



Fracture and Karst Features Affecting Reservoir Performance in a Mississippian Reservoir, Cheyenne County, Colorado



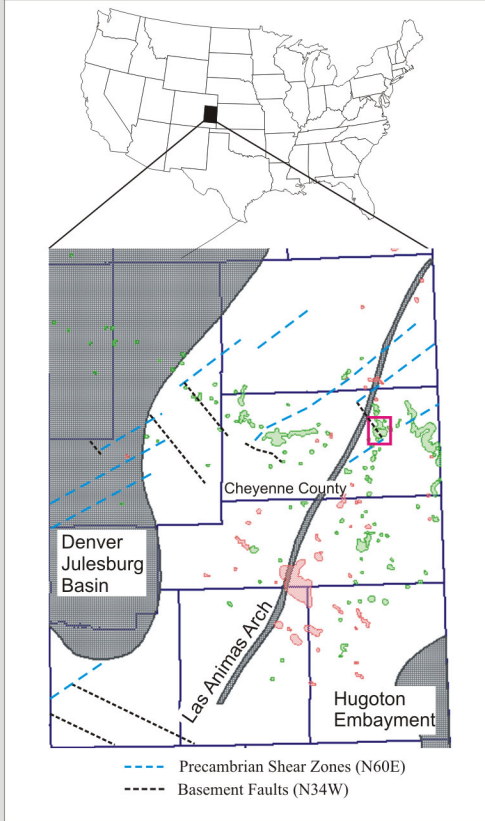
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Abstract

As part of a project to improve geologic and engineering models of mid-continent fracture and karst-modified reservoirs using new 3-D seismic attributes, we are conducting an integrated study of a Mississippian reservoir in Cheyenne County, Colorado, which has scattered and variable production. The focus of this study has been to integrate new 3-D seismic attributes with geological data to increase probability of identifying fractures and karst features that affect reservoir performance. Core and wireline log data have been used to determine lithofacies, depositional facies, diagenetic signatures, and petrophysical properties for the reservoir. Geometric attributes from a 5.5 square mile 3-D seismic survey over the reservoir show subtle lineaments that parallel regional structural trends. These lineaments may reflect fracture orientations that controlled karst development on the Mississippian surface. Seismic attributes, correlated to log and core data, are used to help delineate fractures and reservoir compartments, as well as to guide distribution of petrophysical properties in a reservoir model. The results of this study provide key input to the synthesis of a best-practices workflow for characterizing fractured and karst-modified reservoirs in other areas.

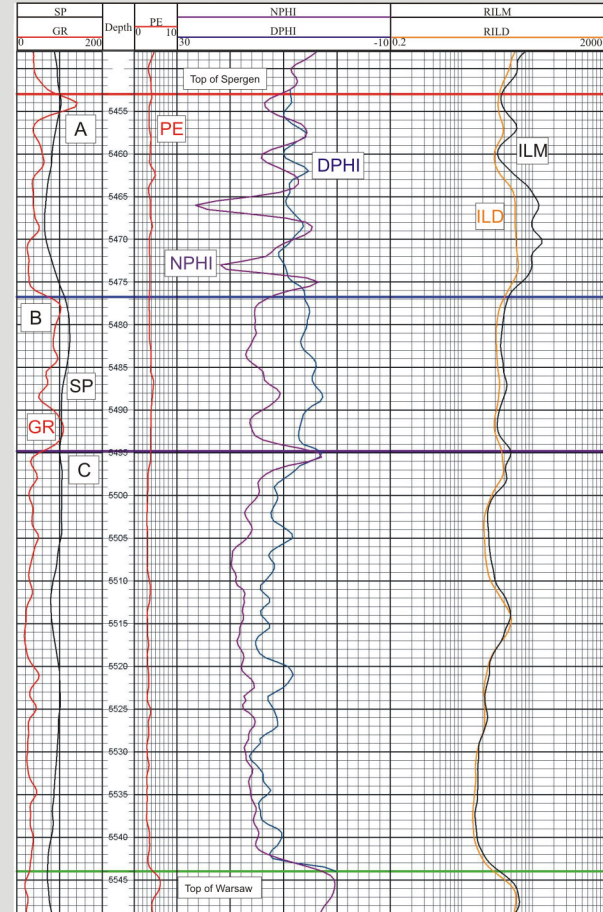
Geological Overview



Map of major structural features of eastern Colorado showing oil (green) and gas (red) fields. The pink box outlines the location of the study area (Cheyenne Wells and Smoky Creek fields), map modified from Sims et al. (2001) and <http://oil-gas.state.co.us/infosys/maps>.

Era	System	Series	Stratigraphic Unit
Paleozoic	Pennsylvanian		Wabunsee Group
			Shawnee Group
			Douglas Group
			Lansing Group
			Kansas City Group
			Pleasanton Group
			Marmaton Group
			Cherokee Group
			Atokan
			Morrowan
Mississippian		Meramecian	Salem (Spergen) Ls. Warsaw Ls.
		Osagian	
		Kinderhookian	

Stratigraphic column for east central Colorado. Spergen reservoir interval is highlighted in green.



Logs of the Spergen for a well in the study area. Top of Spergen (red), top of Warsaw (green), and three field wide correlatable zones (A, B, C) are shown.

Lithology and Depositional Environment of Spergen Reservoir Interval in Eastern Colorado

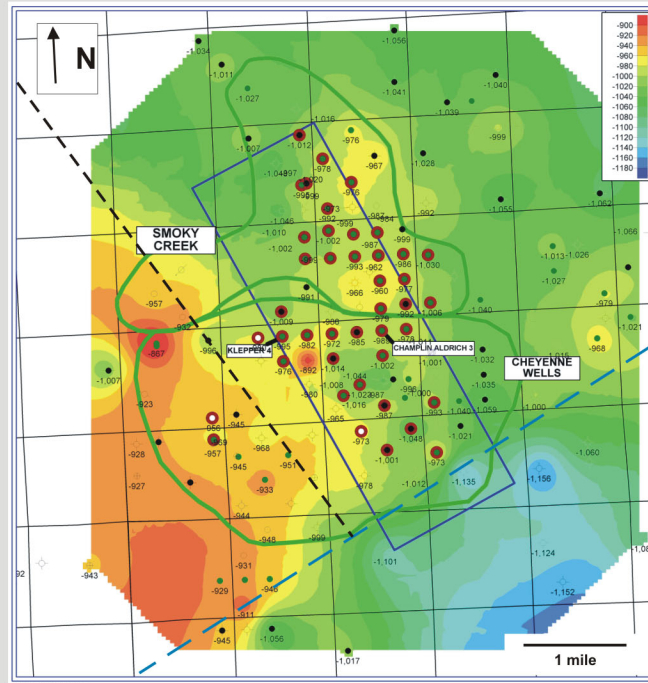
- The Spergen is very finely to medium crystalline saccharoidal dolomite and dolomitic limestone with silica and calcite replacement, localized ooids, glauconite, pyrite and chert, and calcedony, megaquartz, and baroque dolomite fracture and void fills. Kidwell and McKenna (1983) describe the Spergen as nonargillaceous and fossiliferous to very argillaceous carbonate rock. Nonargillaceous facies are associated with the flanks of Mississippian paleohighs.
- Deposited in platform or shelf-like conditions (Goebel, 1966).
- Dolomitization has overprinted most original textures and structures.

Regional Tectonics

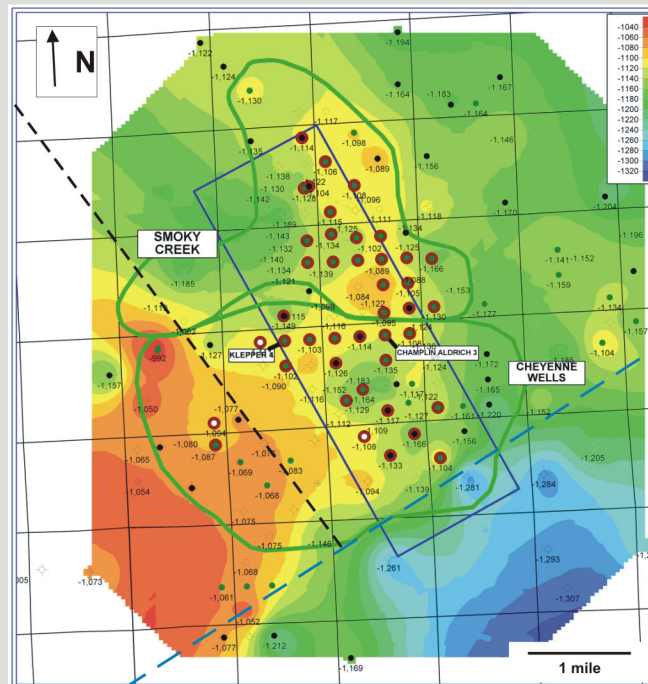
- Las Animas Arch - N-NE trending episodic history of tectonism (Ouachita and Laramide).
- Precambrian shear zones (N60E) and high-angle basement faults (N34W) (Sims et al., 2001).

Cheyenne Wells & Smoky Creek Fields

- Discovered in 1968
- Produced in excess of 8 Million barrels of oil
- Produces primarily from Mississippian Spergen Dolomite



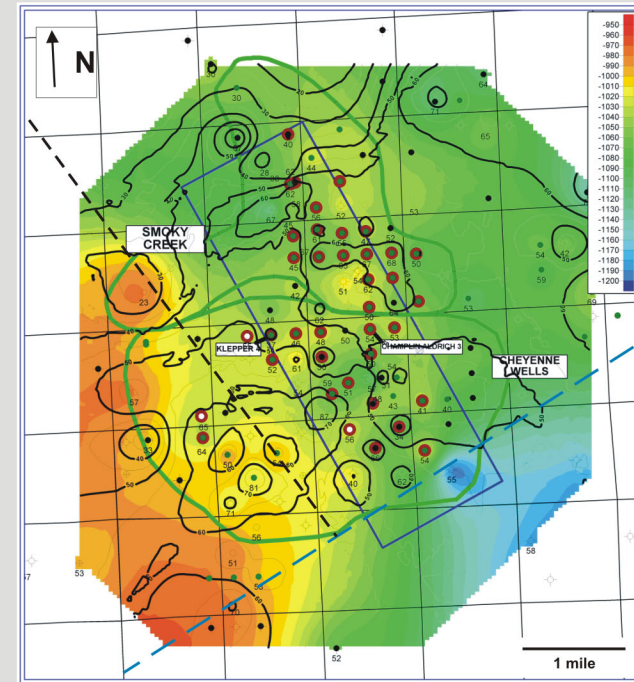
Structure map on the base of the Morrow Shale/ top of Keyes Formation (BMS/KYS). Spergen producers (red), field outlines (green), 3-D seismic area (blue), high-angle basement fault (dashed black), and Precambrian shear zone (dashed blue) are shown. Wells with core are labeled.



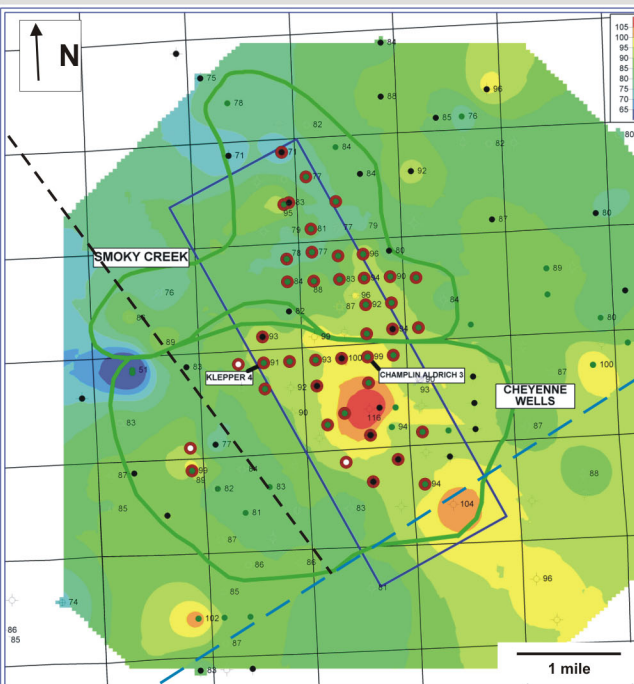
Structure map on top of the Spergen. Legend as on BMS/KYS map above.

Structure and Isopach Maps

- Precambrian shear zone and basement faults (Sims et al., 2001) bound low and high areas on the structure maps.
- Spergen production sits on a structural high with an apparent overall northeasterly trend in the Cheyenne Wells field and a north to northwesterly trend in the Smoky Creek field.
- St. Louis structure and Keyes isopach maps show areas of possible pre-Pennsylvanian karst (?) depressions on top of the St. Louis.



Isopach of Gross Spergen thickness. Legend as on BMS/KYS map above.

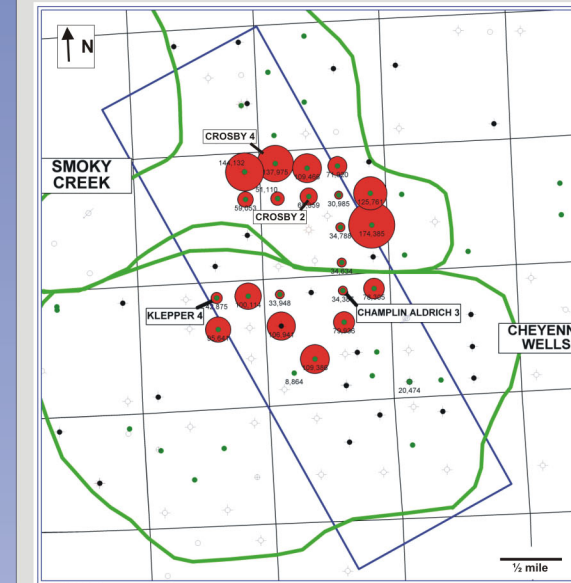


Isopach of Gross Spergen thickness. Legend as on BMS/KYS map above.

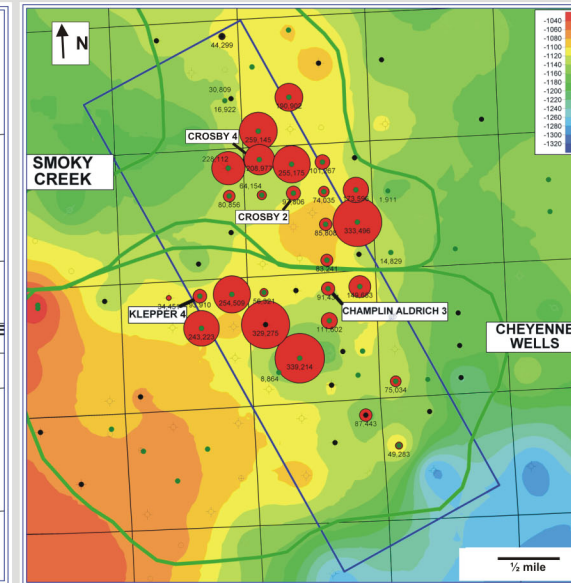
Production

Well performance in the Cheyenne Wells and Smoky Creek fields is extremely variable. Completion dates range from the 1970's to 1990's. In order to compare the production from these wells we have calculated the production from the first 60 months of a well's history for wells completed in the 1970's compared with the wells completed 1990's. The two figures below show us a wide range in oil cumulatives. Based on calculations from matrix porosities alone, some wells have performed better than expected, while others have underperformed. For example, comparing the Neutron Density Average (ND Average) porosity in the perforated interval of the Crosby #2 and #3, the Klepper #4, and the Champlin Aldrich #3 (Table and Graphs below) we can see that variability appears to have little relationship to porosity. Fractures are believed to contribute to this variability.

The amount of Spergen production is not directly related to structure or the thickness of the Spergen, indicating that local variations in rock properties and/or fracturing play a significant role in production.



First 60 months oil production cumulatives (Bbls) for wells with monthly Spergen production values.



Total oil production cumulatives (Bbls) for wells with Spergen production; shown with top of Spergen structure map.

Well Name	Completion Date	Perf Interval ND Average	# of Feet Perforated	60 Month Oil Cum. (Bbls)	Oil Production Cum. (Bbls)
Crosby #2	12-20-1992	8.77%	5	65,359	97,806
Crosby #3	8-15-1993	12.0%	10	137,975	208,977
Klepper #4	6-28-1993	14.1%	8	42,875	93,910
Champlin Aldrich #3	8-6-1991	16.4%	8	34,387	91,434

