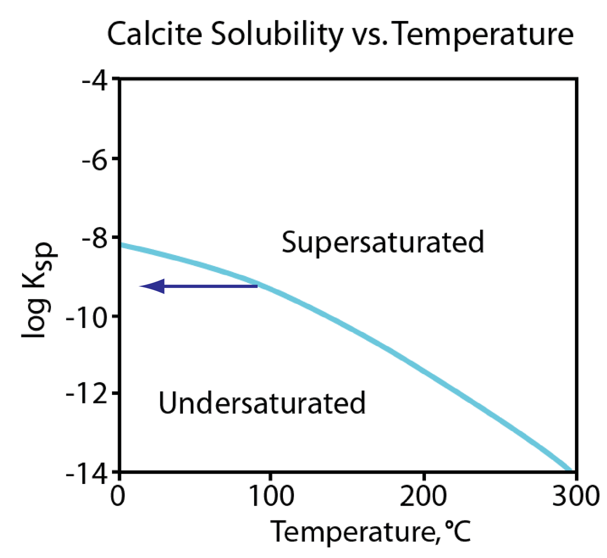
Same facies not leached, not microporous

Example from Cretaceous Cogollo Group - Leaching is key to reservoir development - leaching most common around strike-slip faults - much less common elsewhere

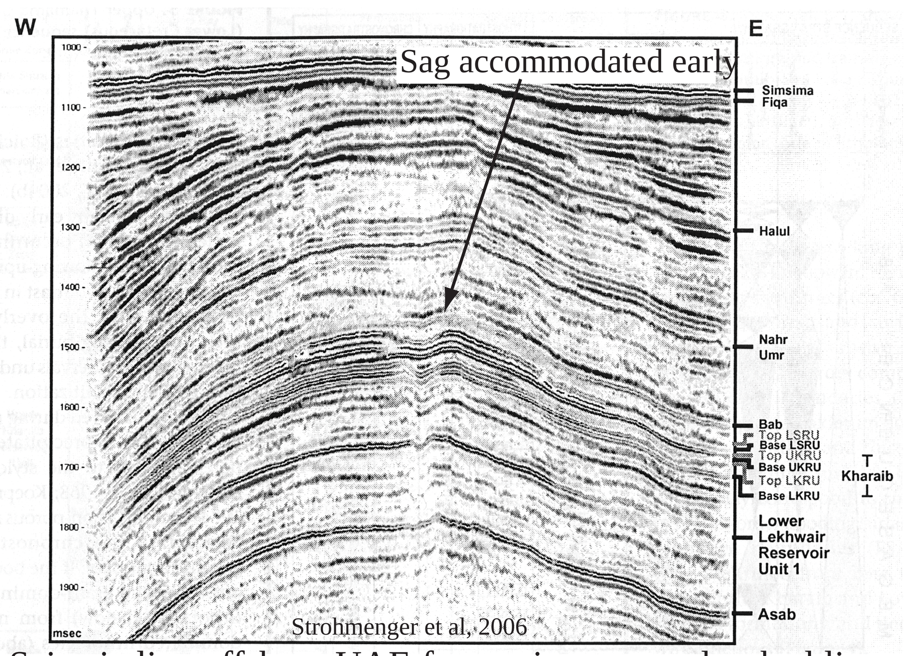




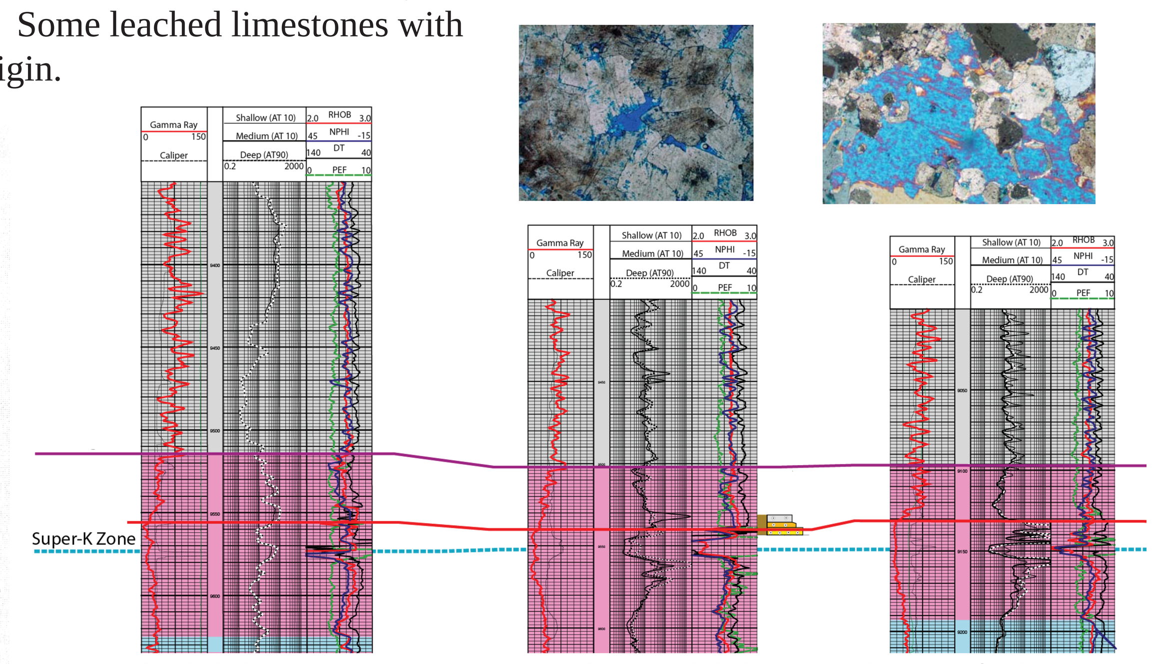
A halo of leached microporous limestone commonly occurs around fault-related hydrothermal dolomites. This example is from the Ladyfern Field in the WCSB where there may as much gas in the leached limestone as there is in the dolomite. Some leached limestones with little or no associated dolomites may be of a hydrothermal origin.



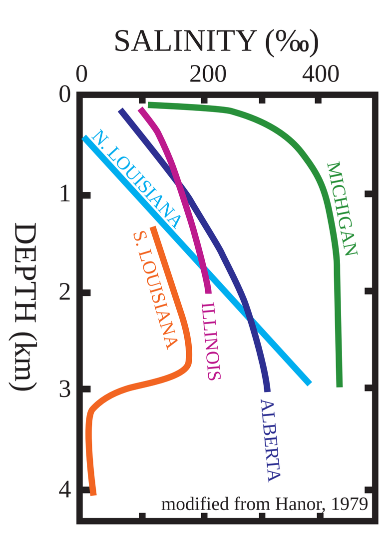
Cooling fluids become progressively undersaturated



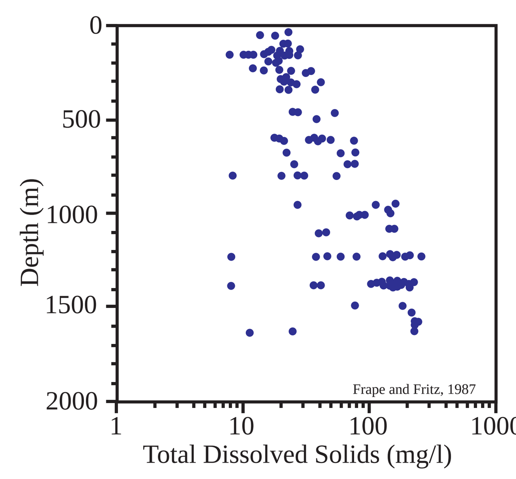
Seismic line offshore UAE from microporous leached limestone field shows fault-related sag - possible leaching source



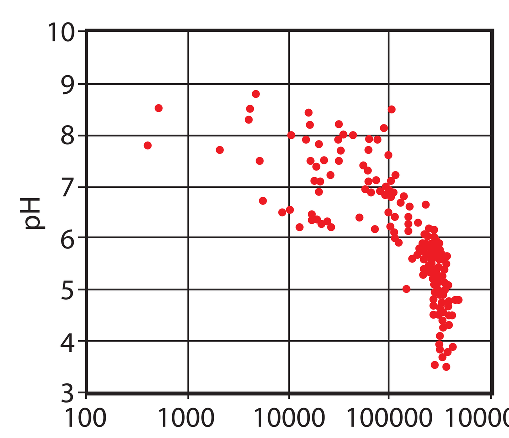
Leached dolomite - In some cases, leached dolomite (that is of a high-T origin) can enhance perm and in some cases make super-k zones



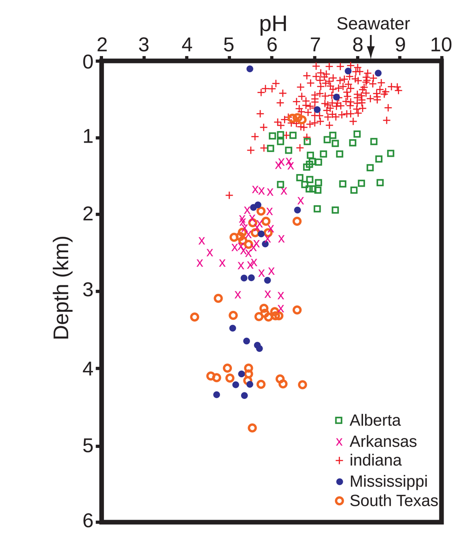
Salinity in sedimentary basins generally increases w/depth



Salinities of pore fluids from crystalline rocks of Canadian Shield also increase with depth



PH decreases with increasing salinity



pH decreases with depth- fluids flowing up faults will have lower pH than overlying units