

PS Geological Evaluation of Natural Gas Sandstone in the Snyderville Shale Member, Oread Limestone Formation, Medicine Lodge-Boggs Field, Barber County, Kansas*

Keithan Martin¹ and Benjamin Crouch²

Search and Discovery Article #20343 (2016)**

Posted February 1, 2016

*Adapted from poster presentation given at AAPG Mid-Continent Section meeting in Tulsa, Oklahoma, October 4-6, 2015

**Datapages © 2016 Serial rights given by author. For all other rights contact author directly.

¹Kansas State University, Manhattan, KS, USA (keithan@ksu.edu)

²Kansas State University, McPherson, KS, USA

Abstract

The Medicine Lodge-Boggs Field was discovered in 1927 and produces oil, gas, and NGLs from carbonate and siliciclastic reservoirs of Ordovician through Pennsylvanian age. This study focused on a natural gas productive sandstone in the upper Snyderville Shale located the southwest part of T33S R13W, Barber County, Kansas. Ten wells that produced from sandstone in the Snyderville Shale were identified, initiating a petrophysical analysis of openhole logs combined with review of drill stem tests, mud logs, and gas chromatographs provide the basis for mapping of sandstone thickness, porosity, resistivity, hydrocarbon saturation, productivity, and structural interpretations of the reservoir. The sandstone reservoir is bound by low permeability shale, which acts as a seal for trapping migrated hydrocarbons and isolating laterally correlative sandstone into isolated hydrocarbon systems. Production from the Snyderville sandstone is controlled by reservoir quality and structural attitude. In this case, natural gas that migrated into the reservoir, from deeper in the basin, became trapped in a structural anticline sealed updip as the sandstone 'shales-out' and sealed vertically by the Heebner Shale Formation. This study provides insight into identifying productive Snyderville sandstone reservoirs based on reservoir characterization and structural controls that may prove important in finding additional hydrocarbon reserves in South-central Kansas and Northern Oklahoma.

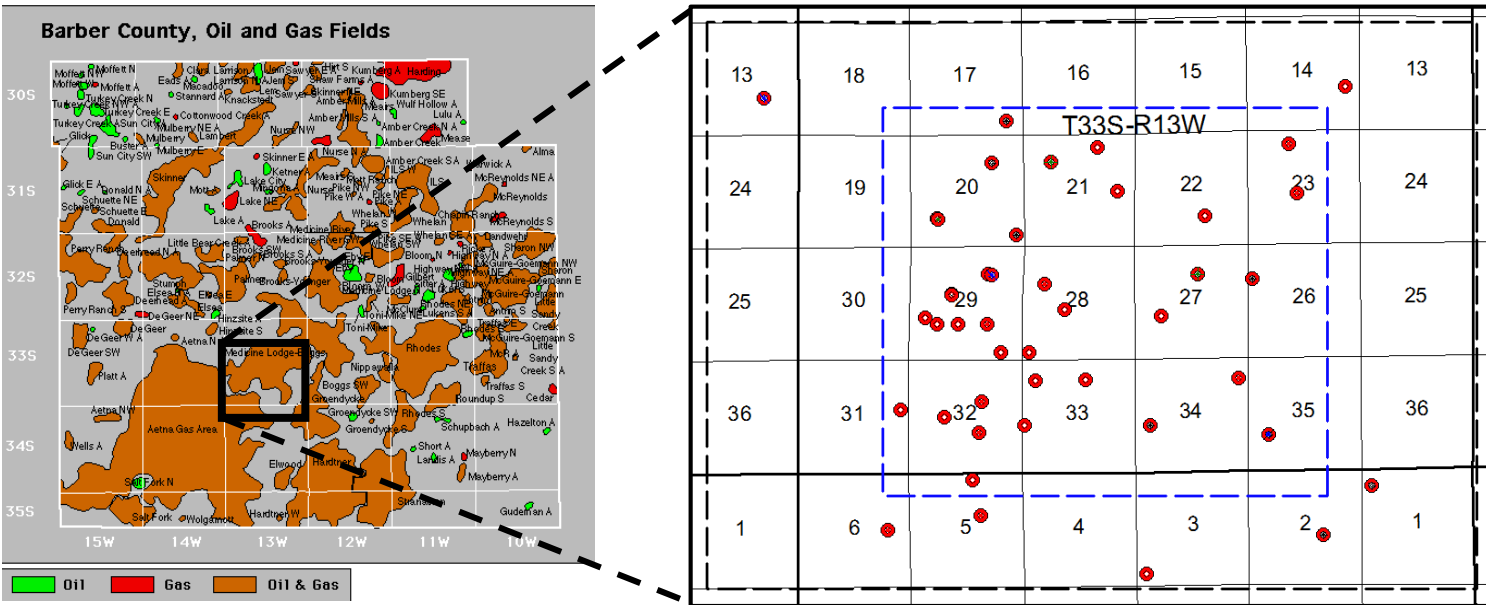
Geological Evaluation of Natural Gas Sandstone in the Snyderville Shale Member, Oread Limestone Formation, Medicine Lodge-Boggs Field, Barber County, Kansas

By Keithan G. Martin¹ and Benjamin W. Crouch II¹
Kansas State Univeristy¹

Abstract

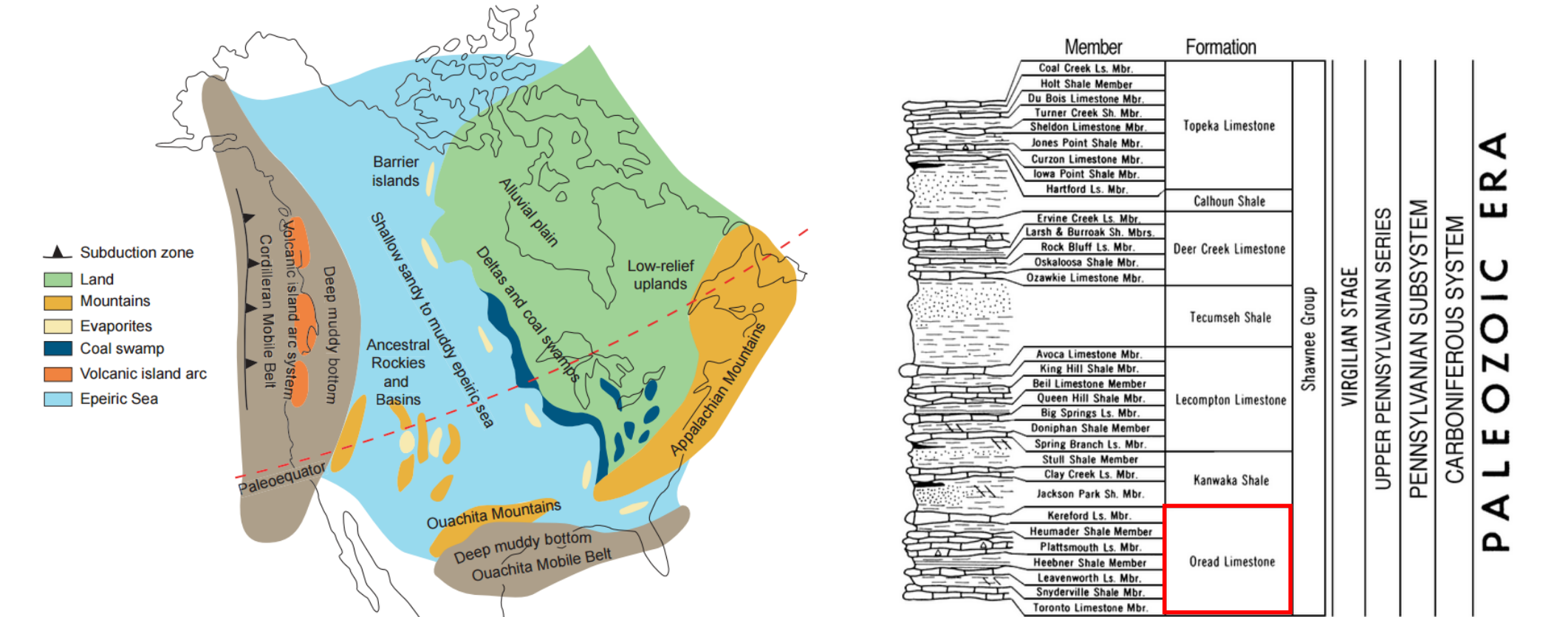
The Medicine Lodge-Boggs Field was discovered in 1927 and produces oil, gas, and NGLs from carbonate and siliciclastic reservoirs of Ordovician through Pennsylvanian age. This study focused on a natural gas productive sandstone in the upper Snyderville Shale located in the southwest part of T33S R13W, Barber County, Kansas. Public domain data was used to identify a pool of 10 wells that produced from sandstone in the Snyderville Shale. Petrophysical analysis of openhole logs combined with review of drill stem tests, mud logs, and gas chromatographs provide the basis for mapping of sandstone thickness, porosity, resistivity, hydrocarbon saturation, productivity, and structural interpretations of the reservoir. Productive reservoir is described as light gray, micaceous, very fine grained sandstone to siltstone with disseminated very fine grained pyrite, friable to very friable texture, ten percent density porosity and five ohms resistivity or greater. The sandstone reservoir is bound by low permeability shale which acts as a seal for trapping migrated hydrocarbons and isolating laterally correlative sandstone into isolated hydrocarbon systems. Production from the Snyderville Sandstone is controlled by reservoir quality and structural attitude. In this case, natural gas that migrated into the reservoir, from deeper in the basin, became trapped in a structural anticline sealed updip as the sandstone “shales-out” and is sealed vertically by the Heebner Shale Formation. This study provides insight into identifying productive Snyderville Sandstone reservoirs based on reservoir characterization and structural controls that may prove important in finding additional hydrocarbon reserves in the Snyderville Sandstone in Southcentral Kansas and Northern Oklahoma.

Study Area



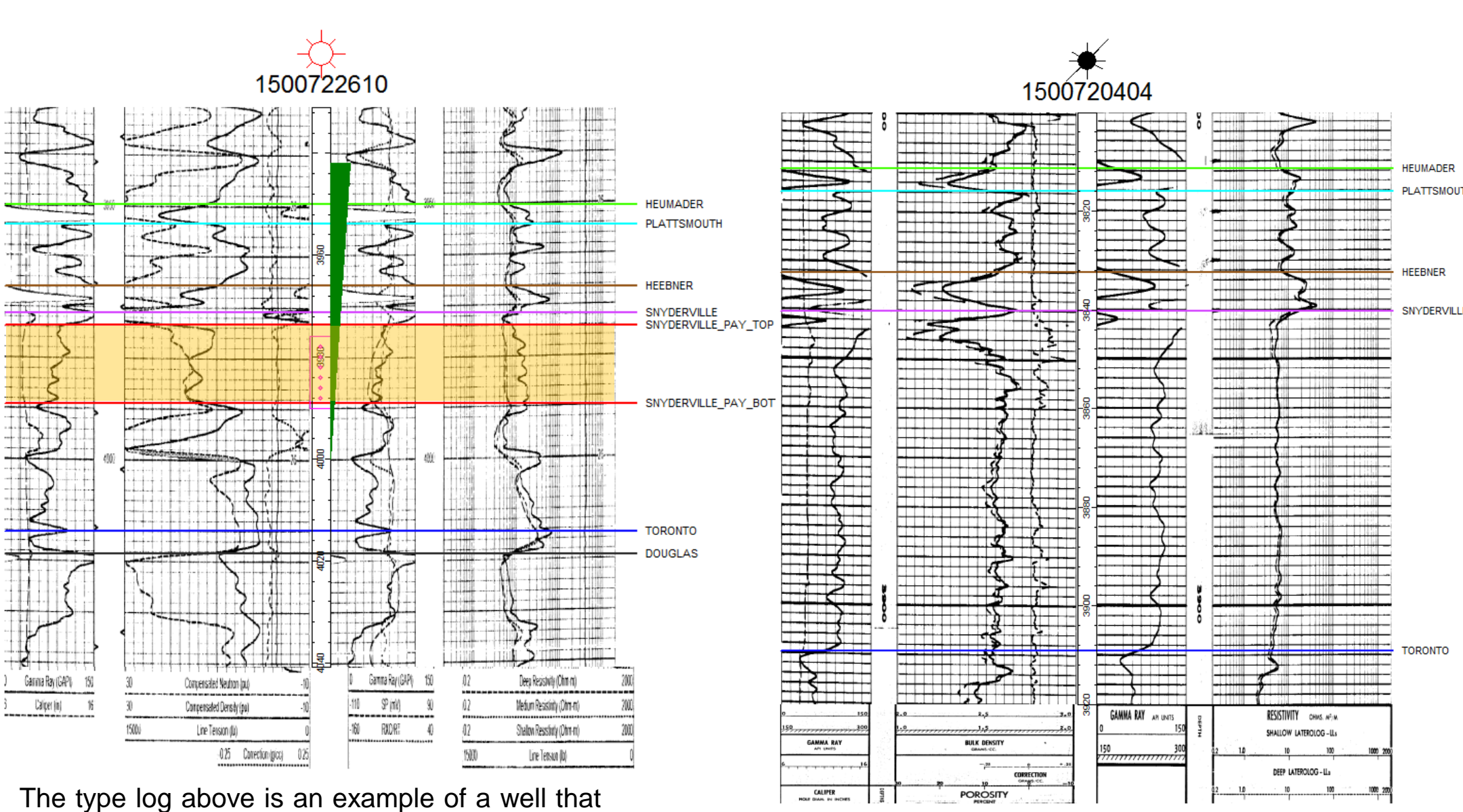
The study area is located in the southern portion of Township 33 South, Range 13 West, and is identified by the blue rectangle. Township 33 is enlarged to display wells that were used in for the creation of several maps. Barber County oil and gas field image from (KGS, 2011).

Paleogeography and Regional Stratigraphy



The left image displays the paleogeography of North America during the Pennsylvanian Period (-300 million years ago). During this period the Snyderville reservoir was deposited in a shallow sea near the paleo-equator. (Wicander and Monroe, 1989). The right image displays Regional stratigraphic column, which highlights the Oread Limestone. Modified image from (Zeller, 1968).

Identifying the Snyderville Pay Zone



The type log above is an example of a well that contains Snyderville pay.

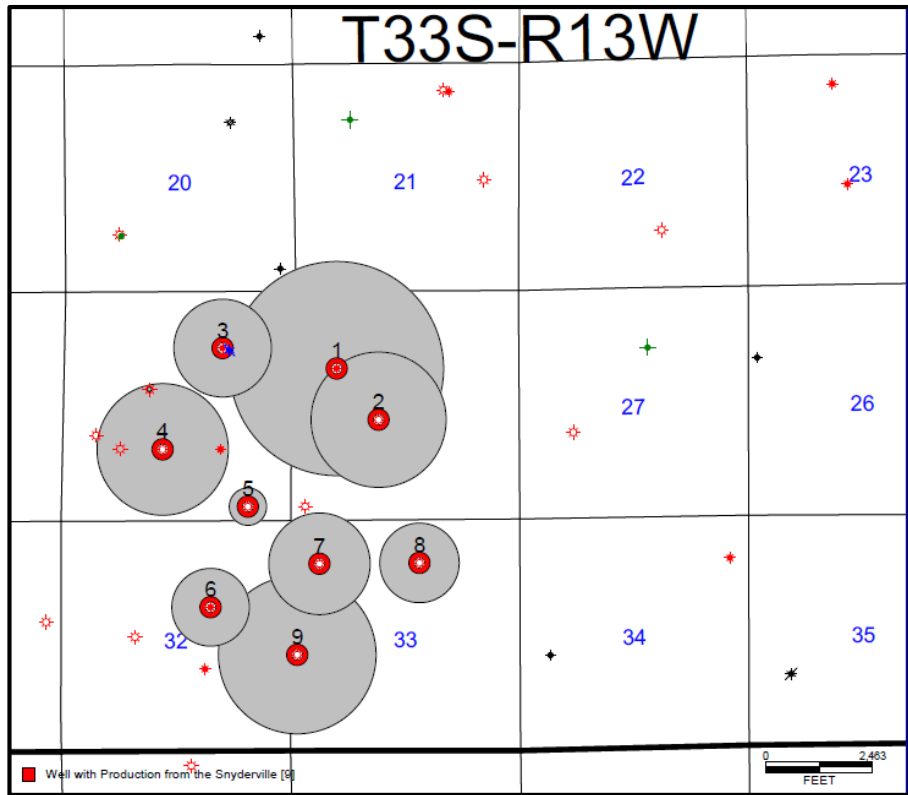
For this study we defined the cutoffs for the Snyderville Pay Zone based on density porosity, thickness, and R_{wa} .

The pay zone within the Snyderville is an interbedded argillaceous sandstone having a minimum: density porosity of 10%, height of 10 feet, and R_{wa} of 0.04 ohms.

The log above is an example of a well that contains no Snyderville pay.

Non-reservoir interval, seen in this log, lack significant sandstone deposition and instead are dominated by shale deposition typically having between 40' and 60' of shale zone forming local sealing traps adjacent to the sandstone pay.

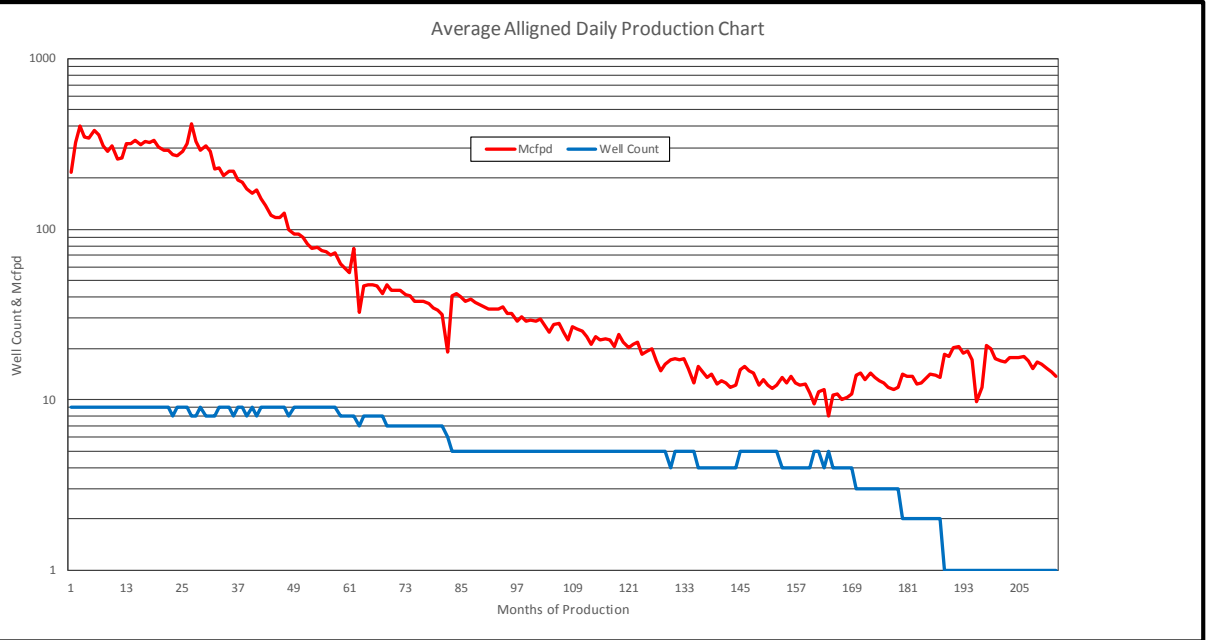
Snyderville Production



The above map shows the wells with production from the Snyderville Sandstone. The labels above each well correlate to Table 1 and the gray circles around each well represents the cumulative hydrocarbon production values for each well. (A bigger radius equals higher cumulative production). For exact cumulative product value, view Table 1 (upper right).

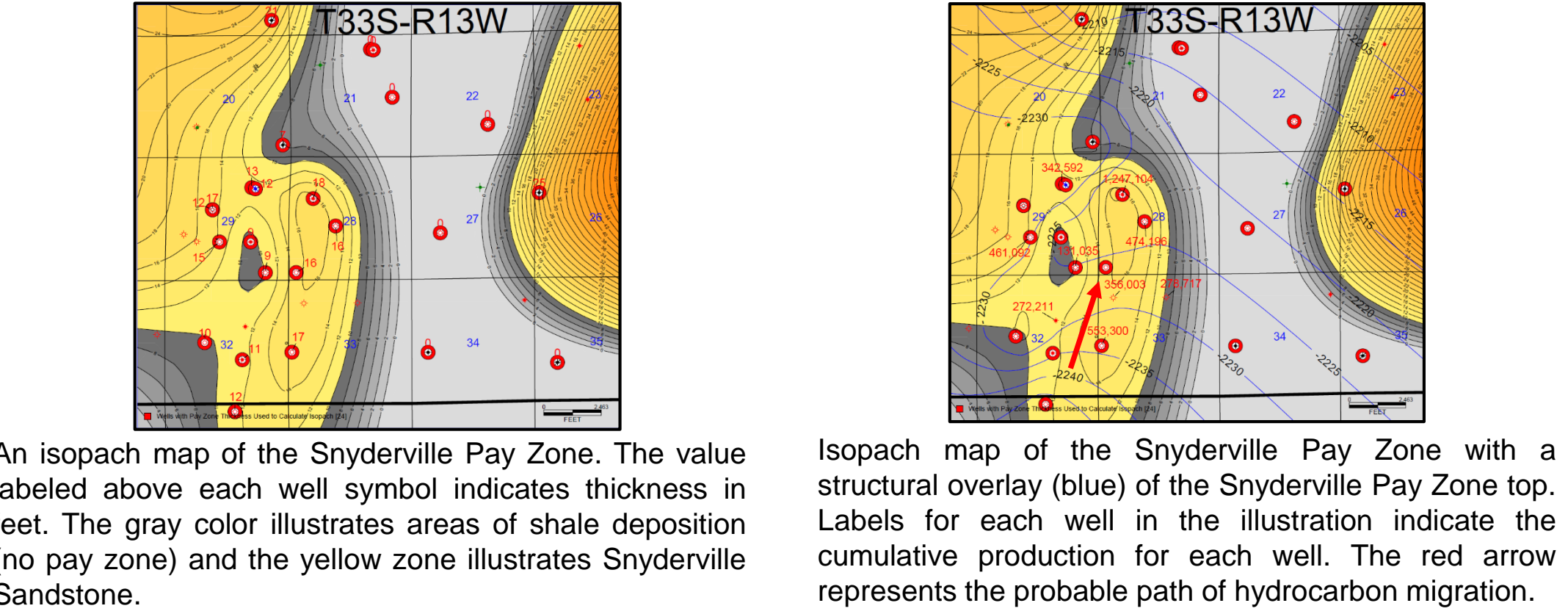
Well No.	API	Total Depth	Snyderville		Total Thickness (ft)	Pay Zone	Porosity (%)	Resistivity (ohms)
			Perforation Interval	Cumulative Production (McF)				
1	15-007-22510-001	5240	3902-3912	1247104	37	14	14	6
2	15-007-22546	4140	N/A	474396	54	14	13	N/A
3	15-007-22581	4550	3917-3929	342592	58	14	15	8
4	15-007-22610	4600	3967-3990	461092	27	15	13	9
5	15-007-22604	4550	3966-3967	131035	32	10	12	N/A
6	15-007-22280-001	4924	4002-4062	272211	28	N/A	N/A	N/A
7	15-007-22279-002	5100	3964-3980	356003	26	N/A	N/A	N/A
8	15-007-22576-001	4550	N/A	278717	29	N/A	N/A	N/A
9	15-007-22602	4350	4058-4058	153300	18	25	13	7
Averages				457,365	34.33	15.33	13.33	7.5

Table 1: Well data for study area wells produced from the Snyderville Sandstone.



The above production curve illustrates the average aligned daily gas production from the study area wells (see Table 1 above) and the associated well count.

Snyderville Sandstone Distribution



An isopach map of the Snyderville Pay Zone. The value labeled above each well symbol indicates thickness in feet. The gray color illustrates areas of shale deposition (no pay zone) and the yellow zone illustrates Snyderville Sandstone.

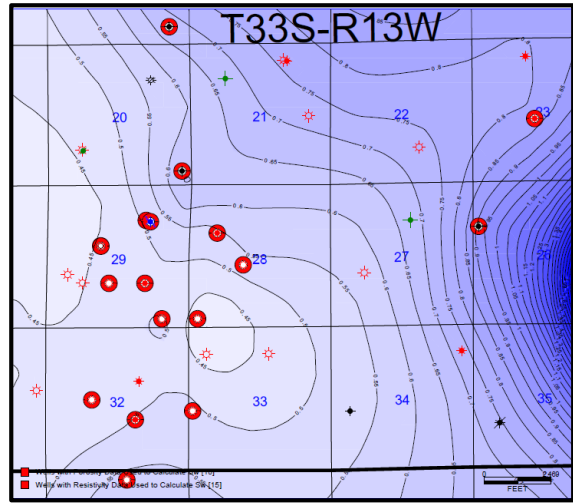
Isopach map of the Snyderville Pay Zone with a structural overlay (blue) of the Snyderville Pay Zone top. Labels for each well in the illustration indicate the cumulative production for each well. The red arrow represents the probable path of hydrocarbon migration.

Porosity, Resistivity, Water/Hydrocarbon Saturation Maps

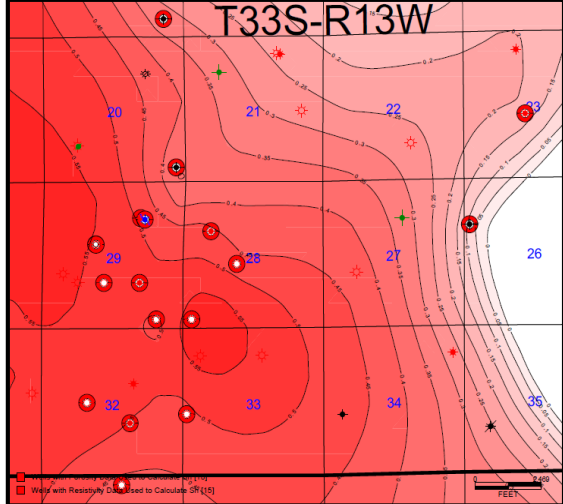
Archie's Equation: $S_w = (a \cdot R_w / (R_t \cdot \Phi^m))^n$

Definitions:
 S_w = Water Saturation
 Φ = Porosity
 R_w = Formation water resistivity
 R_t = Resistivity
 a = Constant
 m = Cementation factor
 n = Saturation exponent

Values used in Calculation:
 S_w = Calculated Value
 Φ = Porosity grid
 R_w = 0.04 ohms
 R_t = Resistivity grid
 a = 0.81 (assumed value for sandstone)
 m = 2 (assumed value for sandstone)
 n = 2 (assumed value for sandstone)



Water Saturation Map: S_w was calculated from Archie's Equation using known variables and supplementary porosity and resistivity grids.



Hydrocarbon Saturation Map: Calculation: $S_h = 1 - S_w$

Conclusion

The Snyderville Sandstone in the study area has proven productive for natural gas in local combination (structural and stratigraphic) traps in Barber County, Kansas. This study is important in establishing a Snyderville Sandstone reservoir analog that may be used to help identify productive Snyderville Sandstone reservoirs based on reservoir characterization and structural controls that may prove important in finding additional hydrocarbon reserves in the Snyderville Sandstone in Southcentral Kansas and Northern Oklahoma.

References

Brown, S.L., 1967, Stratigraphy and Depositional Environment of the Elgin Sandstone (Pennsylvanian) in South-central Kansas, http://www.kgs.ku.edu/Publications/Bulletins/187_3/index.html
Kansas Geologic Survey, May 2005, Guidebook- Geology of Northeastern Kansas, <http://www.kgs.ku.edu/Extension/fieldtrips/guidebooks/NEKS1.html>
Kansas Geologic Survey, September 2014, Barber County Oil and Gas Production- County Map, <http://www.kgs.ku.edu/PRS/County/abc/barber.html>
Kansas Historical Society, 1994, Barber County, Kansas Map, http://www.kshs.org/geog/geog_counties/view/county/BA
Original Pennsylvanian stratigraphy discussed in Jewett, J.M.; O'Connor, H.G.; and Zeller, D.E., 1968, Pennsylvanian System, in, Zeller, D.E., (ed.); The stratigraphic succession in Kansas: Kansas Geological Survey, Bulletin, no. 189, pp. 21-43.
http://www.kgs.ku.edu/Publications/Bulletins/189/07_penn.html
Troell, A.R., 1969, Depositional Facies of Toronto Limestone Member (Oread Limestone, Pennsylvanian), Subsurface Marker Unit in Kansas, <http://www.kgs.ku.edu/Publications/Bulletins/197/index.html>
Wicander, R., and Monroe, J. S., 1989, Historical Geology--Evolution of the Earth and Life through Time: St. Paul, Minnesota, West Publishing Company, 578 p.