

# **A Hydrothermal Dolomite Model for the Cheyenne Wells and Smoky Creek Fields, Colorado\***

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## **Abstract**

The adjacent Cheyenne Wells and Smoky Creek Fields, along the Las Animas Arch in southeastern Colorado, have together produced over 9.2 million bbls oil (2019), largely from the Mississippian Spergen Formation. Hydrocarbons are produced from combination traps, where lime grainstones are dolomitized, resulting in enhanced porosity. Dolomitized zones are irregularly distributed across the fields resulting in highly variable well recoveries.

As a result of the Mississippian collision of the North and South American plates, the Mississippian section is densely block-faulted. Late Mississippian uplift of the blocks resulted in a paleotopography that provided the necessary relief for a well developed karst topography on top of uppermost carbonate unit, the Mississippian St. Louis Formation and within the underlying carbonate units. This is evidenced by formation thickness changes shown in well logs. Previous workers documented that the paleotopography helped localize later overlying Morrow Formation channels. Sinkholes and caves in the Mississippian section may retain porosity or be sediment filled with porosity destroying Pennsylvanian sediments.

Hydrothermal dolomitization is a porosity producing mechanism described for several fields in the United States and Canada. Dolomite porosity in the Mississippian carbonates at these fields is generated by this mechanism. With this model, basin sourced hydrothermal fluids rise along faults and through solution-related features to create porosity in adjacent carbonates. Mineral indicators of this process include the presence of hydrothermal minerals such as saddle (baroque) dolomite, megaquartz and chalcedony. All are present in cores taken from the field complex.

Fluid inclusion work on the cores confirms the alteration temperature range of hydrothermal dolomitization. Saddle dolomite fluid inclusions commonly range between 80-235° C. Previous workers determined that saddle dolomite fluid inclusion data from cores in these fields give a temperature of 121.5-135° C near the middle of the expected range. Two samples of megaquartz taken from cores provide fluid inclusion temperatures of 80-115° C and 67.3-124.8° C. The upper ends of these ranges correspond with published hydrothermal dolomite model homogenization temperatures for megaquartz.

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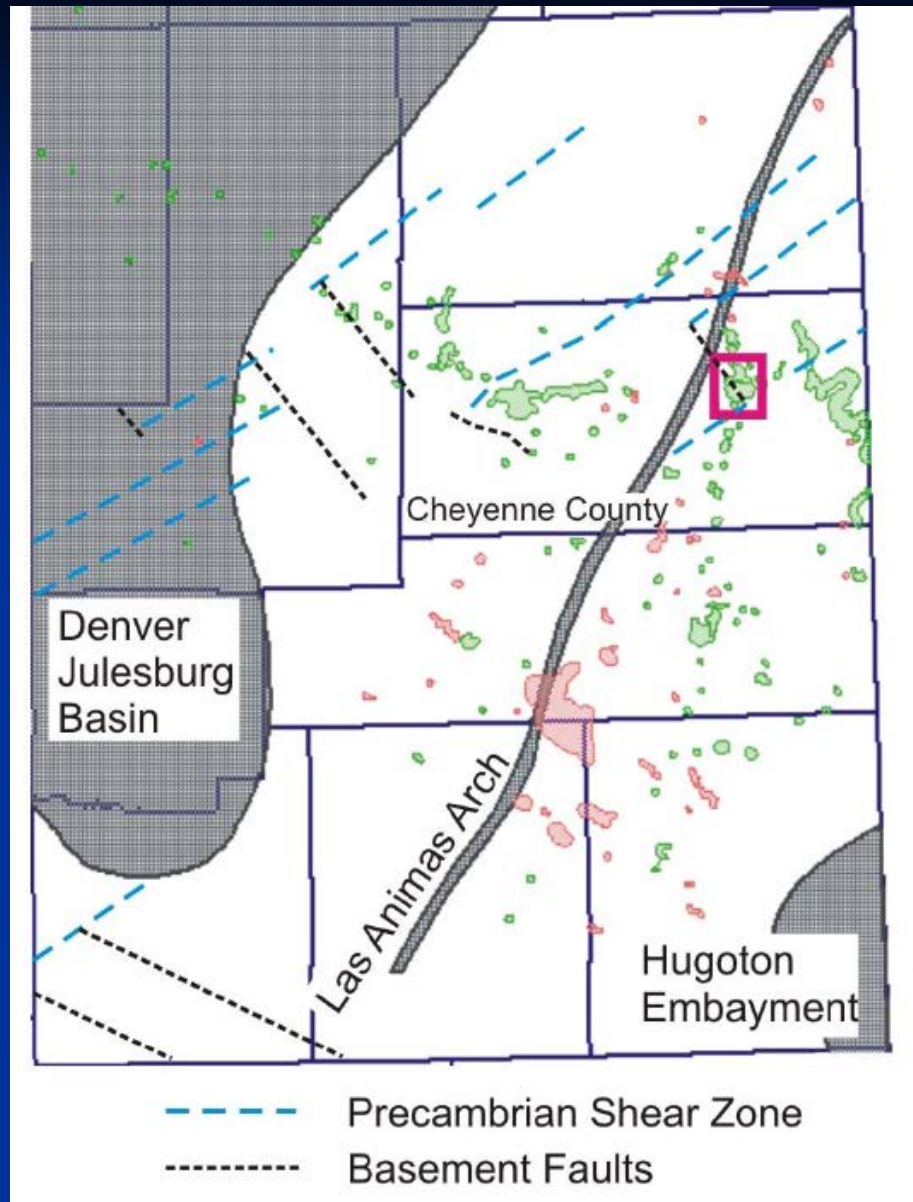
Sonnenberg, S.A., 1985, Tectonic and Sedimentation Model for Morrow Sandstone Deposition, Sorrento Field Area, Denver Basin, Colorado: AAPG Bulletin, v. 69/8, p. 1319.

# A Hydrothermal Dolomite Model For the Cheyenne Wells / Smoky Creek Fields, Colorado

By

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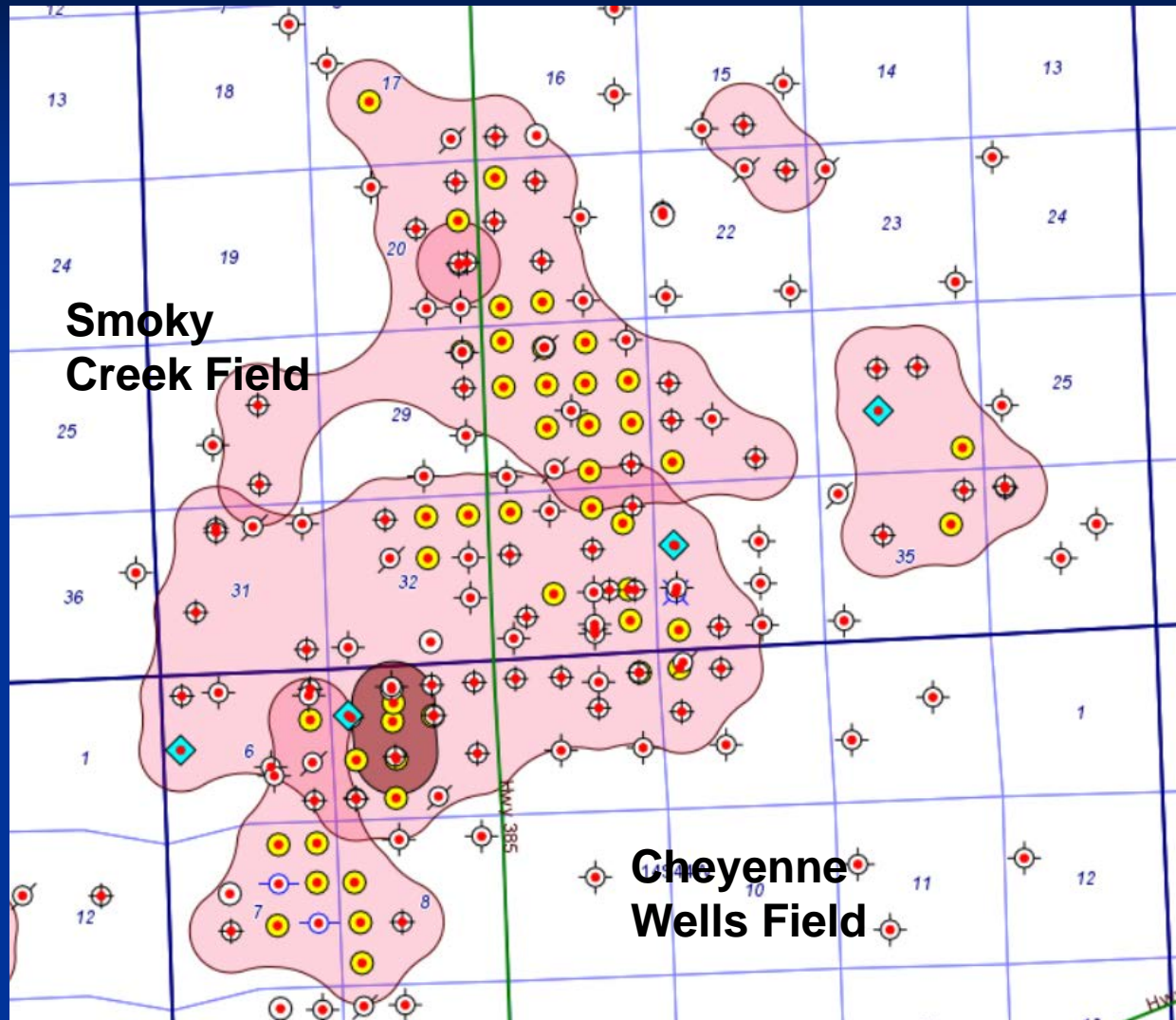
# Field Location Map in SE Colorado



From Givens(2006), Lineaments from Sims et al (2001) , Fields From <http://oil-gas.state.co.us/infosys>

# Cheyenne Wells and Smoky Creek Fields

T 13 S



R 44 W

From Colorado Oil and Gas Commission

# Combined Field Production

- Cheyenne Wells Field: 23 Wells
- Smoky Hills Field: 22 Wells
- Combined Production Over 9.200,000 bbls oil since discovery in 1968
- Average Production: 204,000 bbls / well to present (2019)
- Most of the Production from Mississippian Spargen Carbonates

# Stratigraphic Units

- Field Area Production

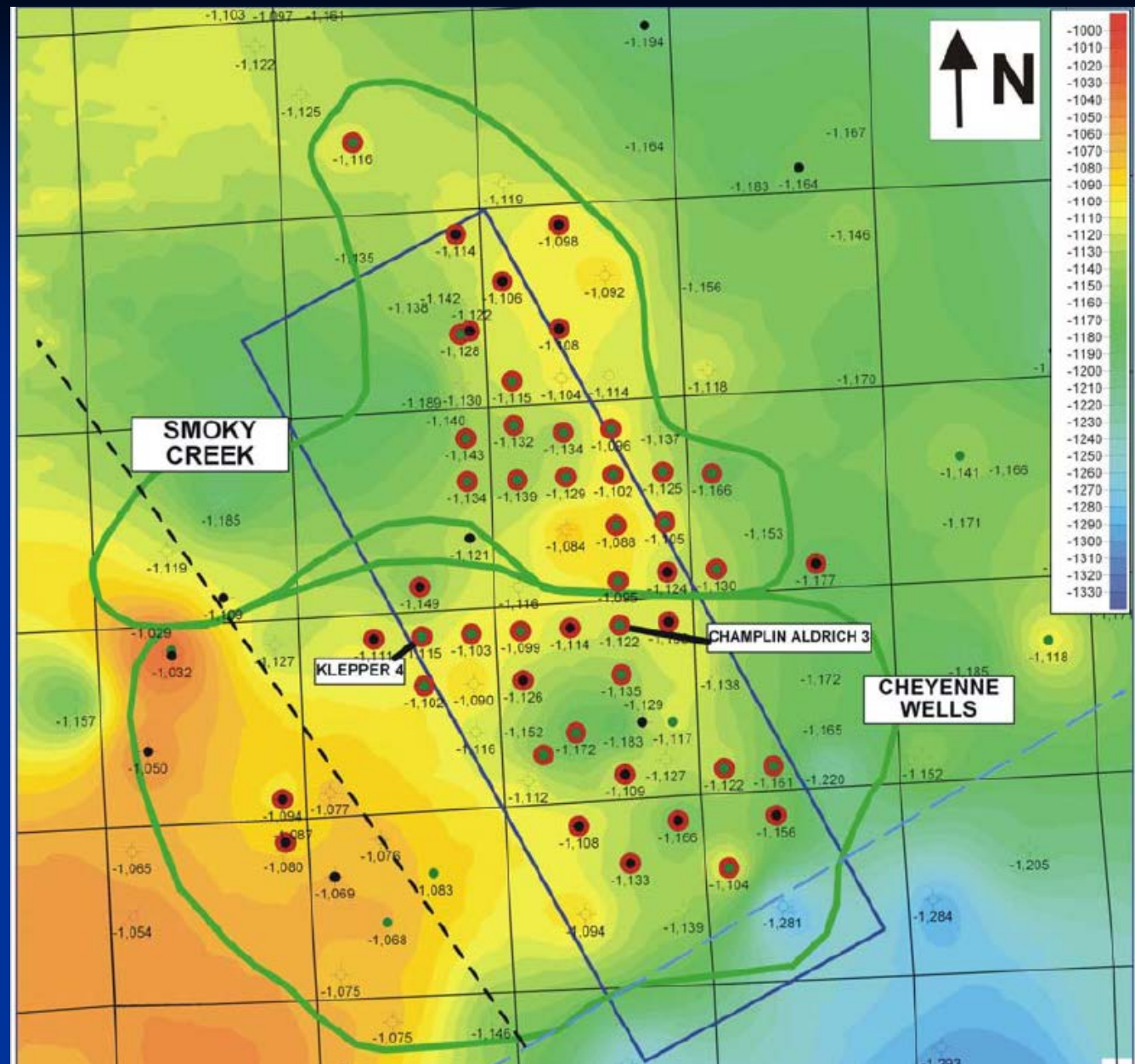
Era	System	Series	Stratigraphic Unit
Paleozoic	Pennsylvanian	Virgilian	Wabunsee Group
			Shawnee Group
			Douglas Group
		Missourian	Lansing Group
			Kansas City Group
			Pleasanton Group
		Desmoinesian	Marmaton Group
			Cherokee Group
		Atokan	
		Morrowan	Morrow Ss. Keyes Formation
	Mississippian	Meramecian	St. Louis Ls.
			Spergen (Salem) Fm.
			Warsaw Ls.
		Osagian	Harrison Shale St. Joseph Ls.
			Gilmore City
		Kinderhookian	

Modified From Givens(2006)



# Color Coded Spergen Structure Map

Legend:  
Warmer Colors  
Are Higher  
Elevations



From Givens(2006)

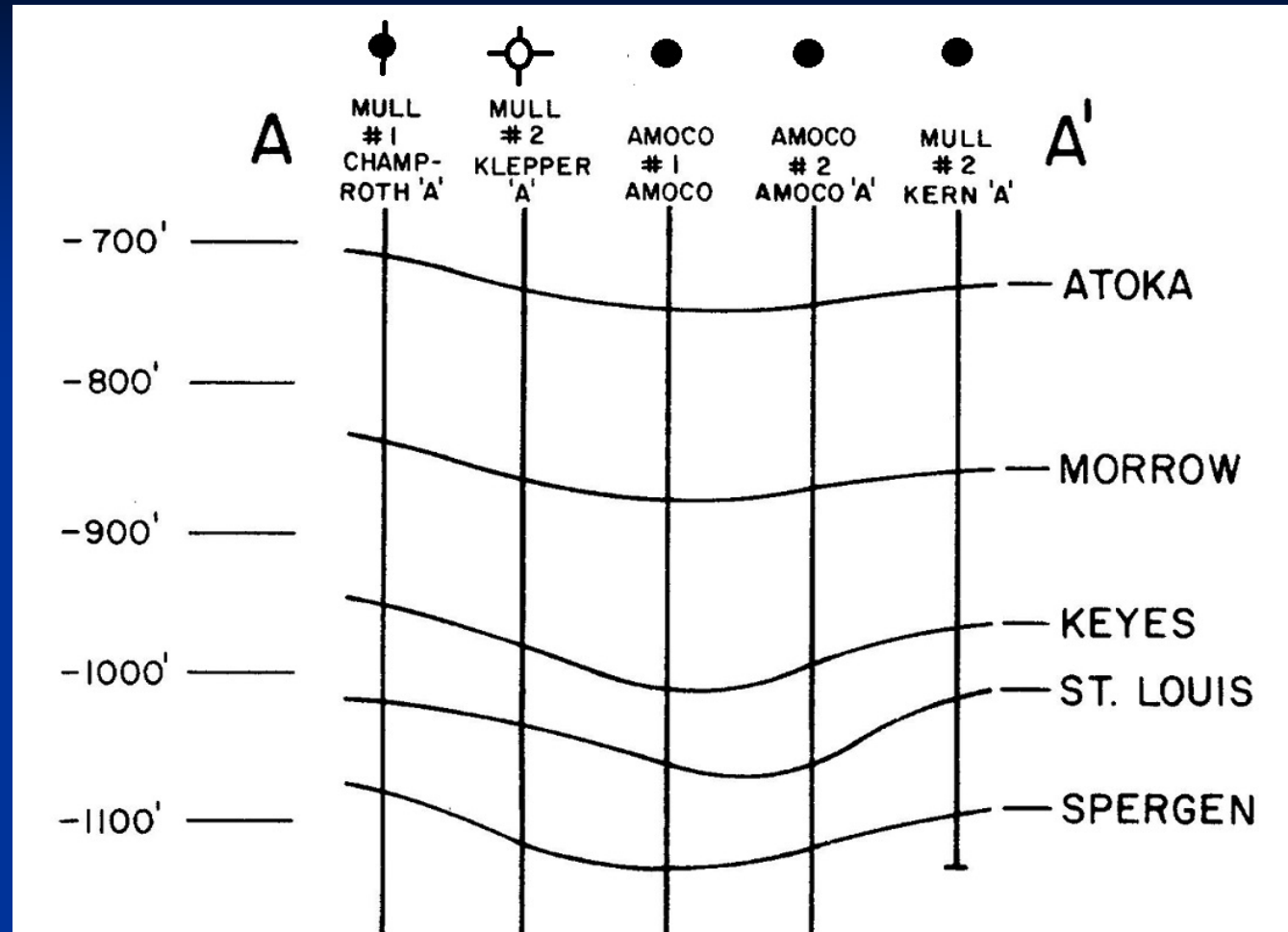


# Cross- Section A-A'

Topographic map of Cheyenne Wells, Colorado, showing a red line connecting points A and B. The map includes contour lines, spot elevations, and a grid. A red line starts at point A (elevation 1076) and ends at point B (elevation 1095). The map is labeled 'CHEYENNE WELLS' at the bottom.

# Spergen Structure

## Cross- Section A-A'

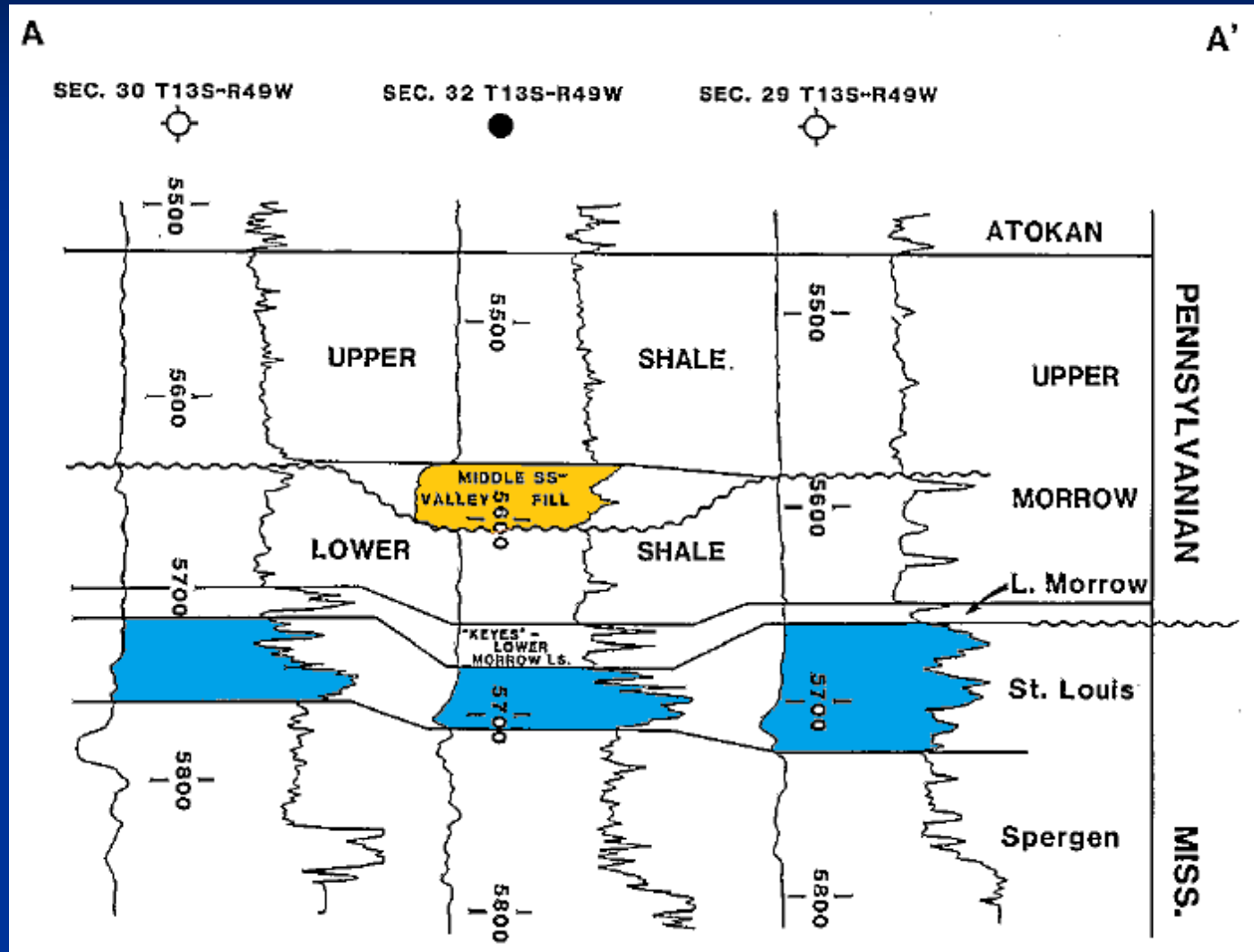


From Kidwell and McKenna (1982)

# First Solution Stage: Late Mississippian Paleokarst Development

- Collision of the North and South American plates resulted in faulted Mississippian blocks
- Faults provided access to ground water while the relief generated by the faulting enhanced ground water solution of the Mississippian Carbonate section
- Early Pennsylvanian sediments covered the topography, filled the features and preserved the paleokarst
- Relief on the Mississippian surface helped localize Morrow Fm sediments

# Morrow Sand Localized by Mississippian Karst Topography at Nearby Sorrento Field



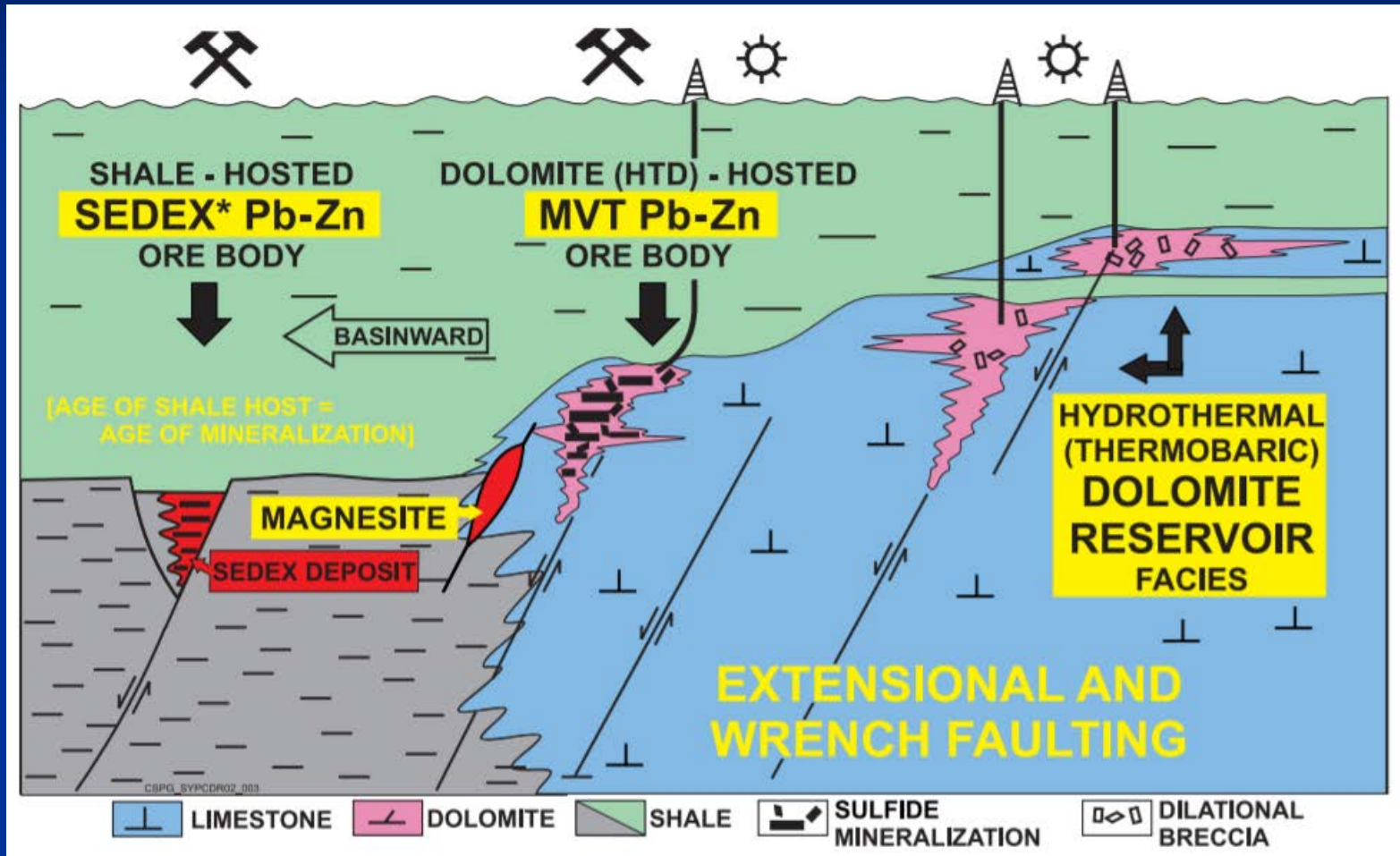
After Sonnenberg (1985)

# Second Solution Stage: Hydrothermal Karst Development

- Fluid migration into Spergen Fm from adjacent basin(s)
- Faults provided hydrothermal fluid access
- Porosity increase resulting from dolomitization



# Idealized Hydrothermal Flow and Dolomitization Model

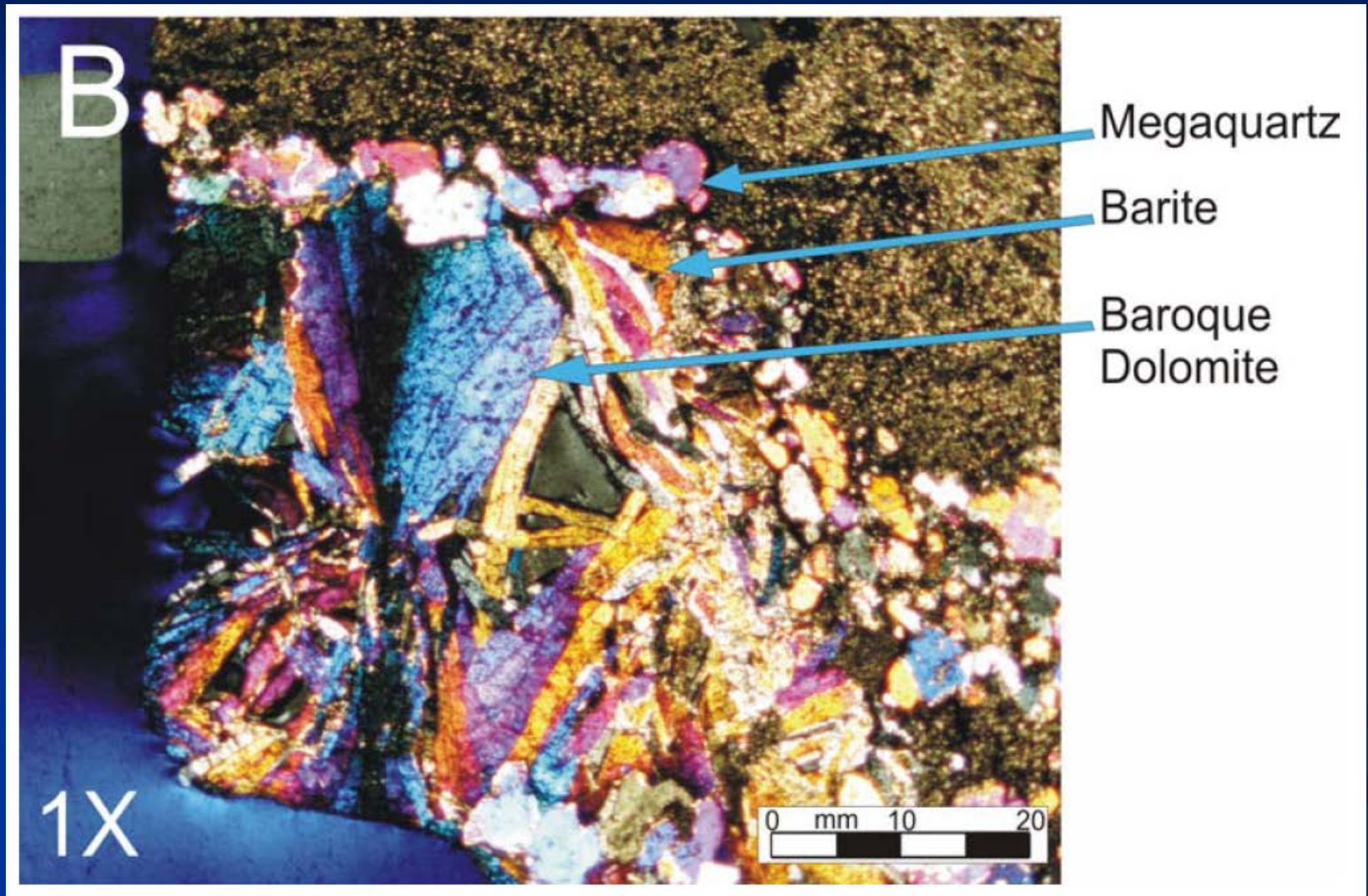


From Davies and Smith (2006)

# Hydrothermal Minerals Identified in Spergen Formation Cores by Givens(2006)

- ◆ Chalcedony
- ◆ Megaquartz
- ◆ Baroque (Saddle) Dolomite

# Crossed Nicols Thin Section Champlin Aldrich #3

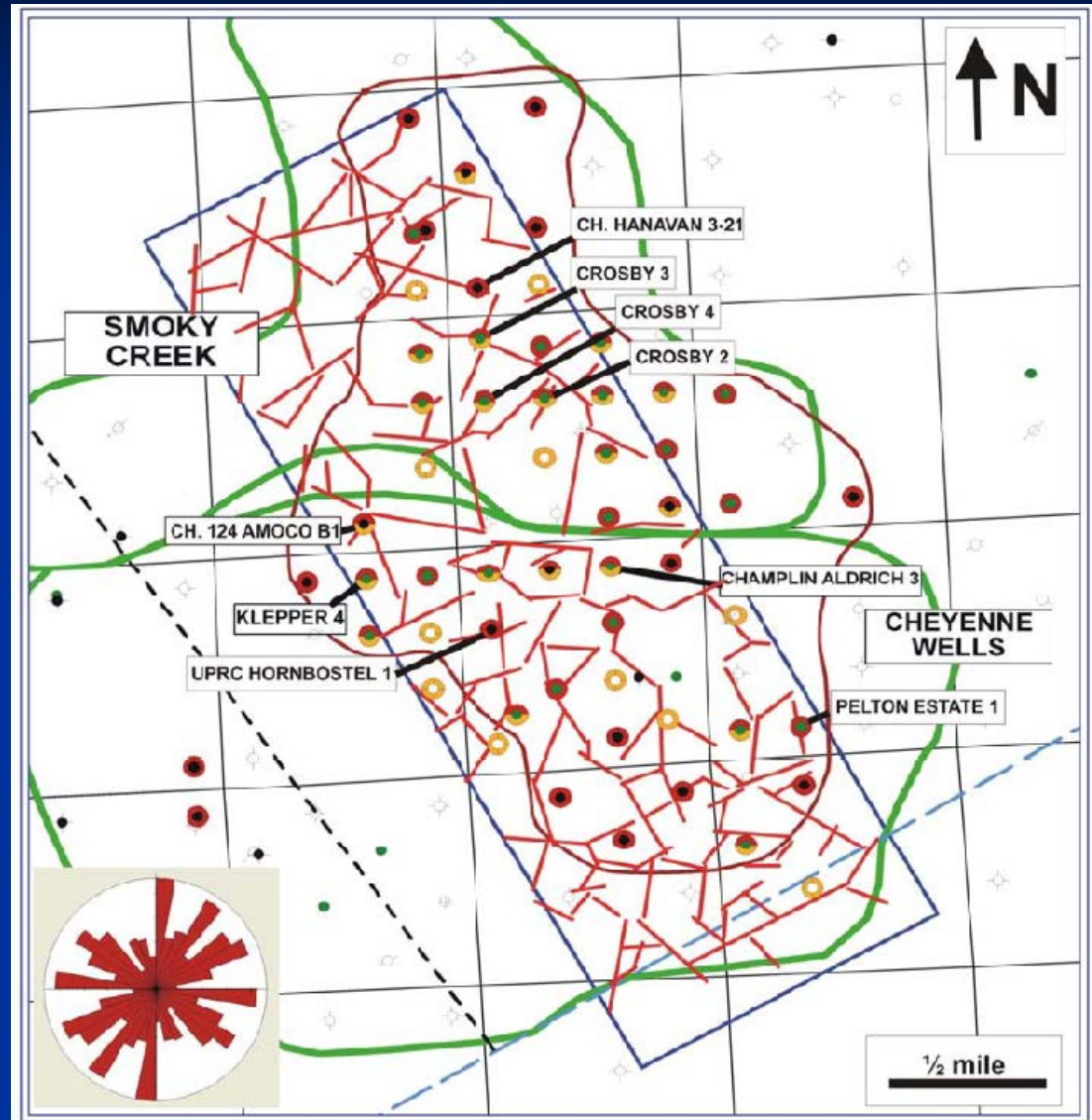


From Givens (2006)



# Sequence of Events Cheyenne Wells / Smoky Creek Fields

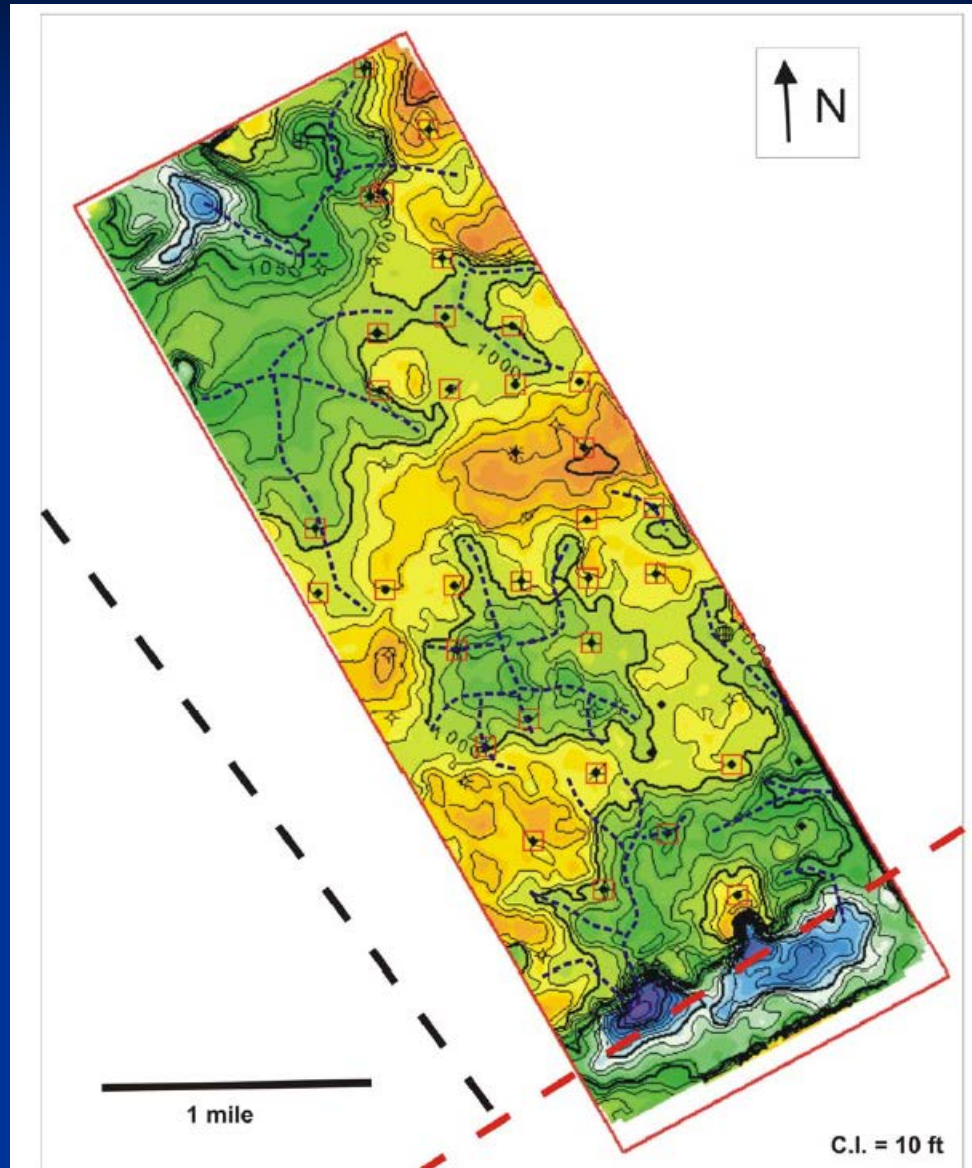
## Stage 1: Mississippian Faulting



From Givens (2006)

# Sequence of Events Cheyenne Wells / Smoky Creek Fields

## Stage 2: Topographic Relief Results From Karst Development

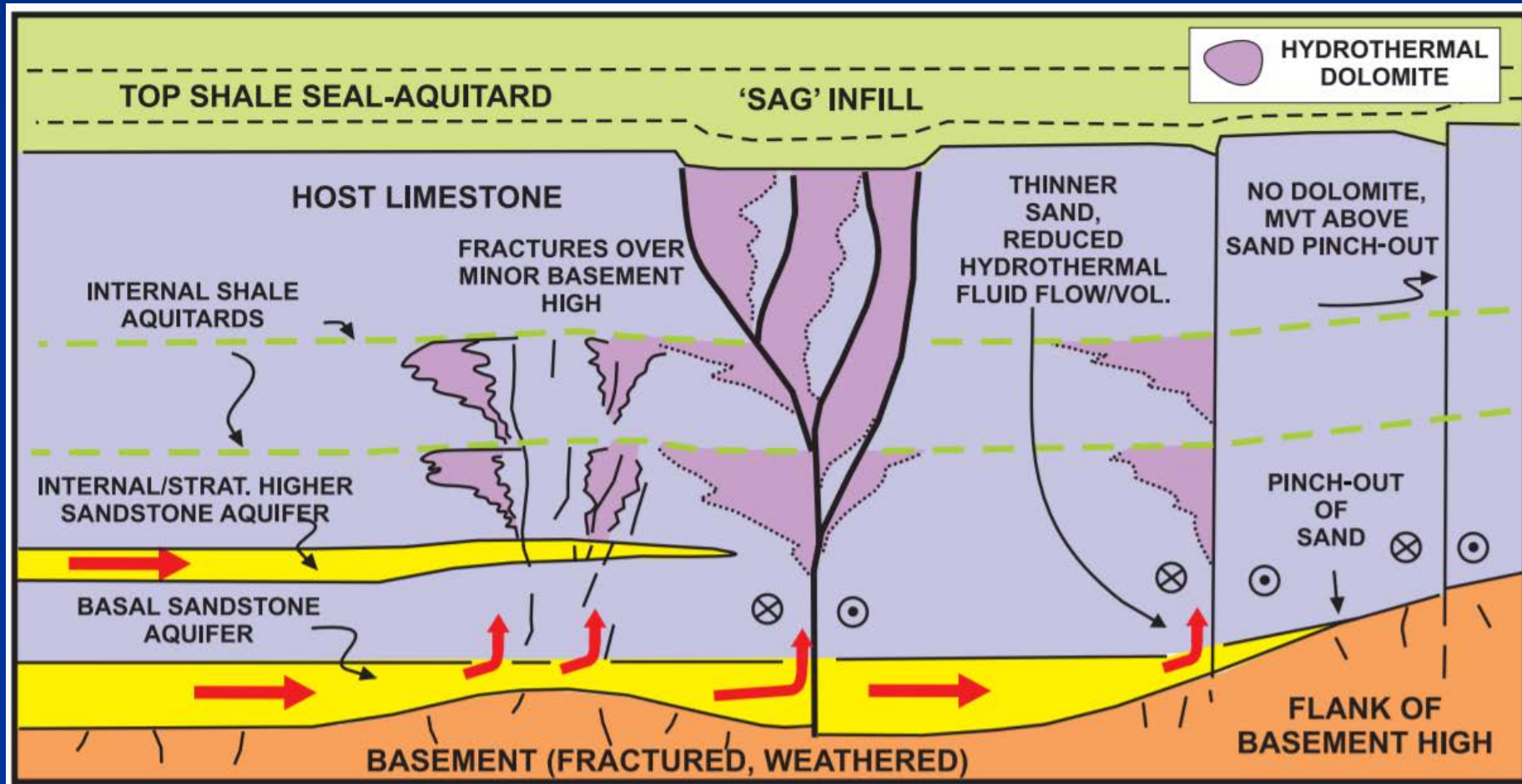


Seismic Map of Base Morrow Structure From Givens (2006)



# Sequence of Events Cheyenne Wells / Smoky Creek Fields

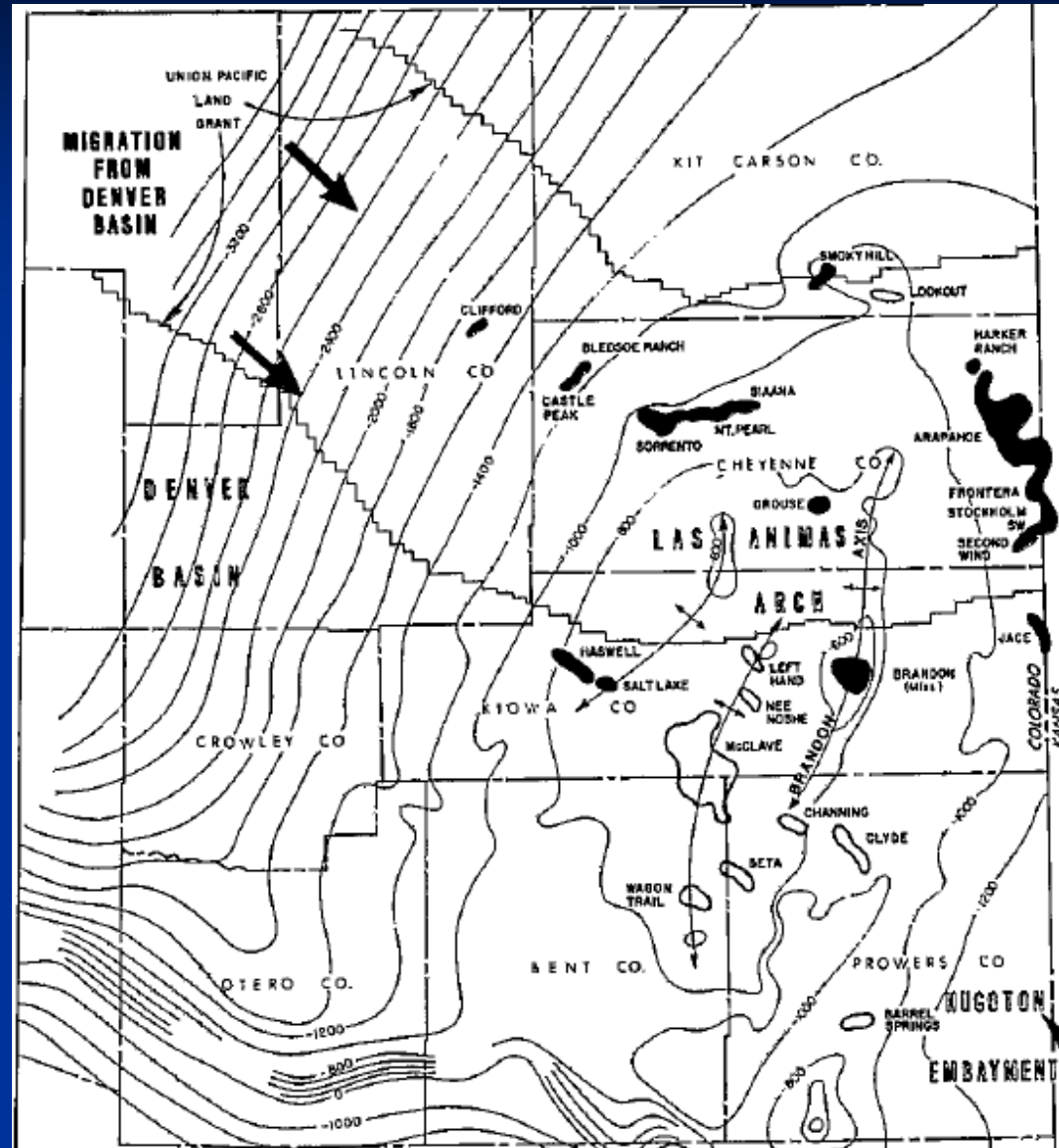
## Stage 3: Porosity Enhancing Fluid Migration along Faults, Flower Structures Form Through Collapse.



From Davies and Smith (2006)

# Sequence of Events Cheyenne Wells / Smoky Creek Fields

## Stage 4: Oil Migration From the DJ Basin



From Sonnenberg, Shannon, Rader and von Drehle (1990)