Regional Aspects of Stratal Architecture of the Subsurface Mississippian in Kansas Based on Wireline Log Cross-Sections and Seismic

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Abstract

The lithostratigraphic architecture of the Mississippian in subsurface Kansas is inherently complex, and to complicate it further, it was then overprinted by syndepositional as well as pre-Cherokee tectonics. Yet, the component lithostratigraphic units within the section, and most importantly the petroleum reservoirs therein, can in fact be identified on log cross-sections and resolved seismically, with detailed subsurface mapping and core-well cuttings sample analyses. Because different Mississippian lithologic units behave differently in terms of their reservoir production and completion attributes, it is critical to identify the specific exploration objective in an area. The Kinderhookian to basal Osagean part of the section is readily identified based on its generally non-cherty character, local presence of reefs, and mostly aggradational ramp-like, 3-D depositional geometry. These rocks are present throughout Kansas, except for where they have been eroded from positive areas. Overlying Osagean strata dramatically contrast the older rocks, and they are recognized by their siliceous character (spiculite, tripolite, and chert) and dominant progradational geometry, with some internal erosional truncations, that are identifiable seismically. These rocks are present only in southern Kansas, and extend into Oklahoma. Major transgression ensued early in Meramecian time, and the resulting geometries of these units include initially onlapping wedges replaced by later aggradational to progradational, carbonate-dominated systems, both of which locally are truncated by major unconformities.
REGIONAL ASPECTS OF STRATAL ARCHITECTURE OF THE SUBSURFACE MISSISSIPPIAN IN KANSAS BASED ON WIRELINE LOG CROSS-SECTIONS AND SEISMIC

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Mazzullo concurs; he also specifically acknowledges the Nero D’ Avola Wineries.
IN THIS TALK...

* Revisit the outcrop, and subsurface, based depositional systems models and component lithostratigraphic units with special focus on the Osage and lower Meramec

* Illustrate some of the lithostratigraphic complexities particularly along the ‘main-shelf’ / ‘shelf-break’ transition in southern Kansas and northern Oklahoma

* Although seemingly various and complex, these stratal relations form predictable stacking patterns that represent reality and can be recognized:
  1.) on log cross-section, through core/cuttings analysis &
  2.) in seismic, and specifically on seismic impedance models, complete with onlapping, downlapping and progradational geometries

* Being able to delineate different depositional systems on and along the ‘shelf-break’, component petroleum systems and objectives, addressed in the previous talk, can be recognized and sought out.
EACH “t” WEDGE REPRESENTS A REPEAT IN THE BURLINGTON-KEOKUK TO REEDS SPRING (SHALLOW TO DEEP) DEPOSITIONAL MOTIF.
LOG SIGNATURES OF OUTCROP STRATIGRAPHY

** updip **

- Cherokee
- (Burgess Sand)
- Warsaw Fm
- Burlington-Keokuk Lst
- Pierson Lst
- Northview Fm
- Compton Lst
- Kinderhook Shale

** downdip **

- Cherokee
- Burlington-Keokuk Lst
- Reeds Spring Lst
- St. Joe Group

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SUBSURFACE DEPOSITIONAL SYSTEMS MODEL

Cowley Formation

upper Reeds Spring wedge(s)

composite unconformity

lower Reeds Spring wedge(s)

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SUBSURFACE STRATIGRAPHY

central & northern KS

Devonian

pre-Woodford

Kinderhookian

Compton Lst

Northview Fm

Pierson Lst

Burlington-Keokuk Lst

"Warsaw"

Cherokee

Desmoinesian

Merrimacian

Short Creek Oolite Mmr

southern KS & northern OK

Cherokee

"Warsaw"

Burlington-Keokuk Lst

Reeds Spring Lst

tripolite

Cowley Formation

St. Joe Group

St. Joe Group

Kinderhook Sh

Woodford

pre-Woodford

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SUBSURFACE DEPOSITIONAL ARCHITECTURE & FACIES OF THE COWLEY

The Cowley was deposited on a low-angle ramp that graded seaward from relatively shallow to deeper-water environments. These facies prograded seaward as a series of separate, time-transgressive wedges.
LOG SIGNATURES OF SUBSURFACE STRATIGRAPHY

Burlington-Keokuk (updip equiv. of Reeds Spring)

Cowley Fm

Reeds Spring Lst

Pierson Lst

Northview Fm

Compton Lst

Kinderhook Shale

Post-Miss: Cherokee

Cowley Fm

Reeds Spring Lst

Northview Fm

Compton Lst

Kinderhook Shale

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Now that you know the players....

Reeds Spring
Burlington-Keokuk
Cowley

...including their stratigraphic order and the facies therein, it is now time for a

POP QUIZ!
NAME THE FORMATIONS

Post-Miss: Cherokee

T/Kinderhook Sh.
The reality is, you must know what unit you are in because reservoir objectives are specific to these intervals; nomenclature thus, is integral.

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CORE CROSS-SECTION & SUBSURFACE REEDS SPRING-COWLEY STRATIGRAPHIC ARCHITECTURE
(Relative/Eustatic Curve Based on Sedimentology & Conodont Biostratigraphy)

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DIRECTIONS OF REEDS SPRING & COWLEY PROGRADATIONAL WEDGES - THAT DEFINE "BASIN COMPARTMENTS"

Cowley-Reeds Spring play area

"TYPICAL KANSAS COWLEY"

"OKLAHOMA COWLEY"
(‘UPPER COWLEY/REEDS SPRING)
RECOGNIZING COMPONENT LITHOSTRATIGRAPHIC UNITS,

Reeds Spring
Burlington-Keokuk
Cowley Fm.
'upper' Cowley - Reeds Spring

AND THEIR CORRELATIONS, ON LOG CROSS-SECTIONS
POP QUIZ #2 - WHAT ARE THE COMPONENT LITHOSTRATIGRAPHIC UNITS, AND HOW DO THEY CORRELATE?
ST. JOE & 'LOWER' REEDS SPRING CORRELATIONS

HOW DOES THE POST-REEDS SPRING CORRELATE?

ST. JOE

POST-MISSISSIPPIAN UNC.

porous chert/tripolite

KINDERHOOK SHALE

REEDS SPRING

porous chert/tripolite

ST. JOE

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CORRECT!!!

BASED ON LOG CORRELATION COUPLED WITH SAMPLE EXAMINATION

NORTHEAST CHAUTAUQUA COUNTY, KS

WEST

POST-MISSISSIPPIAN UNC.

POTENTIAL COWLEY PINCH-OUT TRAP

COWLEY

ST. JOE

KINDERHOOK SHALE

WARSAW

erosion of Reeds Spring beneath the Cowley

porous chert/ tripolite

TRIPOLITE RESERVOIR POTENTIAL WELL BENEATH AND NOT ASSOCIATED WITH THE POST-MISSISSIPPIAN UNCONFORMITY

REEDS SPRING

porous chert/ tripolite

ST. JOE

EAST
RECOGNITION OF THE COMPONENT LITHOSTRATIGRAPHIC UNITS AND THEIR BOUNDING UNCONFORMITIES ARE KEY TO UNDERSTANDING STRATAL STACKING PATTERNS AND RESERVOIRS DISTRIBUTION THEREIN.
ANOTHER EXAMPLE OF COMPLEX STRATAL STACKING & DEPOSITIONAL ARCHITECTURE

COWLEY ON THE BURLINGTON-KEOKUK FM (SHELF DEPOSITS)

South

Clark County | Ford County

Viola

North

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CLARK - FORD COUNTY EXAMPLE IN THE DEPOSITIONAL MODEL

SHELF MARGIN DEPOSITIONAL ARCHITECTURAL MODEL

NORTH  pre-Meramec unconformity  SOUTH

B-K

Reeds Spring wedges

Cowley wedges

t1

t2

St. Joe Group

t3

t4

shallowing-upward 'upper' Cowley-Reeds Spring wedges

t5

(basal Meramec?)

UPDIP, ONTO THE SHELF, IN THIS MODEL

NORTH  onlapping Meramec (Warsaw) strata  SOUTH

B-K

'Bupper' Cowley

Reeds Spring wedges

Cowley wedges

t1

t2

St. Joe Group

t3

t4

shallowing-upward 'upper' Cowley-Reeds Spring wedges

t5

Previous X-sect: Clark-Ford Co., KS

KNOWING YOUR POSITION ON THE SHELF/SHELF MARGIN IS PAR-
AMOUNT IN UNDERSTANDING THESE STRATAL RELATIONS!!

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PREDICTABILITY OF COMPONENT LITHOSTRATIGRAPHIC UNITS IS DEPENDENT ON POSITION ON THE SHELF AND....
PREDICTABILITY OF COMPONENT LITHOSTRATIGRAPHIC UNITS IS DEPENDENT ON POSITION ON THE SHELF AND....

'lower' Reeds Spring pinch-out, either by erosion or updip facies change to Burlington-Keokuk

extent of the Cowley Formation; updip pinch-out

updpip pinch out of the 'upper' Cowley/'upper' Reeds Spring

MAPPED FACIES BOUNDARIES AND UNIT PINCH-OUTS
The complexity of the lithostratigraphic architecture of the subsurface is resolvable and can be identified, as shown, through:

1. identification/recognition of component lithostratigraphic units (and facies therein), particularly aided by cuttings and core analysis

2. recognition of sequence bounding unconformities

3. positioning in reference to the shelf / shelf margin

Subsurface correlations are attainable via these methods and furthermore, substantiated and resolved

SEISMICALLY

--- specifically through impedance modeling ---
SEISMIC STRATIGRAPHY FROM IMPEDANCE MODEL -- GOOD CORRELATION WITH LOGS --

Red lines indicate regional, sequence bounding unconformities within the Mississippian.

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Possible deeper pinch-out play?

INTERPRETATION OF IMPEDANCE SECTIONS HAS YIELDED FURTHER UNDERSTANDING OF INTRA-MISSISSIPPIAN CORRELATIONS AS WELL AS CONFIRM (OR DENY) ORIGINAL SUBSURFACE CORRELATIONS.
Here is the reality of the subsurface as shown on seismic profile. The complexity illustrated confirms our models developed from the outcrop, sample analysis and log correlation.
KEY TO EXPLORATION ALONG THE SHELF MARGIN

SUBSURFACE STRATIGRAPHIC ARCHITECTURE AS DELINEATED ON SEISMIC

What is your objective and where is your play?  

Reeds Spring wedges  
Cowley wedges  

shallowing-upward 'upper' Cowley-Reeds Spring wedges

St. Joe Group  
Post-MS unconformity

Tripolite?  
Spiculite?  
Dolomite?  
Fractured Chert?

Porosity pinch-out?

NORTH   SOUTH

INASMUCH AS EACH COMPONENT LITHOSTRATIGRAPHIC UNIT ABOVE CONTAINS DIFFERENT PETROLEUM SYSTEMS AND RESERVOIRS

---EACH WITH UNIQUE PETROPHYSICS---  
(*AS WAS ADDRESSED IN THE PREVIOUS TALK)

IT IS PARAMOUNT TO BE ABLE TO RECOGNIZE THESE UNITS

---THEIR GEOMETRIES, DISTRIBUTION AND STACKING PATTERNS---

ON SEISMIC AND IN THE SUBSURFACE.

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THIS IS WHY THE MISSISSIPPIAN PLAY IS COMPLEX --- THE PLAY RESIDES ALONG THE SHELF MARGIN/'BREAK' AREA WITH MULTIPLE PROGRADING WEDGES THAT ARE TRUNCATED AND OVERPRINTED BY TECTONICS & SYNDENPOSITIONAL TECTONICS......
THIS IS NOT WHAT THE MISS IS:

- Oil
- Gas
- Water
CONCLUSIONS:

* The Mississippian/Mississippian Play is not a 'Lime' play consisting of a single unit or objective; nor, is it a "blanket deposit" with erratic lithologic changes.

* The Mississippian is inherently complex in its lithostratigraphic architecture of which, is further complicated by syndepositional and pre-Cherokee tectonics.

* HOWEVER, the Mississippian lithostratigraphic architecture, and reservoir objectives therein, ARE PREDICTABLE through...

  - recognition of component lithostratigraphic units via cuttings and core analysis;
  - identification of these units on log cross-sections and delineating sequence bounding unconformities;
    - knowledge of position on the shelf;
    - mapping unit updip and downdip pinchouts and extents;
    - seismic impedance modeling i.e., recognition of onlapping, downlapping and porgradational geometries;

* In this approach, component petroleum systems and reservoir objectives can be readily identified, within the Mississippian System.