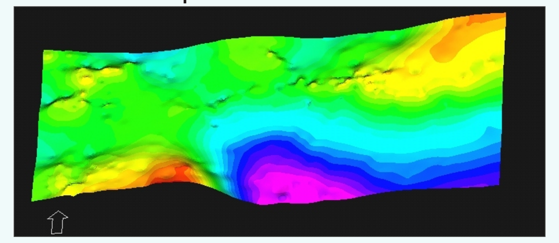
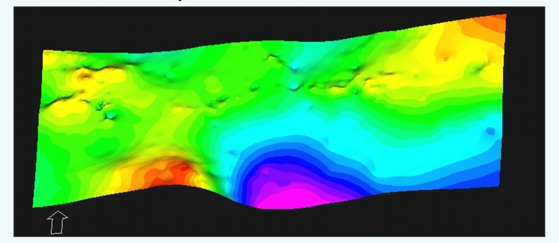
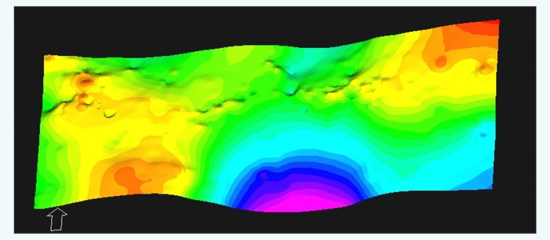
St Louis A top surface



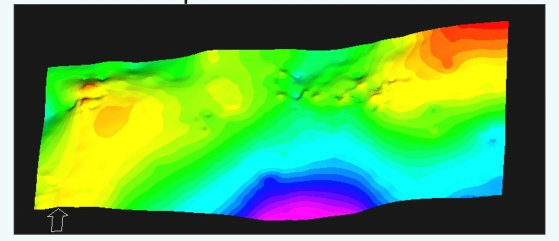
St Louis B top surface



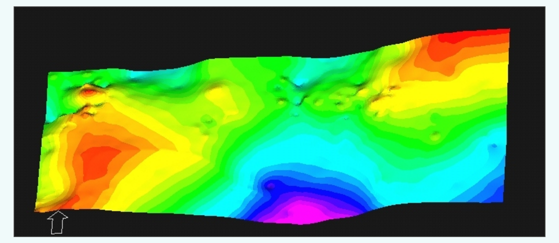
St Louis C top surface



St Louis D top surface

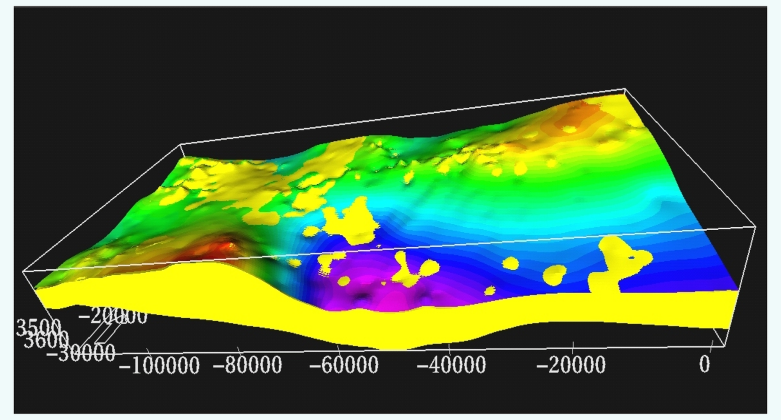


St Louis base surface



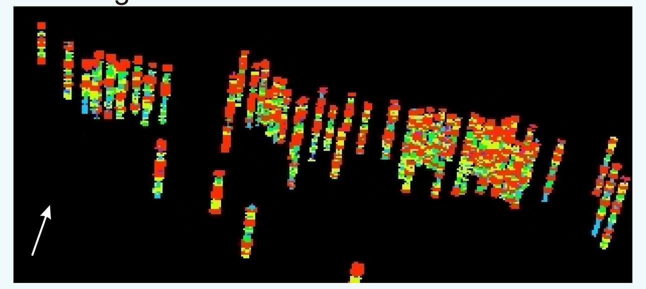
Five surfaces have been imported into RMS to build the Big Bow and Sand Arroyo Creek St Louis Limestone reservoir modeling grid. These surfaces all show the original St Louis structure.

Modeling grids with 4 subgrids (St Louis A, B, C and D)

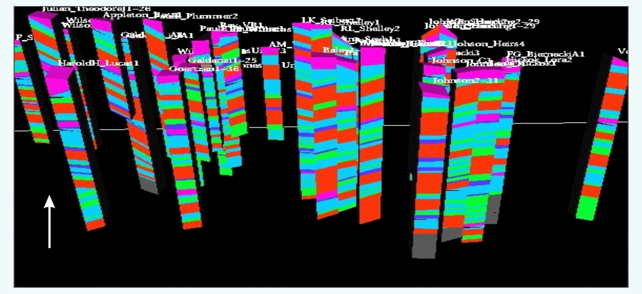


The grid was built with equal X and Y increment to 500 ft and a constant layer thickness = 2 feet parallel to bottom surface within the St Louis A, B, C and D subgrids in Z axis.

Raw log data



Blocked well data



Original well data (lithofacies, porosity, perm and Sw) have been upscaled to the grid size after importing to geostatistical simulation project. Facies logs have been treated as blocked within a facies interval. Average values have been blocked into the grid cells for continuous logs.

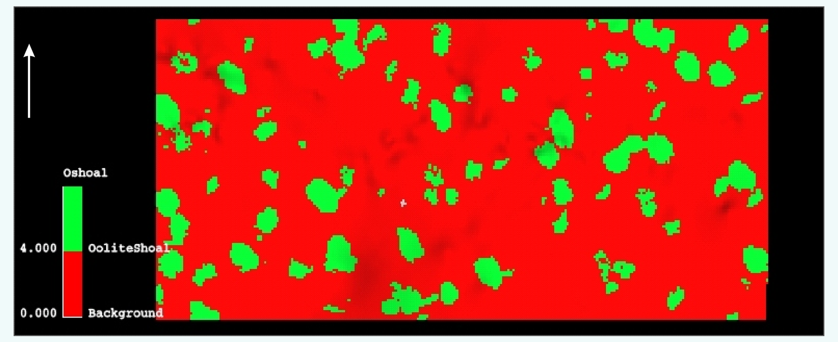
Geometry data for modeling facies

Faices Name		Averaged Minimum	Averaged Maxmum		Source
Ooid Shoal	Thickness	3 ft	11 ft	Ancient	Kelly Bergman, et, 1998
	Length	0.75 miles			
	Dip length	1.5 miles	2.7 miles	Modern	
	Strike length	3.9 miles	6.4 miles		
Tidal Flat	Thickness	2 ft	15 ft	Ancient	
	Length	0.25	12.5 miles		
	Thickness	6.5 ft	28 ft	Modern	
	Dip length	0	25 miles		
	Strike length	8.75 miles	45 miles		
Eolianite	Thickness	4 ft	22 ft	Ancient	F.E.Abegg, et, 2001
	Dip length	0.25 miles	18 miles		
	Thickness	10 ft	50 ft	Modern	
	Dip length	0	30 miles		
	Strike length	10 miles	70 miles		

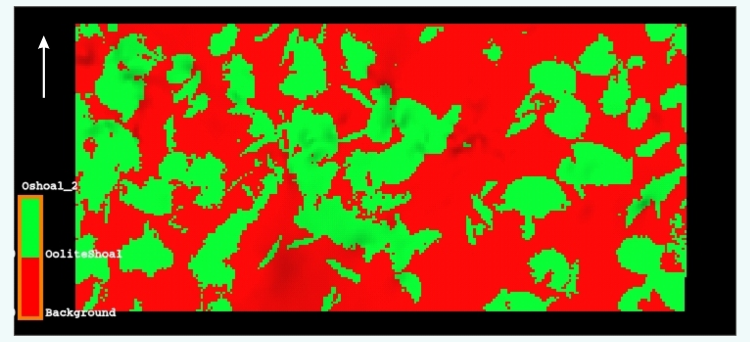
Ooid shoal, tidal flat and eolianite dune generally all have strike-elongated geometry. Above table summarizes the general 3D geometry data of these facies from Bergman, 1998 and Abegg, 2001. Final geometry data was selected after various trials to fit the Mississippian St Louis carbonate system.

Argillaceous limestone (deep marine) and skeletal wackestone (open marine) were combined into marine facies and treated as the background facies (code=0) in modeling. Peloidal grainstone limestone was defined as tidal flat facies (code=1), and cross-bedded quartz-rich carbonate grainstone as eolianite facies (code=4). Ooid skeletal grainstone (code=2) and cemented ooid skeletal grainstone (code=3) were combined into oolitic shoal complex facies. Then, permeability barriers in the complex were modeled by merging the separately modeled cemented oolitic facies into the complex.

Comparison of the effect of different geometry and simulation proportion for oolitic shoal complex



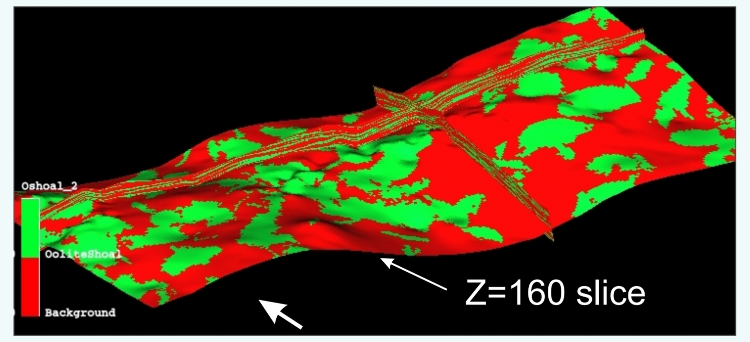
Smaller geometry size with less proportion simulated

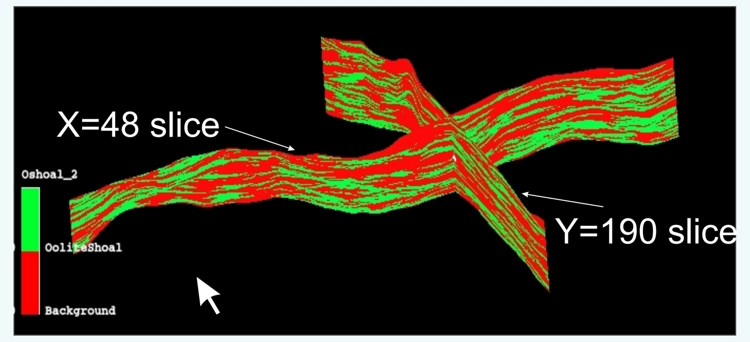


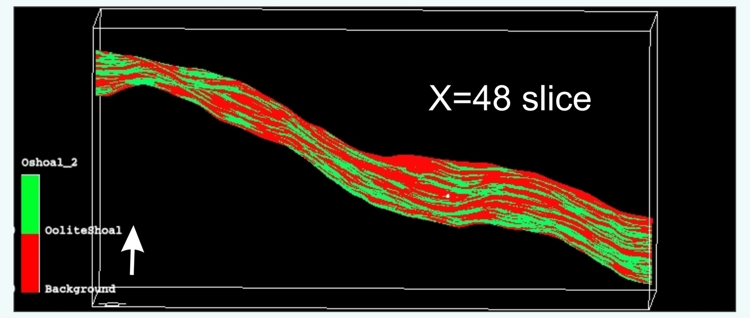
Larger geometry size with more proportion simulated

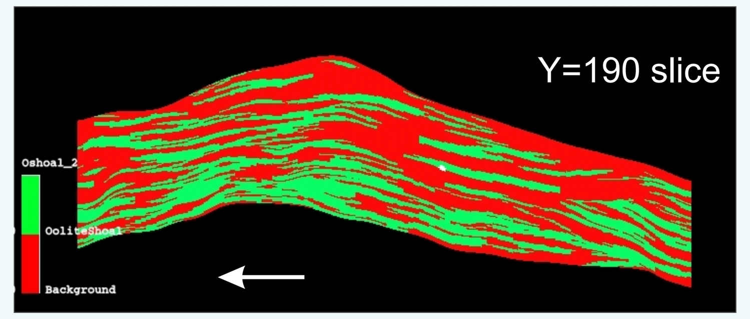
Both show the same layer (Z=165) in the simulation grid

Simulation results for oolitic shoal complex



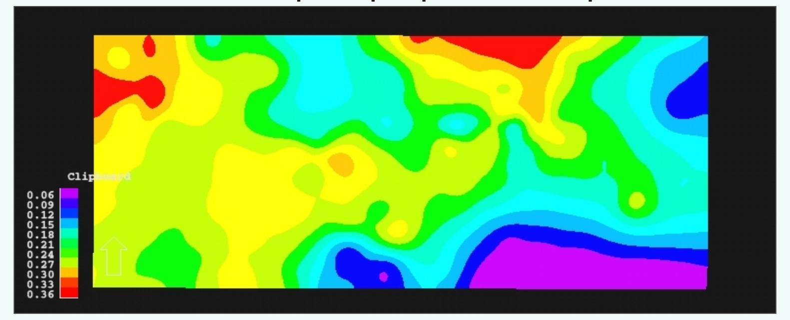




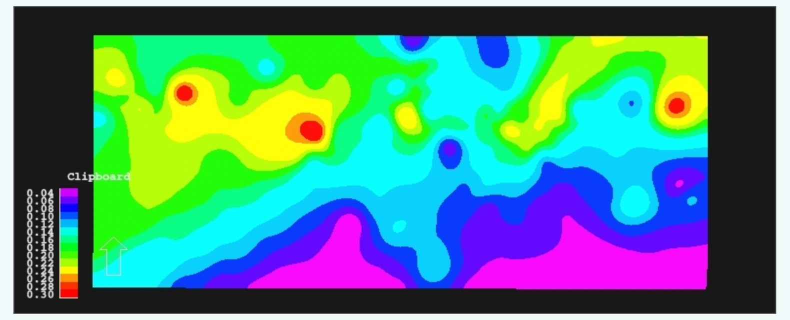


Facies proportion trend

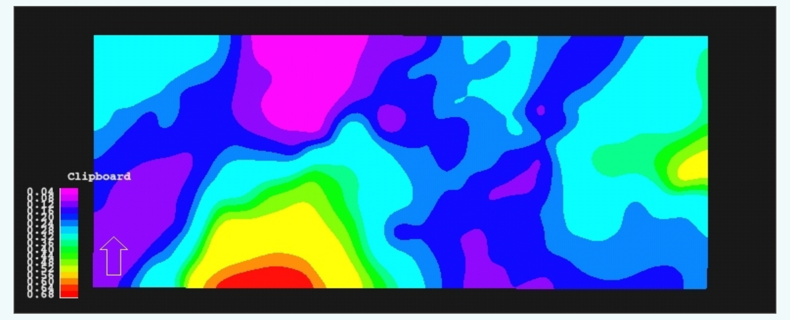
Oolitic shoal complex proportion map



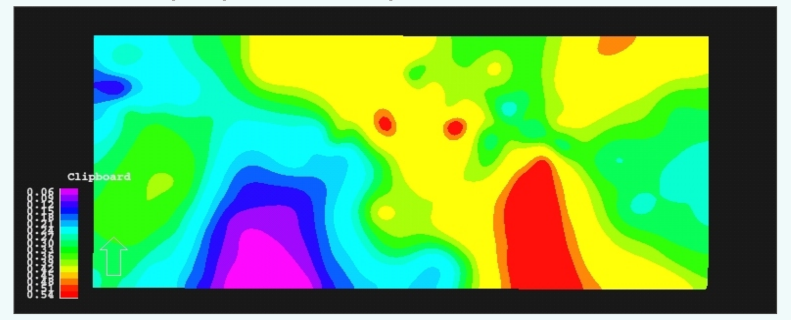
Ooid grainstone proportion map



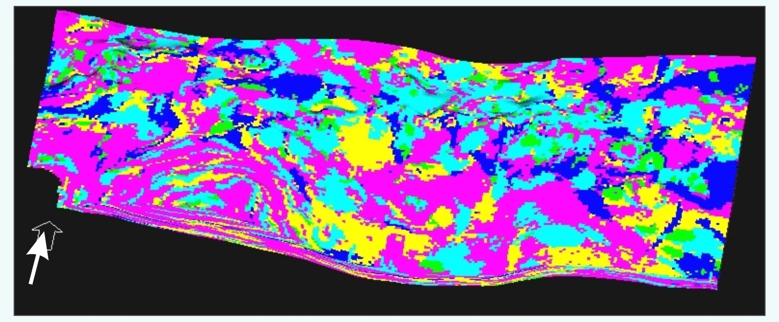
Tidal flat proportion map

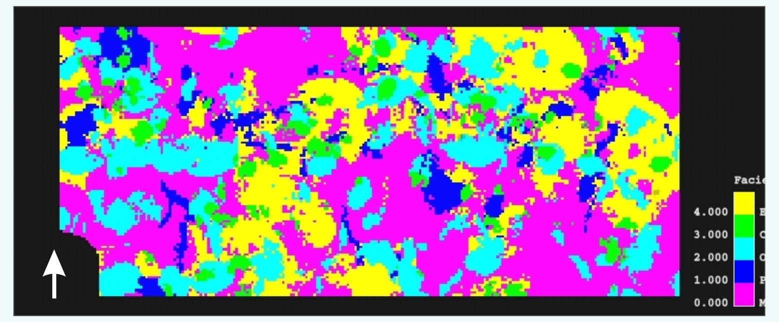


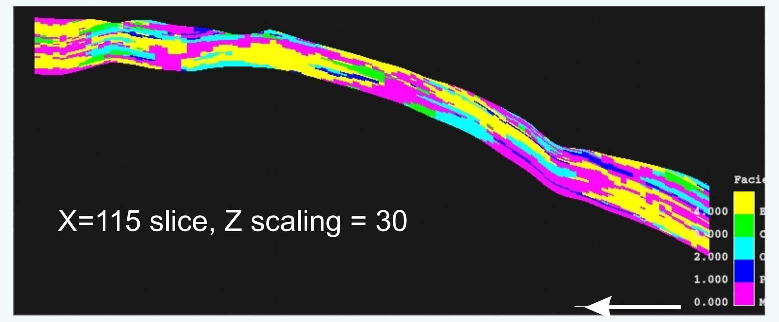
Eolianite proportion map

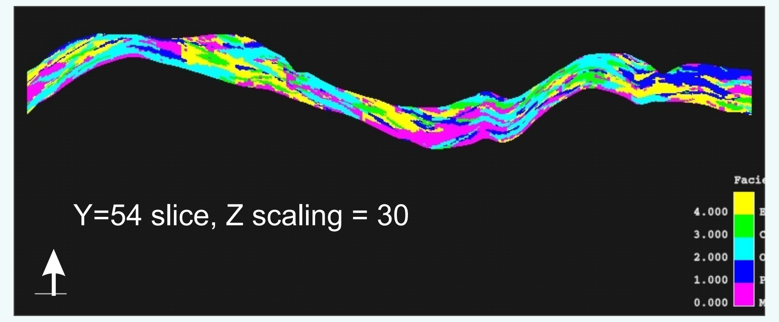


Stochastic simulation result for facies

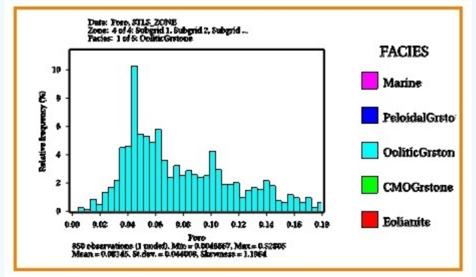




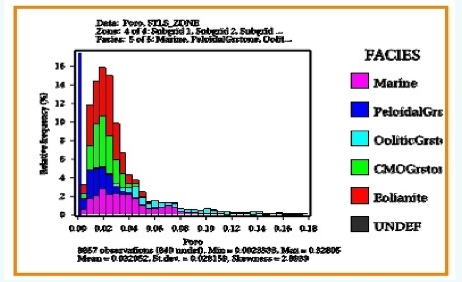




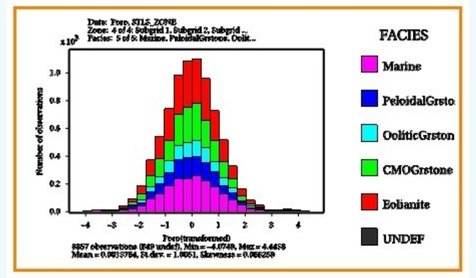
Data Analysis and Transform



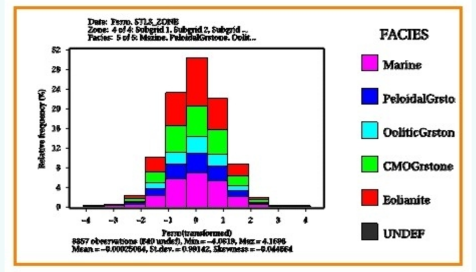
The histogram of porosity (oolitic grainstone) before the transforms



The histogram of porosity (all facies) before the transforms.

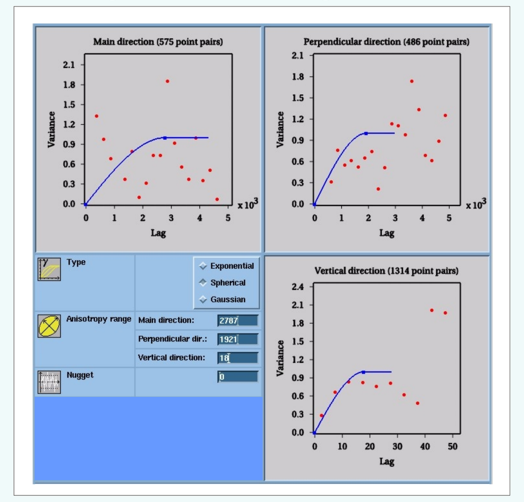


The histogram of porosity (all facies) after the transform (truncation, scale-shift, power and normal score).



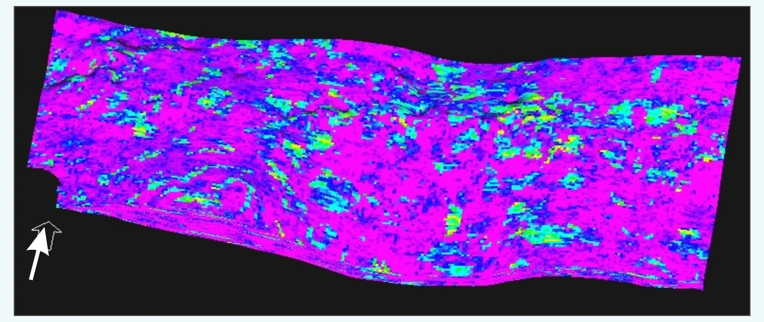
The histogram of permeability (all facies) after the transforms (truncation, scale-shift, power and normal socre).

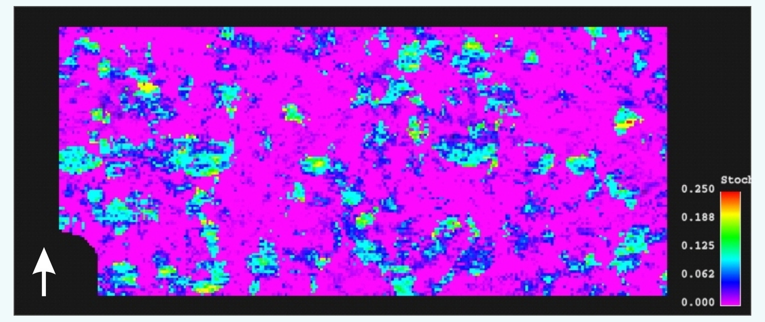
Variogram Modeling

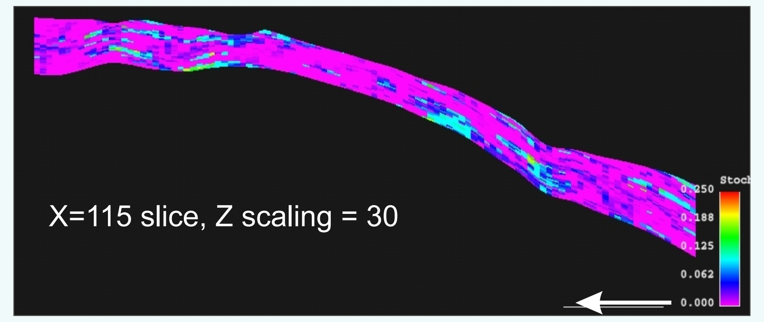


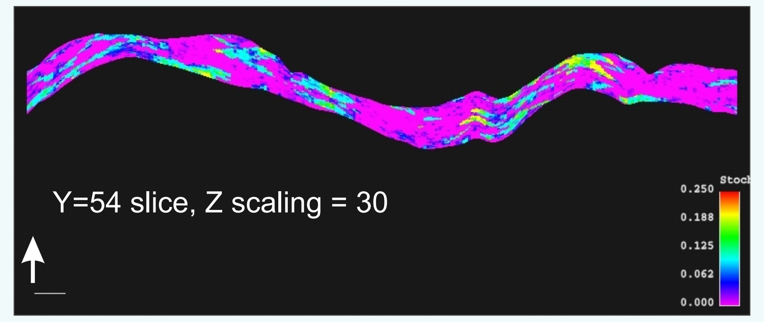
Porosity and permeability variogram models were built for all the facies modeled within 4 different subgrids. This variogram shows the modeling for oolitic grainstone facies in subgrid 3 (St Louis C zone).

Stochastic simulation result for porosity

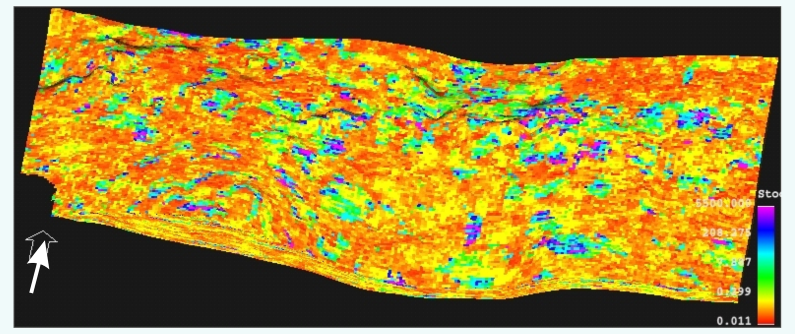


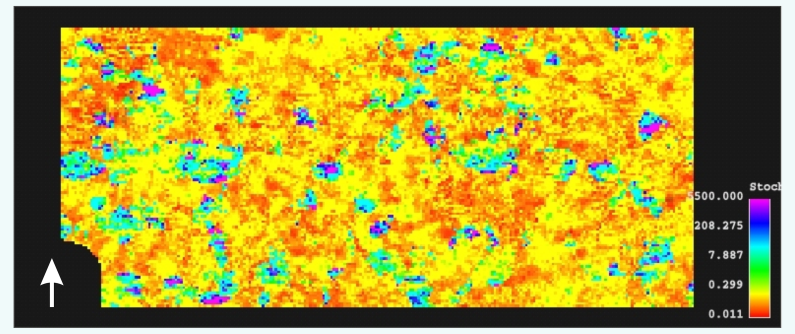




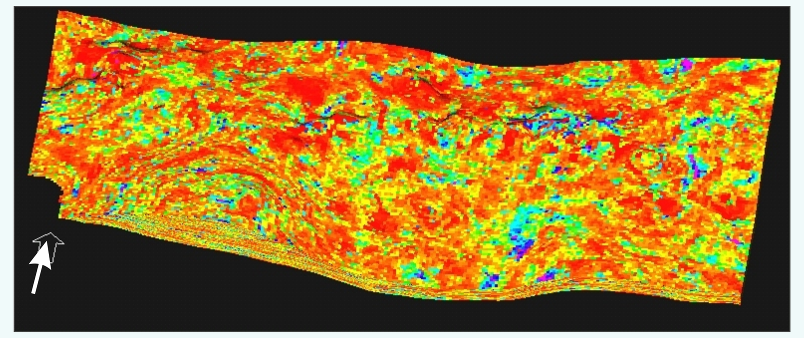


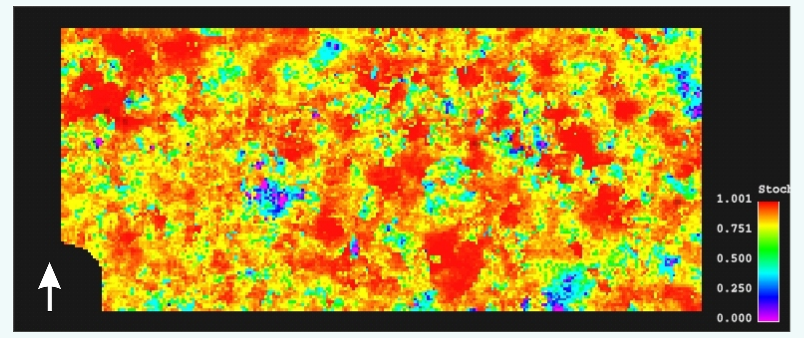
Stochastic simulation result for permeability





Stochastic simulation result for water saturation





Summary:

This poster illustrates the construction of an improved 3D stochastic model and simulation on St. Louis carbonate systems.

1. Six lithofacies were recognized and classified through the description of 10 cored wells of St. Louis oolite shoal reservoirs in Southwestern Kansas.

2. The reservoir lithofacies, ooid skeletal grainstone, has distinctive petrophysical properties.

3. Neural Network models were developed using digital logs (GR, Rt, PE and Porosity) from cored wells. Llithofacies were predicted in cored and non-cored wells with a high degree of accuracy.

4. Lithofacies predicted from Neural Network model can be interpolated between wells to better understand depositional patterns and external geometry of St Louis Limestone.

5. Stratigraphic surfaces were used to build a 3D stratigraphic framework.

6. Object-based stochastic modeling was performed to build lithofacies models in three St. Louis oolite reservoirs to better understand the 3D external geometries of St. Louis oolite shoals.

7. Internal geometries of St. Louis oolite shoal reservoirs were illustrated by building 3D porosity and permeability distribution models using stochastic simulation.

8. Multiple realizations can be built for all the stochastic simulation results.

Further Work:

1. Add facies proportion trends and evaluate effect of azimuthal trend.

2. Rank the stochastic simulation models and select the reasonable models to upscale for streamline simulation test.

3. Compare the streamline simulation results and select the best model to export for flow simulation.

4. Perform reservoir simulation to verify the geostatistical models by production history match.

Reference:

Carr, D. D., 1973, Geometry and origin of oolite bodies in the Ste. Genevieve Limestone (Mississippian) in the Illinois basin: Indiana geological survey Bulletin 48, 81 p.

Carr, T. R. and Lundgren, Carl E, 1994, Use of Gamma Ray Spectral Log to recognize Exposure Surfaces at the Reservoir Scale: Big Bow Field (St. Louis Limestone). Kansas: Unconformity-related hydrocarbons in sedimentary sequences, Rocky mountain association of geologists, p. 79-88, 281.

Gary, Richard J., 1994, Petrophysical Characterization of Mississippian Ooid-Shoal Reservoirs, Hugoton Embayment, Southwest Kansas, Armco, 46 p.

Handford, C. R., 1988, Review of carbonate sand-belt deposition of ooid grainstones and application to Mississippian reservoir, Damme Field, southwestern Kansas: AAPG Bulletin, V. 72, p. 1184-1199.

Garsmueck, Mark, and Weger, Ralf, 2002, 3D GPR reveals complex internal structure of Pleistocene oolitic sandbar: The Leading Edge, p 634-639.

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http://www.kgs.ku.edu/PRS/publication/2004/AAPG/3DReservoir