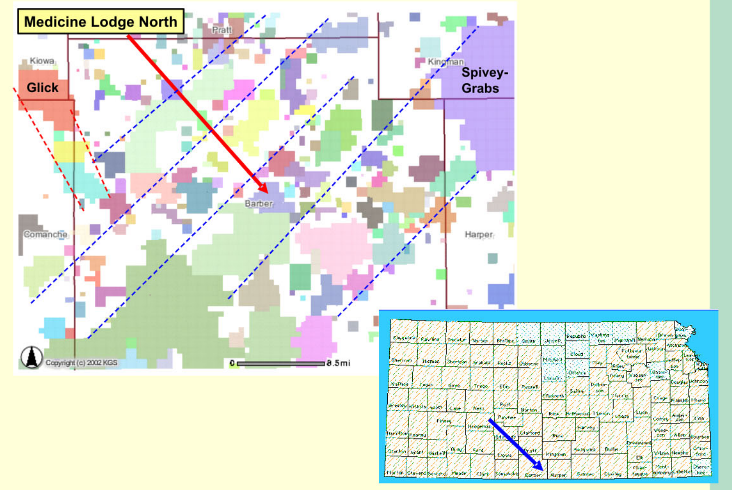
Case Study – Medicine Lodge North

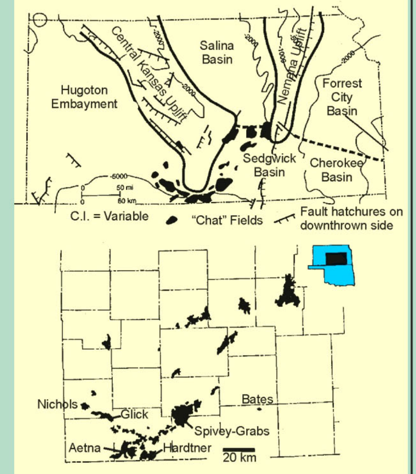
Barber County, Kansas, Mississippian "Chat" Reservoir – Log and Core Petrophysics, Volumetric Modeling

Object of study of Medicine Lodge North Field was to evaluate reservoir for infill drilling sites that could be drilled and fracture stimulated to produce additional oil in a depleting "Chat" reservoir.



Lineaments are added manually based on visual inspection paralleling trends recognized from previous work that indicates deep-seated basement heterogeneity reflected in Paleozoic structure and magnetic and gravity mapping (Watney et al., 2001). Many of these fields Produce oil and gas from the Mississippian "chat". Map is generated from ARC-IMS map server (http://www.kgs.ku.edu/PRS/petroMaps.html).

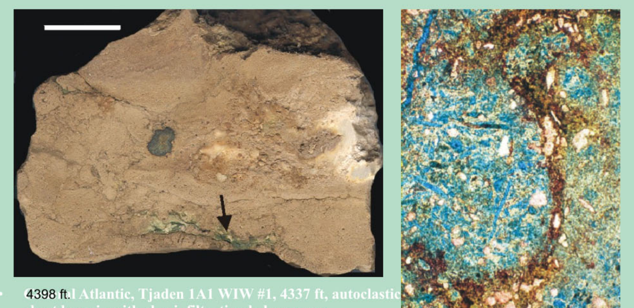
Distribution of Mississippian chat fields in Kansas



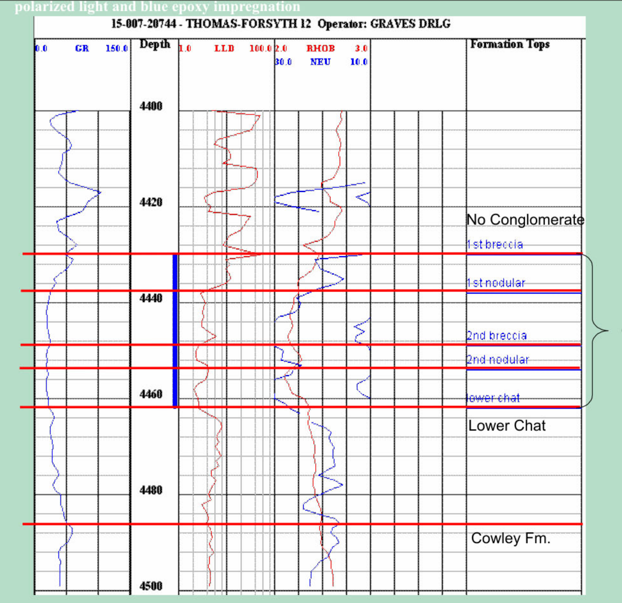
* Low resistivity pays
* stratigraphic traps
* cum. Gas 2.4 TCF
* cum. Oil 280 MM bbls.
* Potential for reexploration and IOR using appropriate recovery technologies

(from Montgomery et al., 1998)

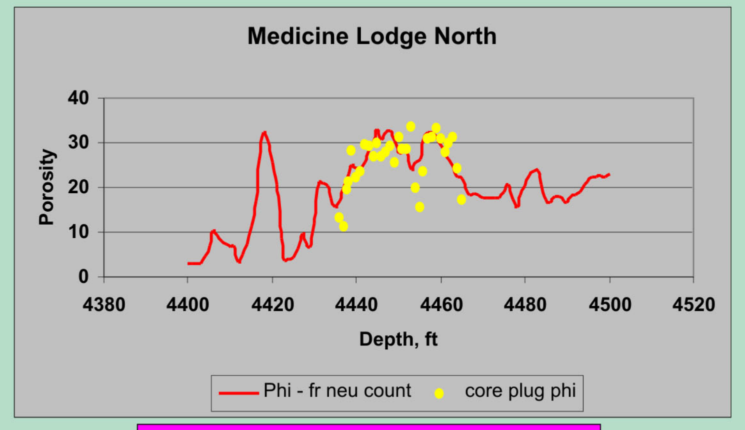
Autoclastic chert reservoir



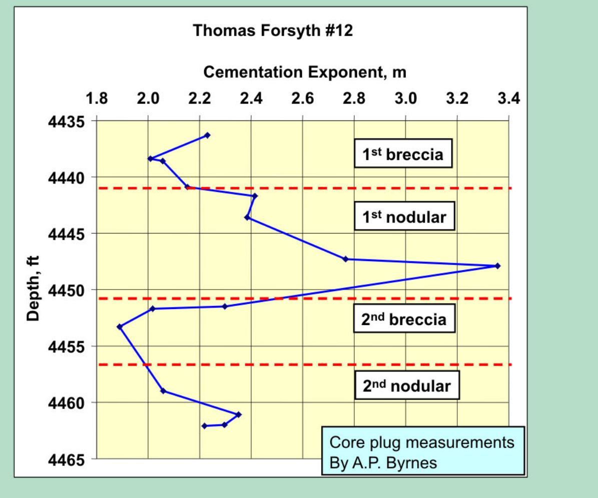
Autoclastic chert breccia with "clasts" lined by clay and brown microcrystalline calcite. Abundant microporosity, molds, and vugs in spiculitic microcrystalline chert.



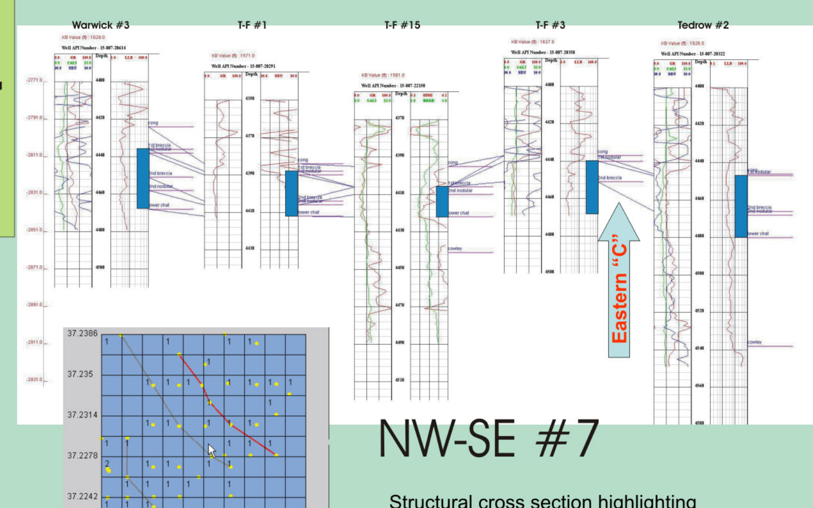
Type log of cored well in Medicine Lodge North Field showing lithofacies and stratigraphic subdivisions of "chat" reservoir. Note that the nodular zones have slightly higher porosity and than the zones of breccia.



Comparison between core plug porosity and porosity calculated from conversion of neutron counts.



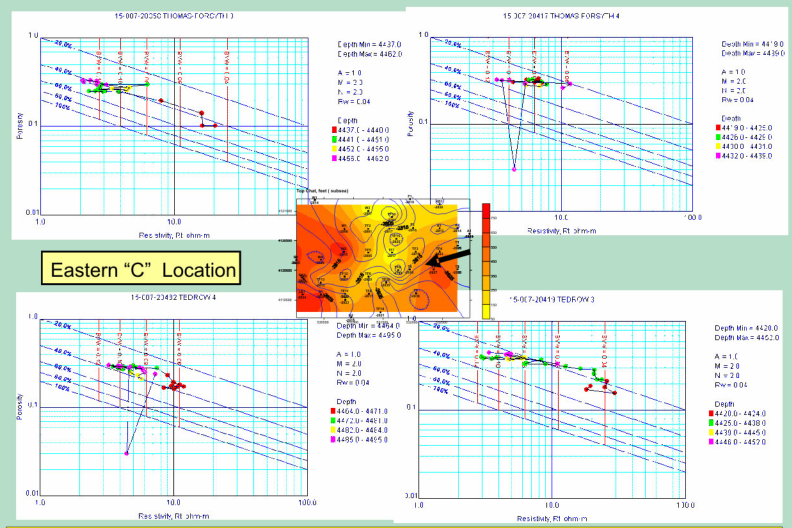
Core measurements of m, the Archie cementation exponent vs. depth indicate that m varies between 1.9 and 3.3.



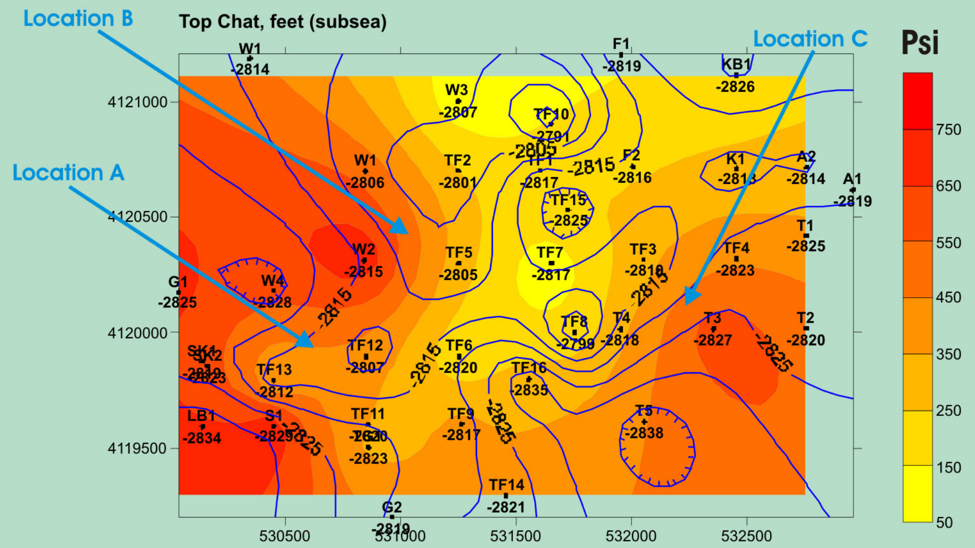
NW-SE #7

Structural cross section highlighting Chat2 and eastern "C"drillsite

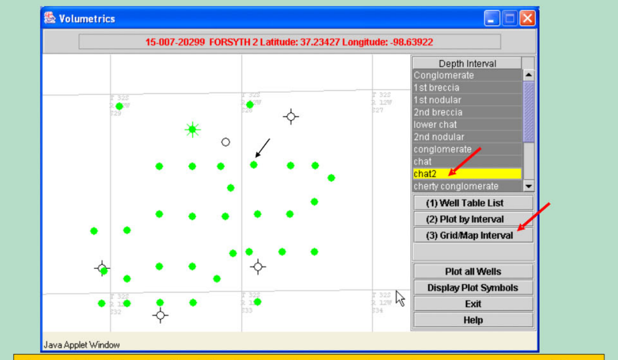
Northwest-southeast structural log cross section identifying another potential infill location. Note local thinning and truncation of the uppermost "chat" reservoir along the basal Pennsylvanian unconformity and local thickening of overlying Pennsylvanian conglomerate some correspondence to areas of underlying truncation of "chat".



Eastern infill location "C" depicted by Pickett crossplots of surrounding wells. The lower BVW, the better the reservoir quality.



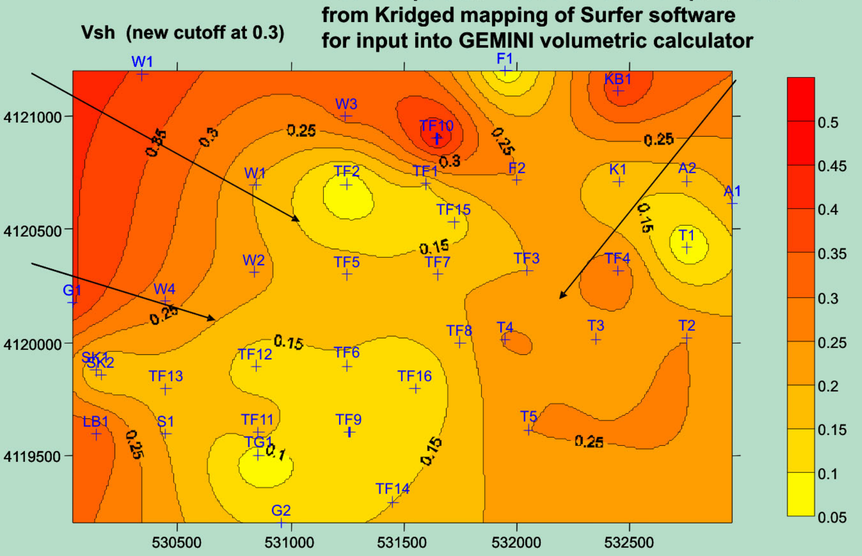
Map depicting both current reservoir pressure in color with contours of overlying structure on top of the "chat" reservoir. Crest of structure and lower pressure closely coincide.



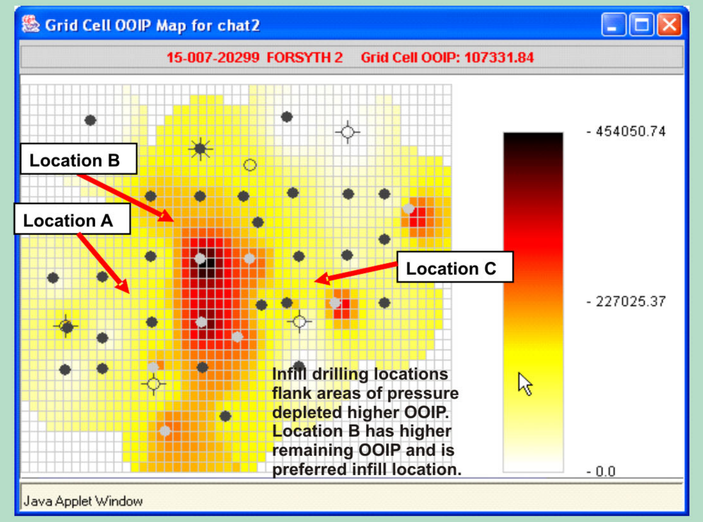
Volumetric dialog for Medicine Lodge North showing various zones and models that were part of the experiment to define the optimum volumetric model for assessing infill drilling locations.

Case Study – Medicine Lodge North Volumetrics and Infill Drilling

Use interpolated values of reservoir parameters from Kridged mapping of Surfer software for input into GEMINI volumetric calculator



Map of average Vsh for pay interval in the chat2 reservoir. Arrows locate prospective infill drilling locations.



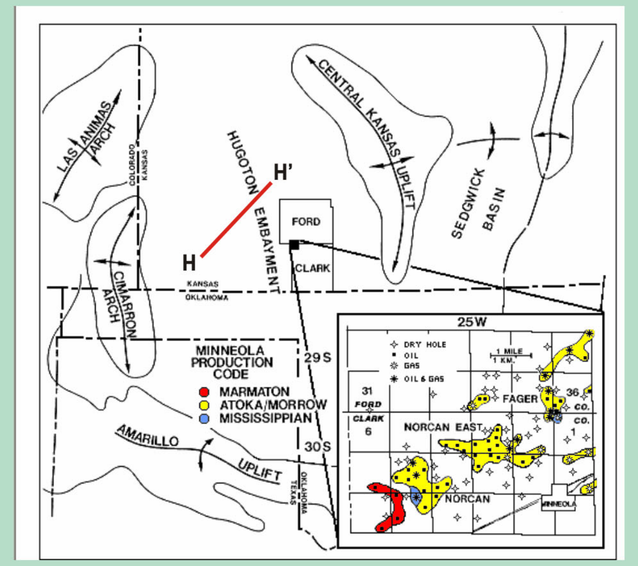
Map of OOIP for Medicine Lodge Field with 200 ft grid cell.

Summary in GEMINI Application to Medicine Lodge North Field

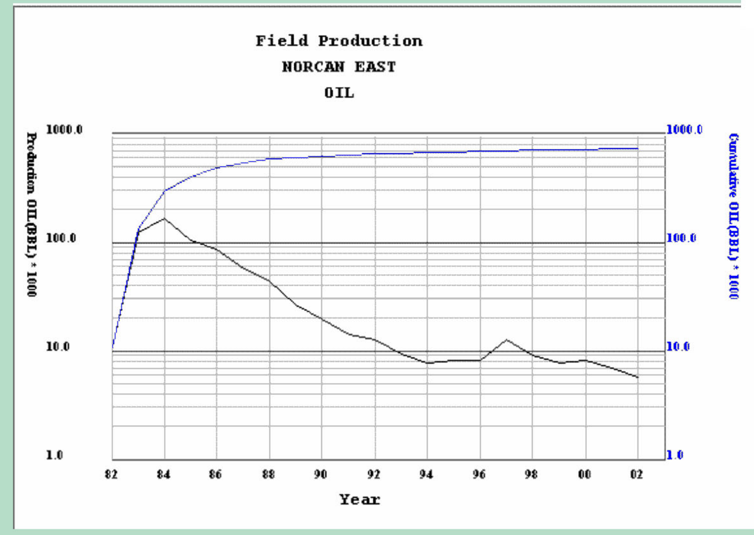
Expeditious construction of a reservoir model of Medicine Lodge North has relied on the ability to integrate various analytical steps from core and log analysis to mapping and volumetric evaluation. Seamless iteration among these analytical tools has helped to achieve an optimized solution. Moreover, web collaboration environment leverages the public-domain data, helps achieve an interdisciplinary solution in spite of distance between collaborators, and provides the ability to share the model and data with partnering companies and eventually the public as part of technology transfer. The option to export results for further modeling has enhanced results. In total, the integrated software makes possible collaborative, interdisciplinary quantitative reservoir modeling in a timely manner.

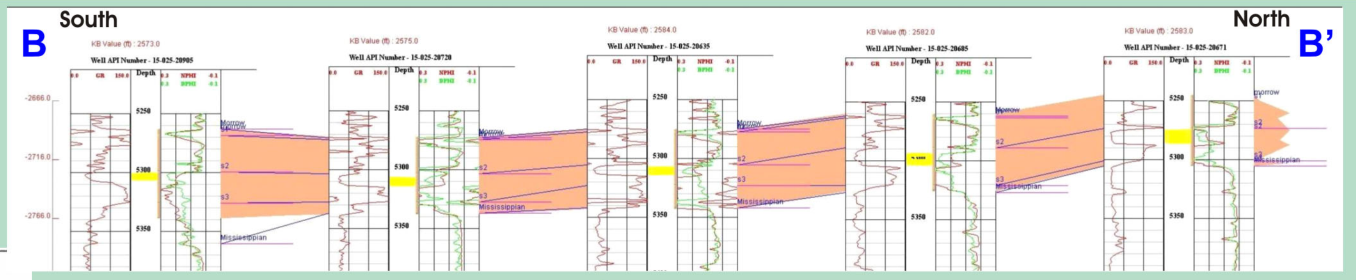
Case Study – Minneola Field Complex

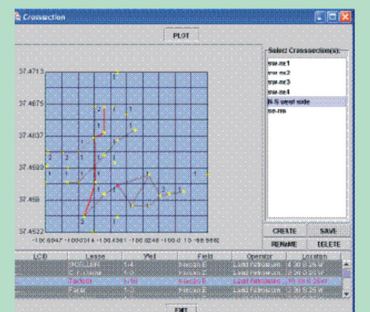
Clark County, Kansas, Pennsylvanian, Atoka/Morrow Incised Valley Fill Sandstone Utilizing Log and Core Petrophysics, Volumetrics



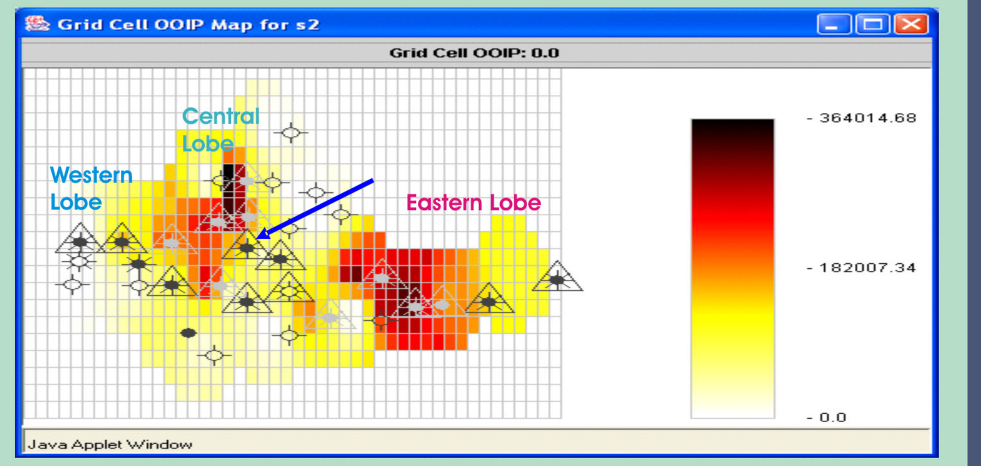
West central Midcontinent showing location of Minneola field complex (from Kruger, 1996)



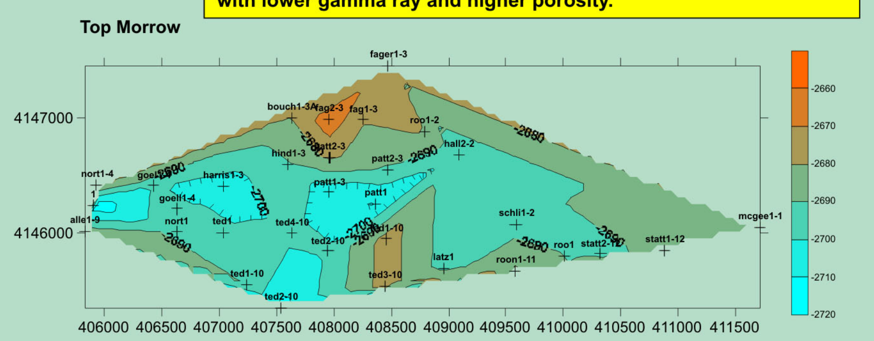


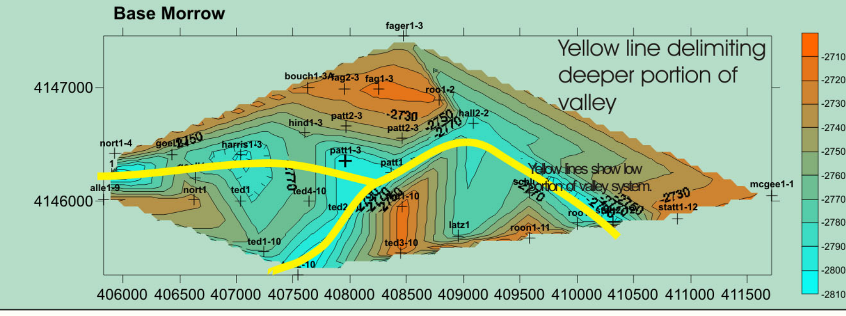


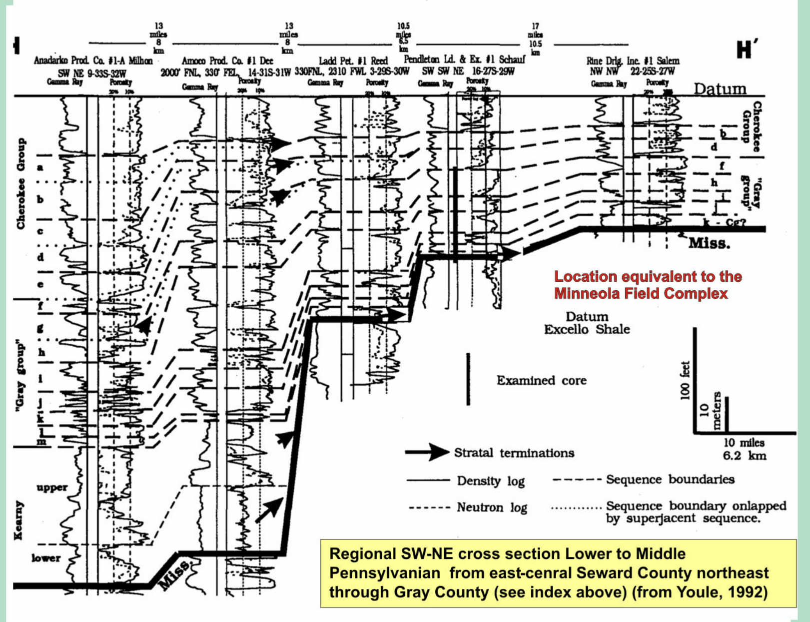
South-to-North structure cross section B-B' highlighting Morrow interval with S1, S2, and S3 cycles. Yellow bar in depth track highlights the porous sandstone reservoir in the S2 cycle that was identified in core and log analysis. Sandstone cleanest to north with lower gamma ray and higher porosity.



The original-oil-in-place shows two distinctive lobes. The injection well, also the cored well, Patton #1-3 (denoted by blue arrow) is located in the middle of the field. the location of the injector is not optimum in terms of sand quality or hydrocarbon pore volume. Any realignment of the waterflood would include reversing the low pressure regime through large water volume needed just to fill up the pore space and regain elevated pressures. Also, loss of solution gas pressure and occupancy of free gas in the pore space will block oil movement from some areas and make incremental oil recovery expensive and difficult. Reservoir simulation will utilize the new volumetric parameters to examine further options for improving oil recovery.

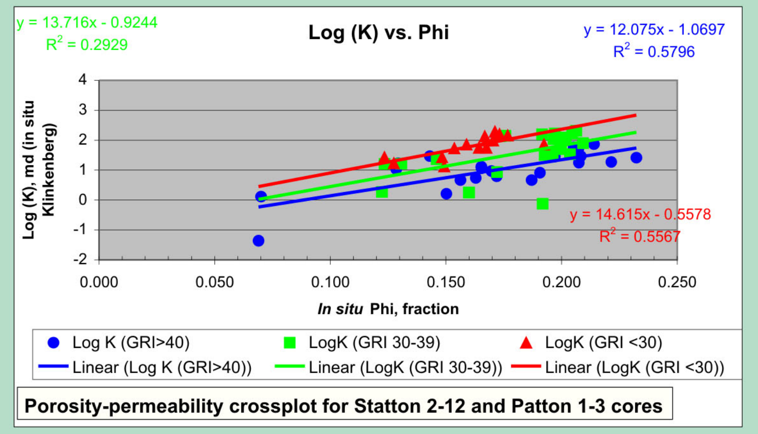






Desmoines
Atoka
Morrow
Datum
Miss.
Location equivalent to the Minneola Field Complex
Datum Excello Shale
Examined core
Stratal terminations
Density log
Neutron log
Sequence boundaries
Sequence boundary onlapped by superjacent sequence.

Regional SW-NE cross section Lower to Middle Pennsylvanian from east-cenral Seward County northeast through Gray County (see index above) (from Youle, 1992)

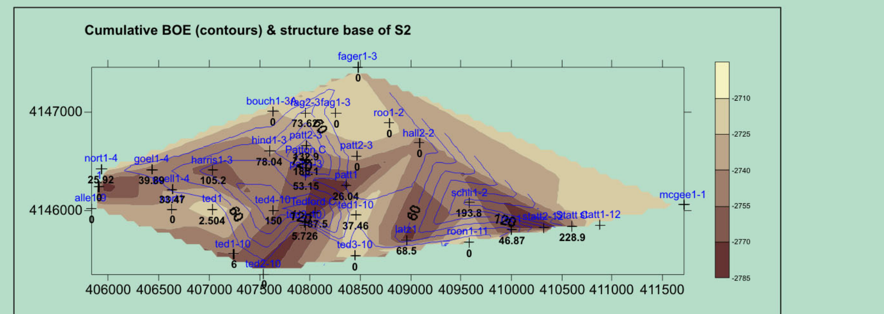


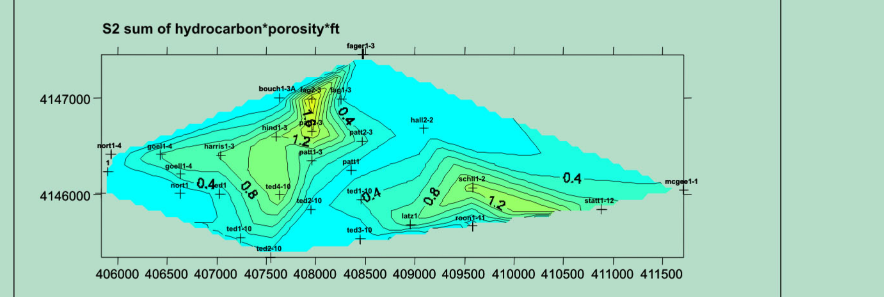
Porosity-permeability crossplot for Statton 2-12 and Patton 1-3 cores

Scatter in the porosity-permeability relationship reduced when samples were classified by shale content, proxied by gamma ray (API units). Higher permeability was noted in cleaner sandstones, thus Vsh, shale fraction, was recognized as a important in delineating favorable lithofacies and prospective hydrocarbon pay.

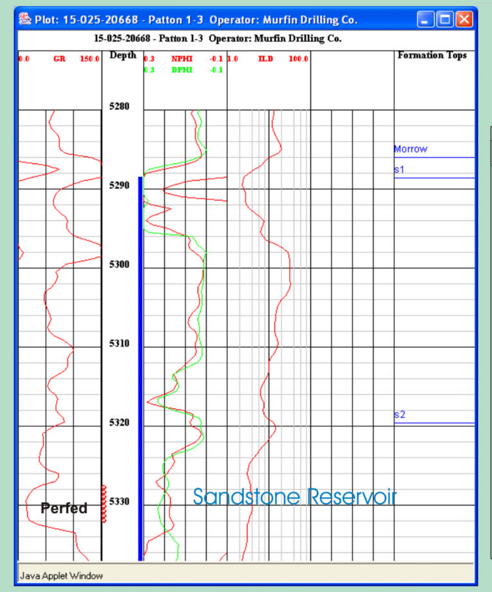
Structure maps (sealevel datum) for the datum at the top and base of the Morrow

The top of the Morrow interval in the incised valley in Norcan East is a current-day structural low higher to the east and deeper to the west. The elevation at the base of the Morrow clearly delimits the incised valley with a deeper axis extending from the southeast up to the central area and then through a narrow constricted part of the valley then southwestward forming an L-shaped pattern.

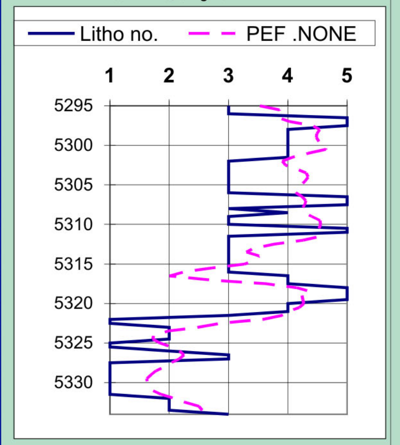




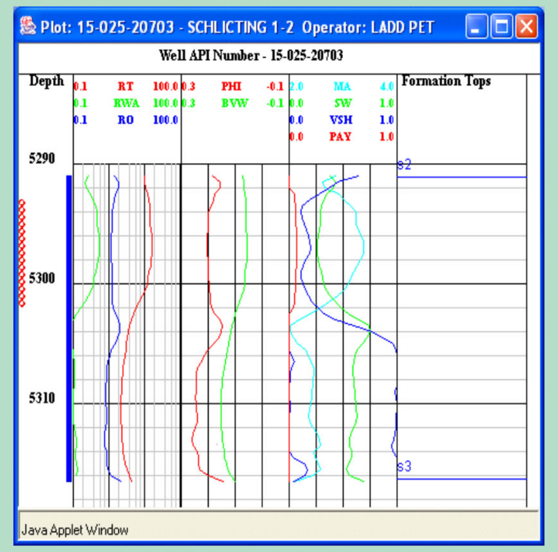
Comparisons of total BOE and So*phi*ft and elevation base of S2 cycle



lith no.	lithology
1	ss, f gr, clean
2	ss, vfg, w/lam. shale
3	shale, calc
4	ls, brn, dense
5	ls, dk.gr-blk

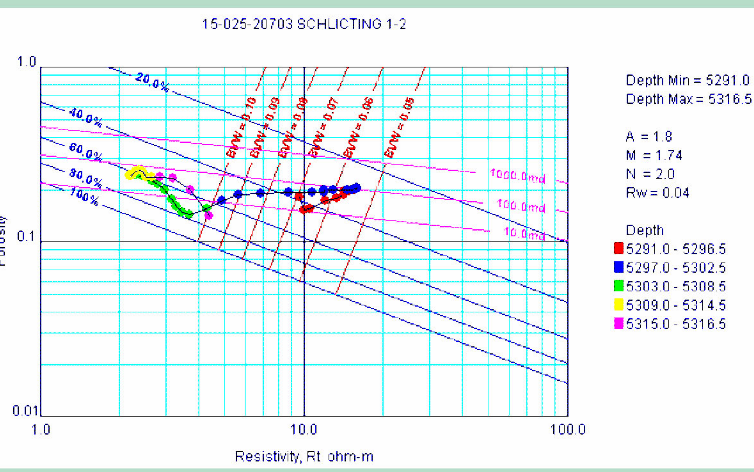


Composite well log plot with stratigraphic units and core description with Pe curve for Patton 1-3.

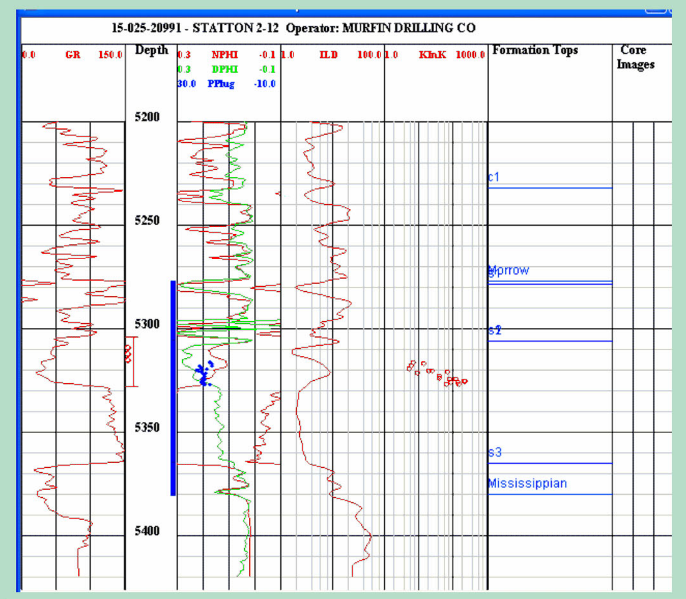


Depth profile of S2 cycle showing sandstone pay.

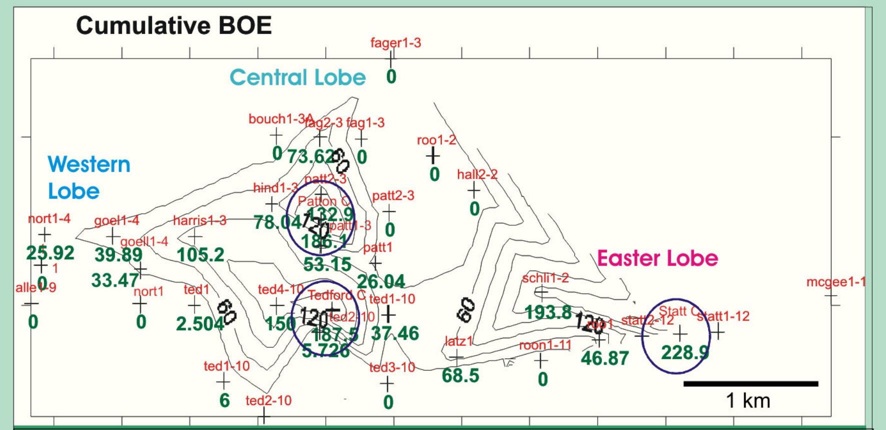
Log analysis was conducted on the S2 sandstone reservoir to define effective pay. The Schlicting 1-2 lease produced a **billion cubic feet of gas**. The S2 sandstone is thick and clean. Well profile shows lobe of sand with Vsh curve and high porosity. Well perforations are also shown. Alongside the log profile is the lease production history showing annual and cumulative (Figure 4.39). Cut-offs include Vsh = 30%, Phi = 12%, Sw = 50%, and BVW = 0.12.



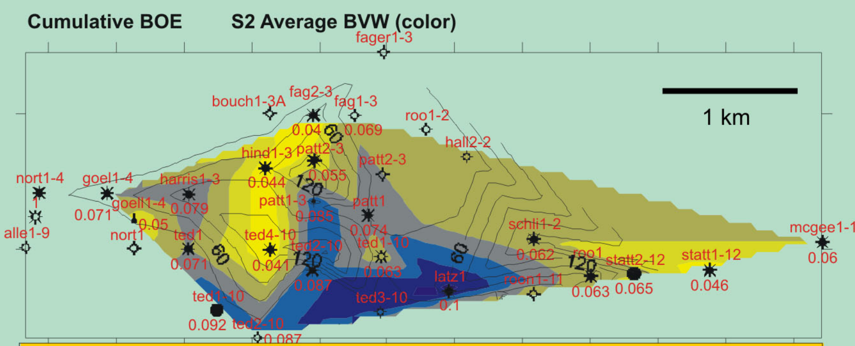
Super Pickett crossplot of Schlicting #1-2 well. Low BVW (high phi and low Sw) combine to describe a good hydrocarbon pay zone that has produced over a BCF of natural gas.



Cored well Statton 2-12 with reservoir sandstone. Cored interval shown by core analyses points. Perforations shown as red circles in depth column. DST interval is also shown in the depth track.



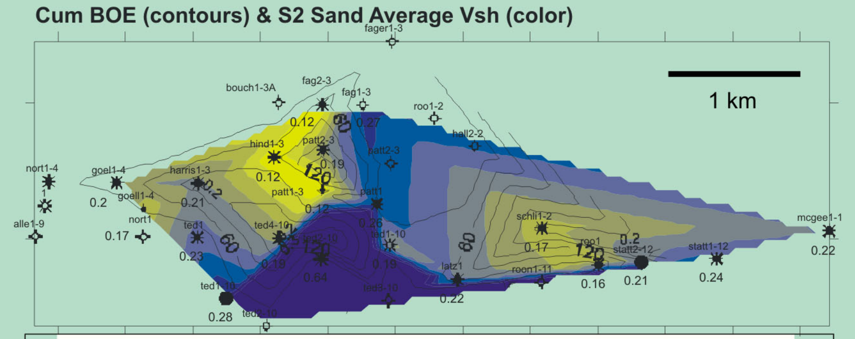
Cumulative BOE in 1000's bbls for Norcan East field. Two areas of high productivity. Blue circles denote leases with multiple wells



Average BVW for S2 sandstone overlain with total BOE contours.

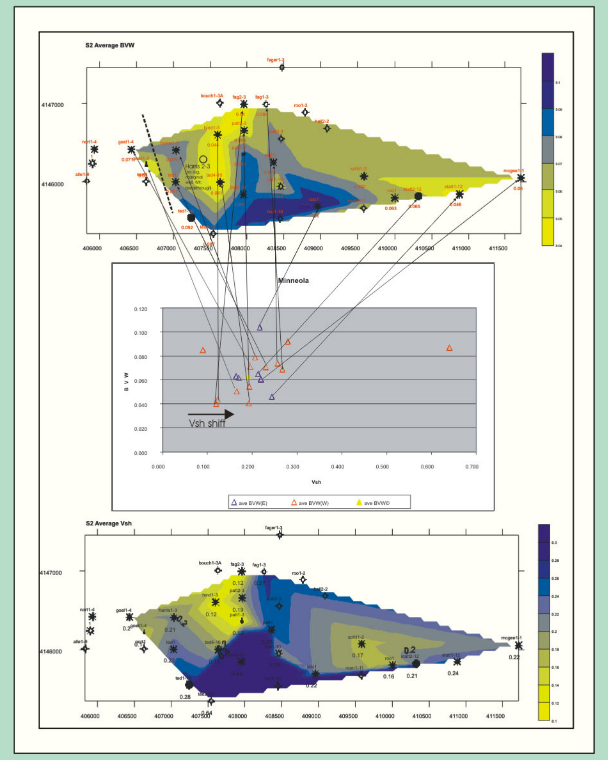
The lower the BVW, the coarser the pores. Note low BVW in central region forming a north-south pattern. Also note southerly gradient of increasing BVW for central zone.

Cum BOE (contours) & S2 Sand Average Vsh (color)



Average Vsh (color) for S2 sandstone overlain with total BVW contours.

The central lobe is cleanest (low Vsh) in the north-central and gradually increases to the southwest. Similarly, the Vsh in the eastern area defines a lobe-shaped clean sand body where Vsh declines to the northwest. The locus of highly productive areas (CUM BOE OVERLAY) closely corresponds to these lobes of cleaner sandstone and it is inferred that the lobes reflect depositional features, low Vsh closest to the source of the sand. Based on comparison of productive and dry wells, the Vsh cut-off was confirmed to be 0.3.



Comparison of plots and maps of BVW and Vsh illustrating trends.

A plot of the average BVW and Vsh distinguishing the east and western lobes shows a positive correlation between increasing BVW and Vsh. Links to maps of BVW and Vsh support the relationship between improved reservoir properties in proximal positions within the lobes of sand, i.e., closest to sources of the sand as previously discussed.

Reservoir Geology of Minneola Field Complex

A possible source of sand supplying the central lobe of sandstone appears to have been from the north where the reservoir properties gradually improve. The inferred proximal source of the southeastern lobe of sand appears to be from the southeastern edge of the valley. Lithofacies suggests that the fluvial channel sand was increasingly modified by marine and tidal influences more distal from the source (northwest).

A stillstand in sealevel and prolonged shoreline at and near this location probably led to sand accumulation in a partially filled, incised valley system (also interpreted as barrier sands by Clark, 1986).

The quartz sand closely resembles the sandy matrix of the underlying Mississippian Ste. Genevieve Limestone into which the incised valley was developed. The sealevel stillstand may also have been responsible for transported products of the weathered limestone, i.e., sandstone, to sites of lower energy such as local fall lines in bays and estuaries such as the valley would provide. This limited sand accumulation is suggestive of local sand supply, rather than a large tributary drainage system. Moreover, the western limit of the S2 cycle sand in Norcan East Field grades to limestone confirmed in cores obtained within a mile southwest of the field (Wears #1 in Section 8-30S-25W and Harris #1 in Section 9-30S-25W). This suggests that marine shelf equivalents to the clastics are carbonate deposits.

Continuing collaborative studies will further refine the geo-engineering model in the Minneola area. Small oil and gas operators have the opportunity to conduct similar studies of their reservoirs leveraging public-domain databases and employing new recovery technologies at reduced risks.

References for Minneola field complex:

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Youle, J.C., 1992, Sequence stratigraphy of the Lower Middle Pennsylvanian and distribution of selected sandstones, eastern Hugoton embayment, southwestern Kansas: Unpubl. M.S. thesis, Department of Geology, University of Kansas, Lawrence, KS, 202 p. (avail. as Kans. Geol. Survey, Open-file Rept., no. 92-55).