

# The Role of Moldic Porosity in Paleozoic Kansas Reservoirs and the Association of Original Depositional Facies and Early Diagenesis With Reservoir Properties

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## Upper Pennsylvanian Lansing-Kansas City Gp

### Geology and Architecture

Lansing-Kansas City oolitic reservoirs exhibit geometries and architectures similar to modern oolites. Reservoirs usually contain multiple stacked, or an echelon sheals that formed in response to sea level fluctuations. It appears that two such lobes are stacked in the Plattburg Limestone at the planned CO2 miscible flood site represented by the core. Oolitic reservoirs formed across the entire Kansas Pennsylvanian ramp, however, thicker, porous and permeable oolite deposits are commonly associated with the flanks or crests of paleostructural highs. These highs, such as that underlying the Hall-Gurney Field, may have influenced the intensity of early diagenesis and may have been responsible for development of good reservoir properties. Grain size variation, location on oolite buildups and interbedded carbonate mud (argillards) influenced the nature and extent of diagenetic overprinting.

### Petrophysics and Reservoir Properties

Porosities in these oolitic limestones range up to 35% and permeabilities range from 0.001-400 md. Permeability is principally controlled by porosity, oolite connectivity, and connection created by matrix crushing and fracturing. Permeability is also influenced by oolite diameter, oolite packing, and matrix properties. Increasing bioclastic constituents within and bounding oolite beds are often associated with increasing mud matrix and decreasing porosity and permeability. Individual wells exhibit porosity-permeability trends with less variance than the overall trend exhibited by L-KC oolitic limestones.

Lansing-Kansas City oolitic limestones exhibit a near log-linear trend between wetting phase saturation and oil-brine height above free water level with capillary pressures decreasing with increasing permeability at any given saturation and can be modeled using the relation:  $P_c = 10^{0.15 - 0.0015k}$  (water-poil).

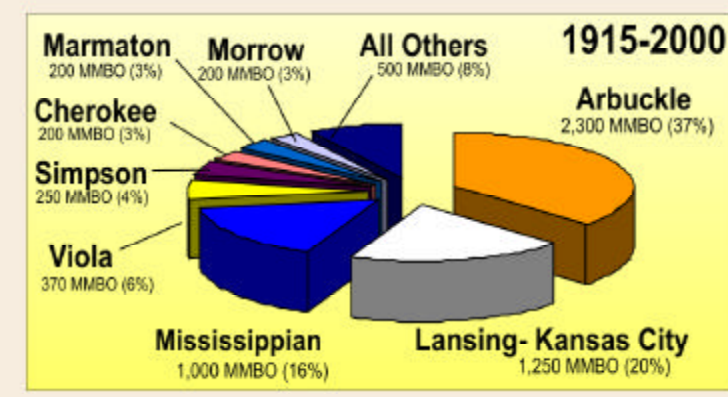
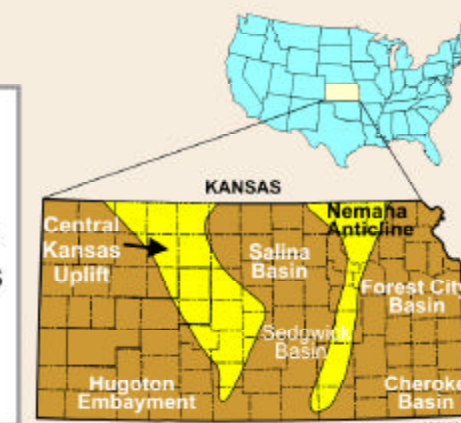
Residual oil saturation to waterflood (Sorw) is a critical variable for both waterflooding and carbon dioxide miscible flooding since this represents the target resource. Most L-KC waterfloods in Kansas have only involved 1-5 pore volumes (PV) throughput before reaching their economic limit. At 5 pore volumes throughput Sorw averages near 30%. Though sampling is limited, Sorw may increase then decrease with increasing permeability (k).

### Purpose

- The multiple goals of this work include:
  - To better understand the nature and distribution of moldic porosity in the shallow shelf carbonate systems.
  - To understand the role of original depositional facies and early diagenesis on subsequent rock geologic and petrophysical properties.
  - To enhance modeling relating moldic porosity, and more broadly pore architecture, to petrophysical properties.
  - To compare and contrast the effects of different kinds of moldic porosity.
  - To improve prediction of reservoir quality in these systems (or better define the limits of prediction).
  - To improve reservoir properties models for reservoir evaluation, characterization, and simulation.

### Importance of Moldic Reservoirs to

Kansas reservoirs have produced nearly 6.3 billion barrels of oil (BBO) to date, with a significant majority of the past production coming from reservoirs in proximity to the Central Kansas Uplift (CKU). Of the 6.3 BBO, 73% (4.5 BBO) has been produced from Arbuckle Gp, Mississippian, and Lansing-Kansas City Gp reservoirs that are



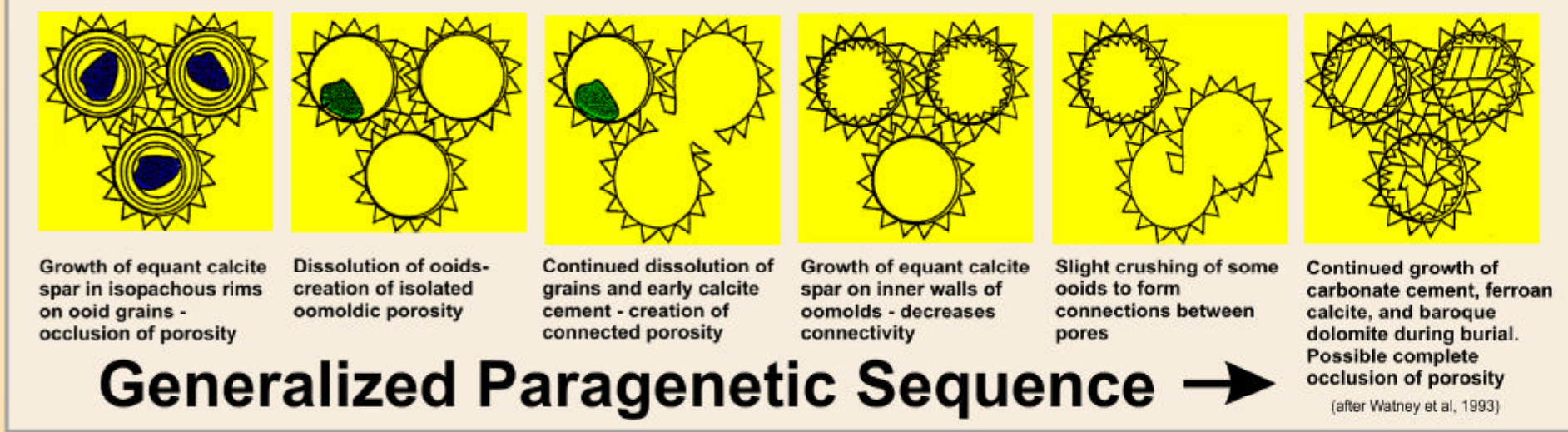
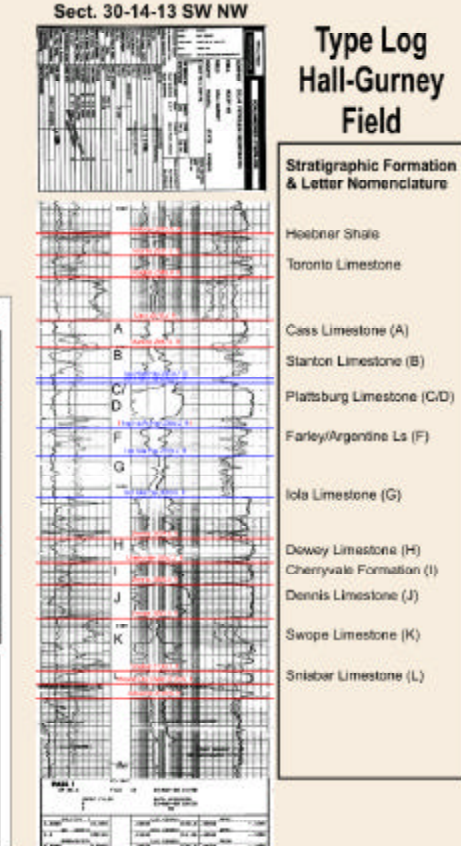
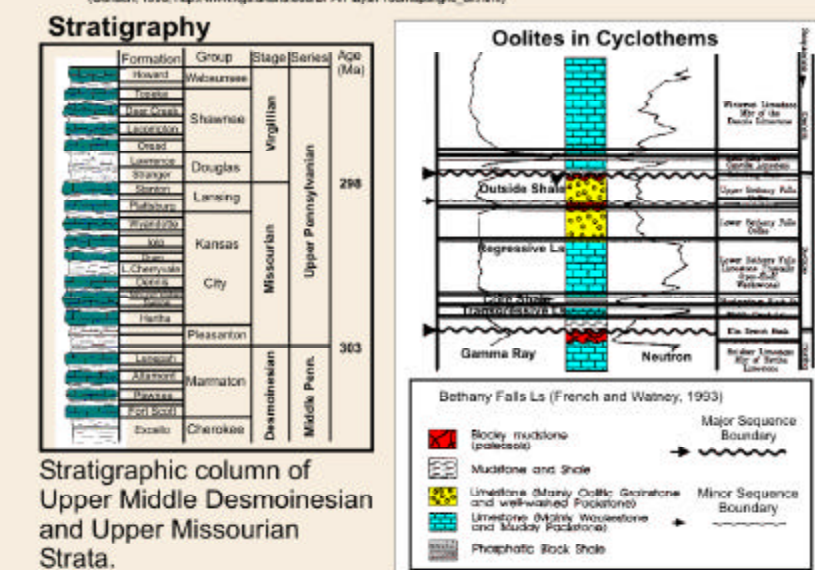
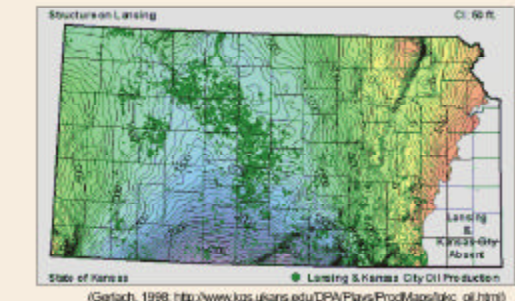
Arbuckle Gp reservoirs account for 37% of all production (2.4 BBO) but are declining in production and presently represent 20% of annual production. With declining Arbuckle Group production, Mississippian reservoirs account for 33% of the total state production over the last decade and are increasing in importance. Lansing-Kansas City reservoirs represent 16% of current

### Results and Implications

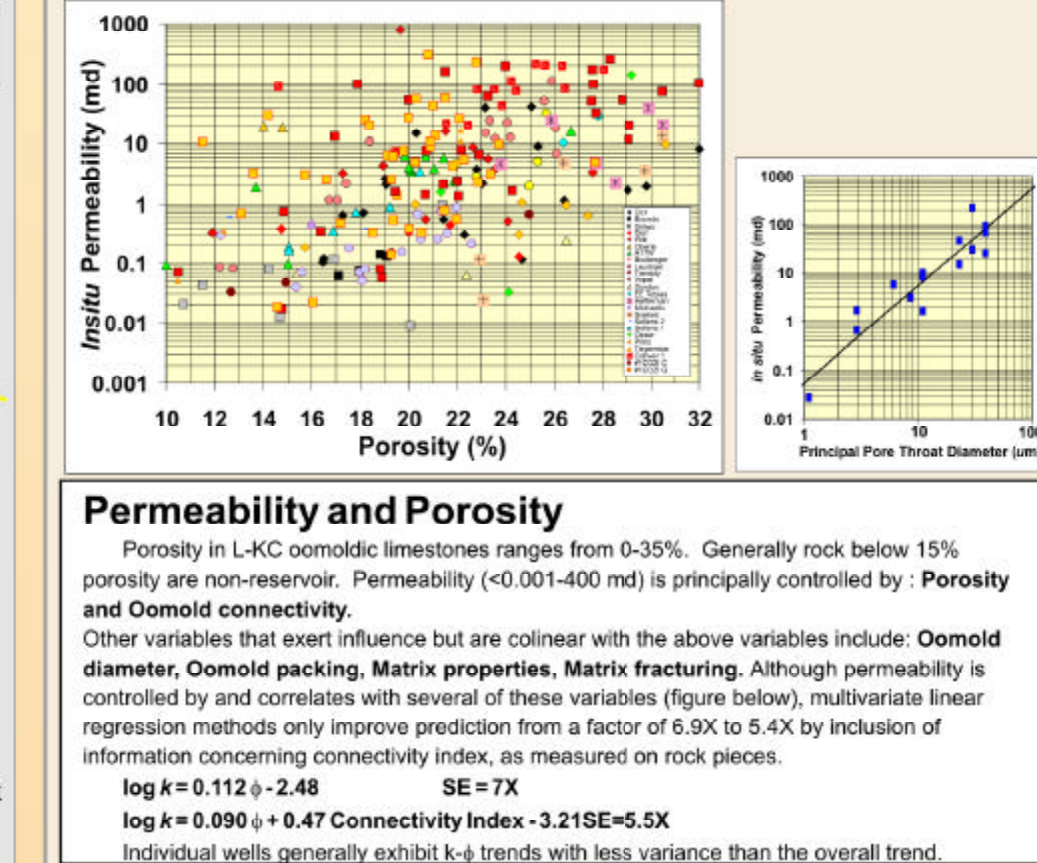
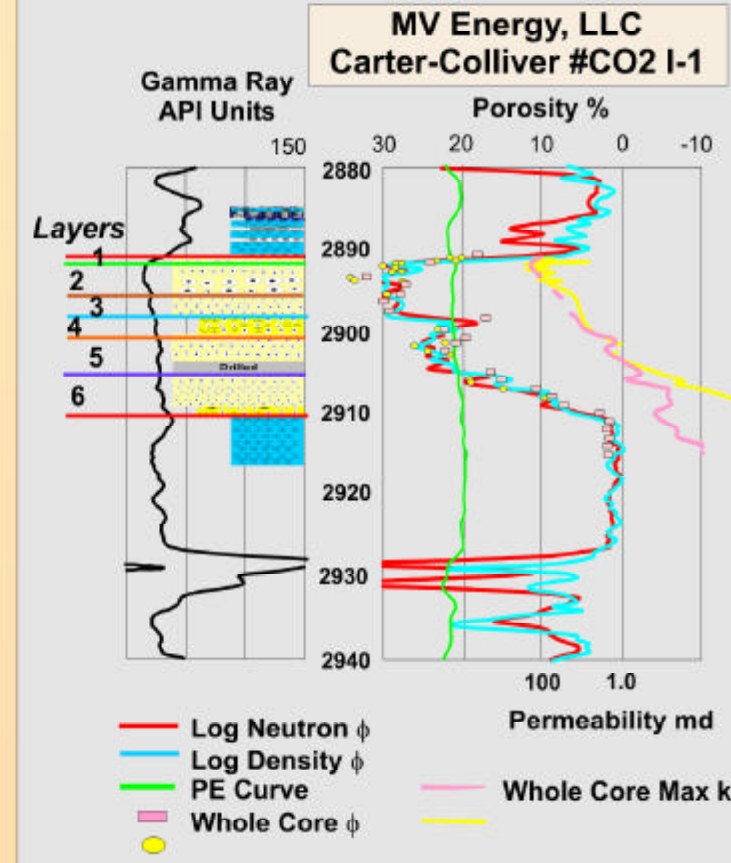
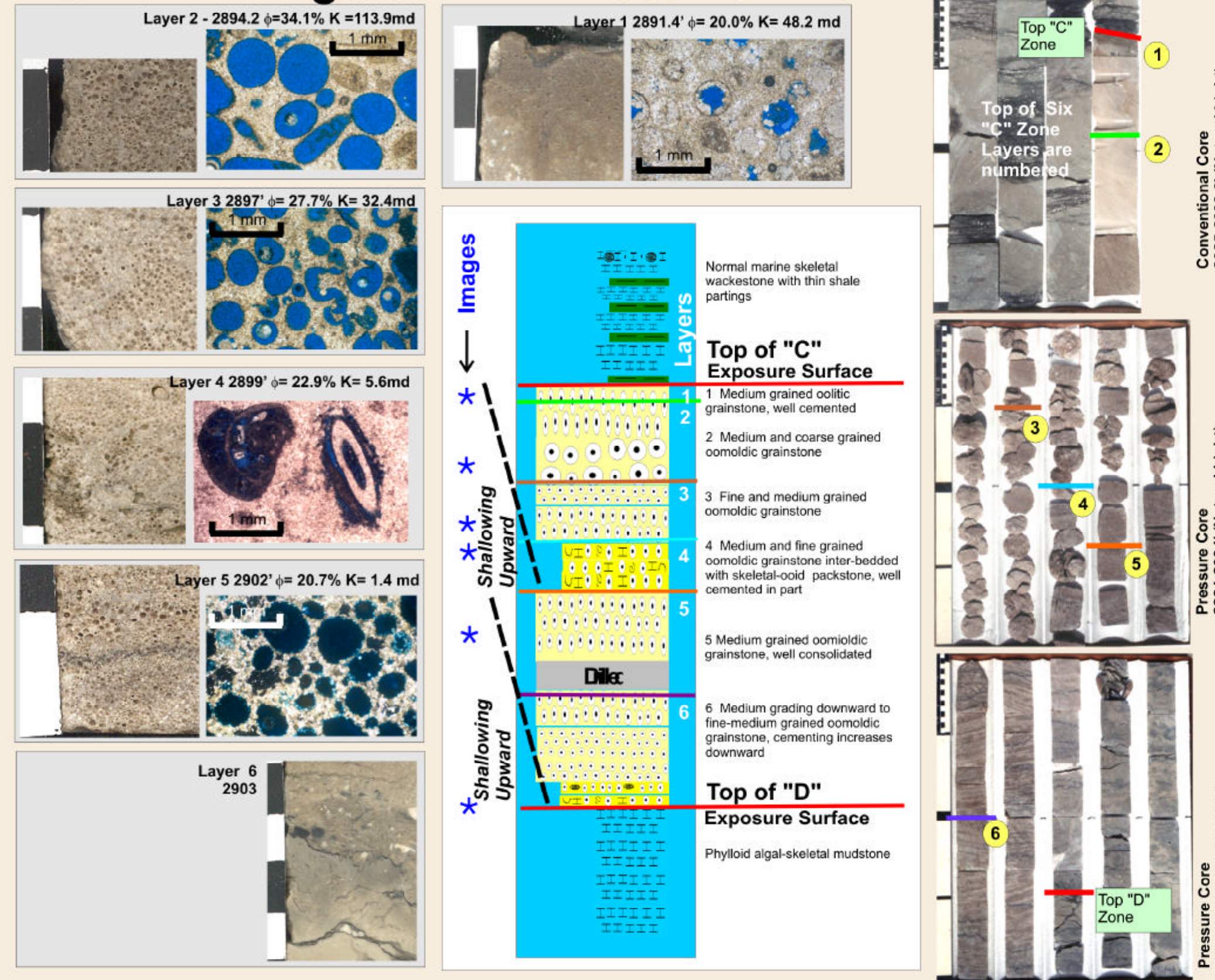
- Core examples from Upper Cambrian- Lower Ordovician Arbuckle, Mississippian & Pennsylvanian shallow-shelf carbonates in Kansas indicate that moldic porosity is abundant in each system, & reservoir properties, including porosity/permeability, are strongly correlated with original depositional facies.
- Despite the nature of the molds varying through time, reflecting changes in primary carbonate grains, reservoir quality is similar in each system & increases from mudstone through grainstone.
- Despite significant diagenetic overprinting in many of the rocks, & even some complete reversal of original solid & pore space, final moldic textures exhibit petrophysical-lithofacies trends that parallel those of original primary porosity carbonates.
- Correlation of permeability and pore throat size in moldic-porosity rocks is similar to that of intergranular-porosity rocks. This can be interpreted to indicate that despite, in some rocks, very high moldic porosity, permeability is primarily controlled by matrix properties.
- Moldic rocks play an enormous role in Kansas oil and gas production. The diverse nature of the matrix, molds and mold content with continued study is providing better understanding of the role of moldic porosity and of pore architecture to fluid flow in porous media.

### General Lansing-Kansas City Geologic Setting

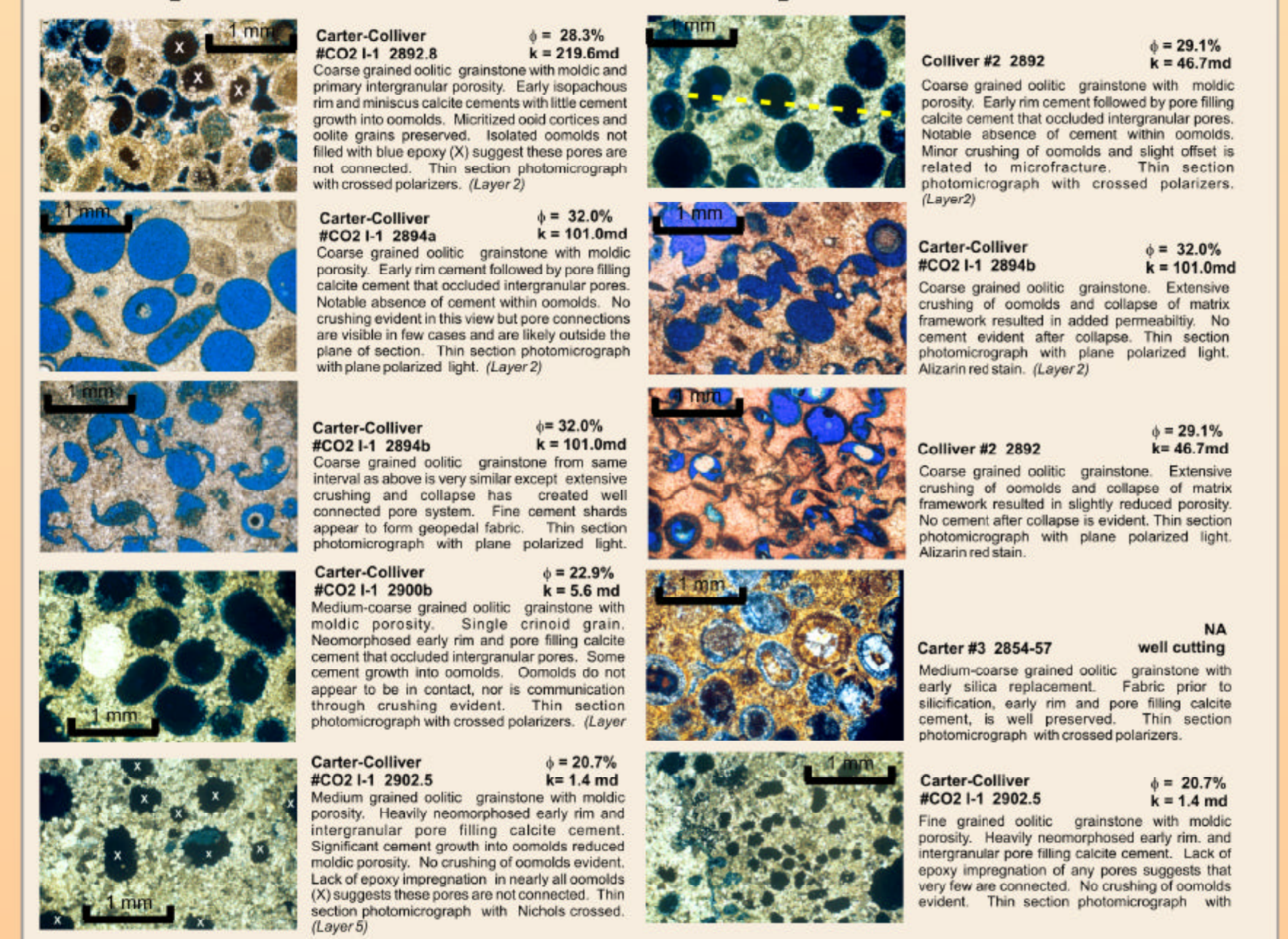
Oolitic packstones and grainstones are the most prolific reservoir lithofacies for the Pennsylvanian Lansing-Kansas City. Oolite shoal facies owe their wide distribution geographically within Kansas and stratigraphically within the Upper Pennsylvanian to bathymetry (very low-angle ramp) and episodic sea level changes. The broad Kansas shallow shelf and oscillating sea level resulted in lateral migration of oolite shoal conductive environments and successive creation of stacked oolite cyclothems (figure).



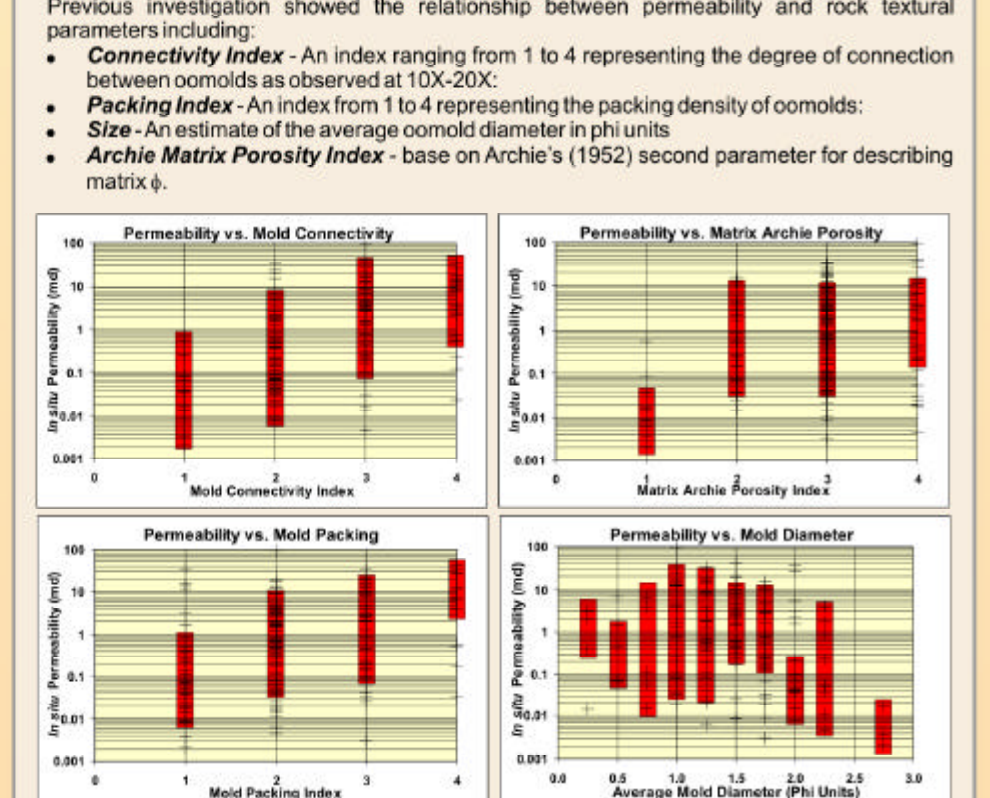
### Murfin Drilling #CO2 I-1: 2985-2914 ft



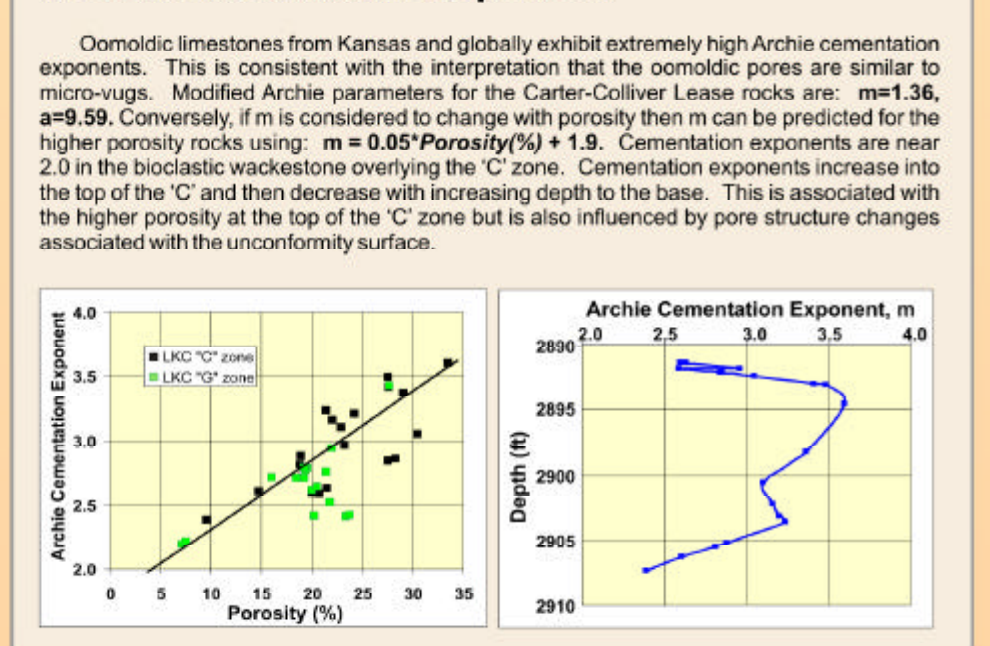
### Important Microscopic Textures



### Correlation of Textural Properties with Permeability



### Archie Cementation Exponent



### "Irreducible" Water Saturation

