The Springer Shale: A Sleeping Giant?*

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Production Summary of Play

As of September, 2014, Continental Resoources is reported to have 11 producing wells in the north-northeast-trending Springer Shale oil fairway in South-Central Oklahoma Oil Province (SCOOP). The average 30-day IP (per well) is 700 BOE/day. The estimated ultimate recovery per well, suggested by the production data, is 940,000 BOE, at an average vertical depth of 12,500 ft and 4500-ft lateral length.

Key Questions

- Source and migration (self-sourced? Or, combined with Woodford?)
- Nature of the Mississippian-Pennsylvanian boundary
- Springer stress regimes and pore pressure; cation exchange capacity.

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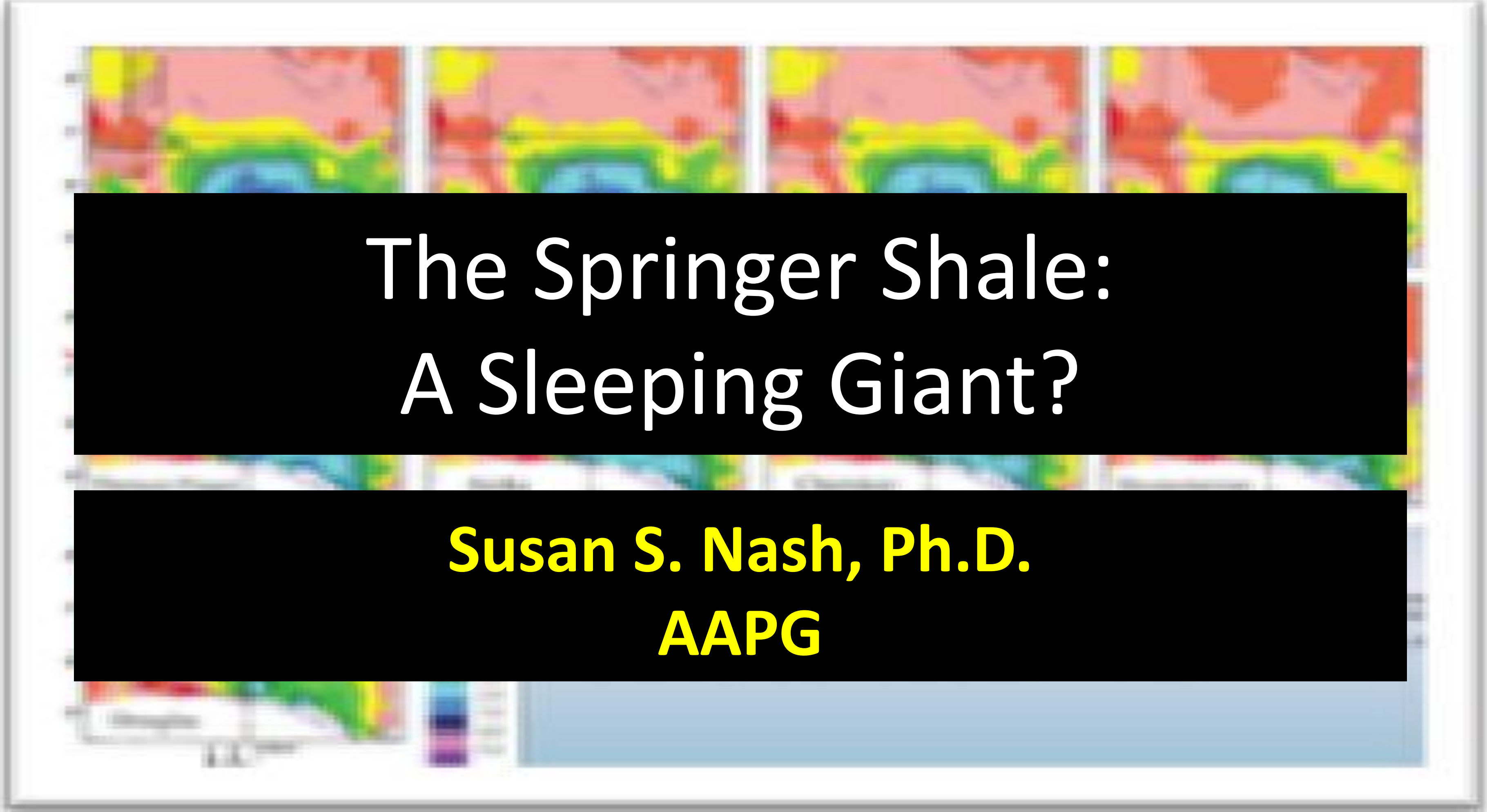


The Springer Shale: A Sleeping Giant?

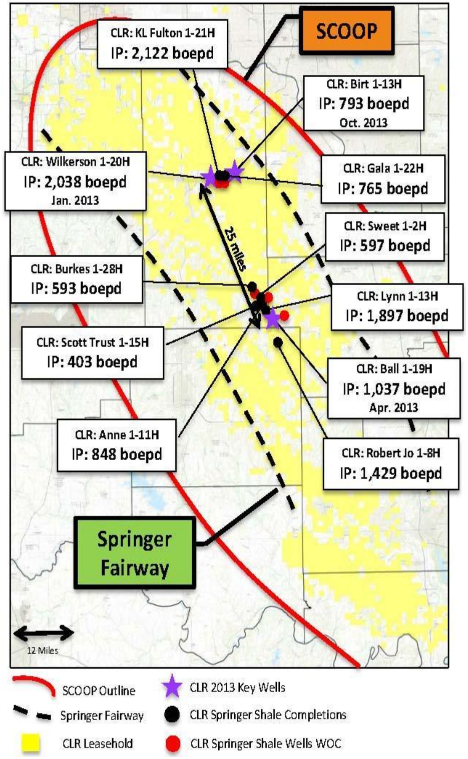
Susan S. Nash, Ph.D.
AAPG

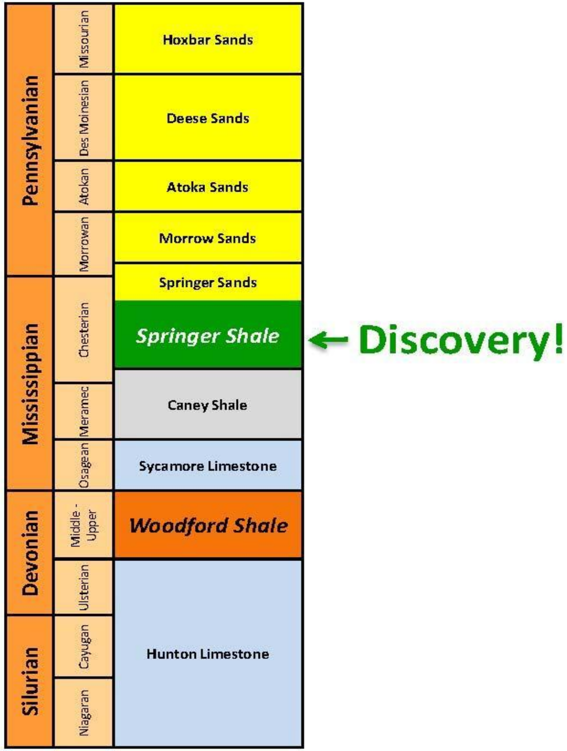
Recent Press Releases

- Continental's exploration team does it again – the Company is announcing a new oil discovery, the Springer Shale, located in the heart of the SCOOP.
- The original discovery well and two subsequent confirmation wells have cumulative production of approximately 640 MBoe in the 20 months following the original discovery well. Continental currently has 11 producing wells in the oil fairway of the Springer Shale with an average 24-hour initial production (IP) rate of 1,140 Boe per day and an average 30-day IP of 700 Boe per day.
- Initial Springer Shale oil fairway production data suggests an EUR of 940 MBoe, with 67% oil and 17% natural gas liquids, for an average 4,500 foot lateral length.

Continental Resources: Springer Shale

- "Fairway" ideal depth, pressure, stacked pay with Woodford (and others)
- 2,000 bopd
- 12,500 ft depth
- 447 MMBoe unrisked
- 127 net MMBoe fairway
- 320 net MMBoe, 1.9 Tcfe in gas / condensate fairways



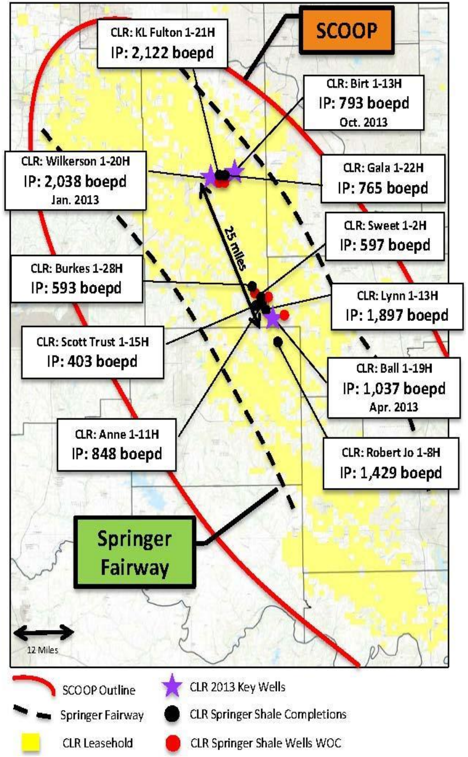


Graphics: Continental Resources

Continental Resources: Springer Shale

- Discovery well: Wilkerson 1-20H (Jan 2013)
- Delineation well: Ball 1-19H (April 2013)
- Confirmation well: Birt 1-13H (October 2013)
- 2014: continued confirmations

- Questions:
  - Where are confirmations?
  - Continuity / conductivity of resources?
  - Pressure Regime – what are the reservoir pressures?

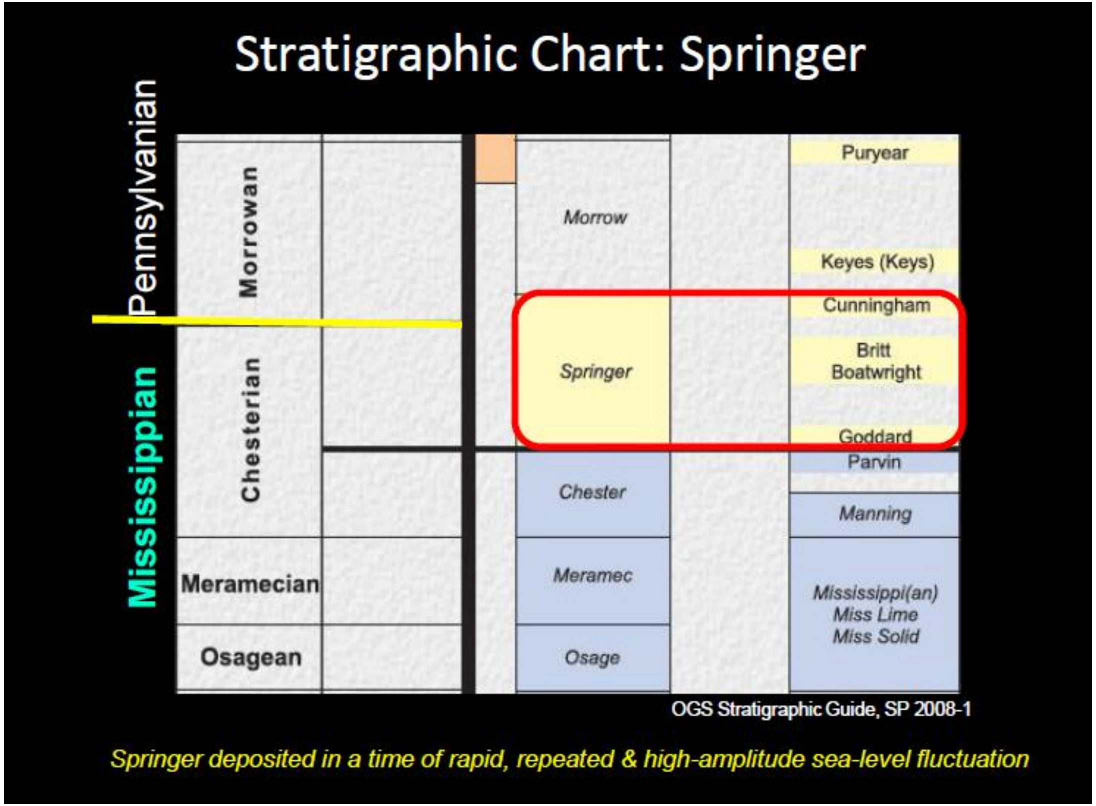


Graphics: Continental Resources

Springer Formation

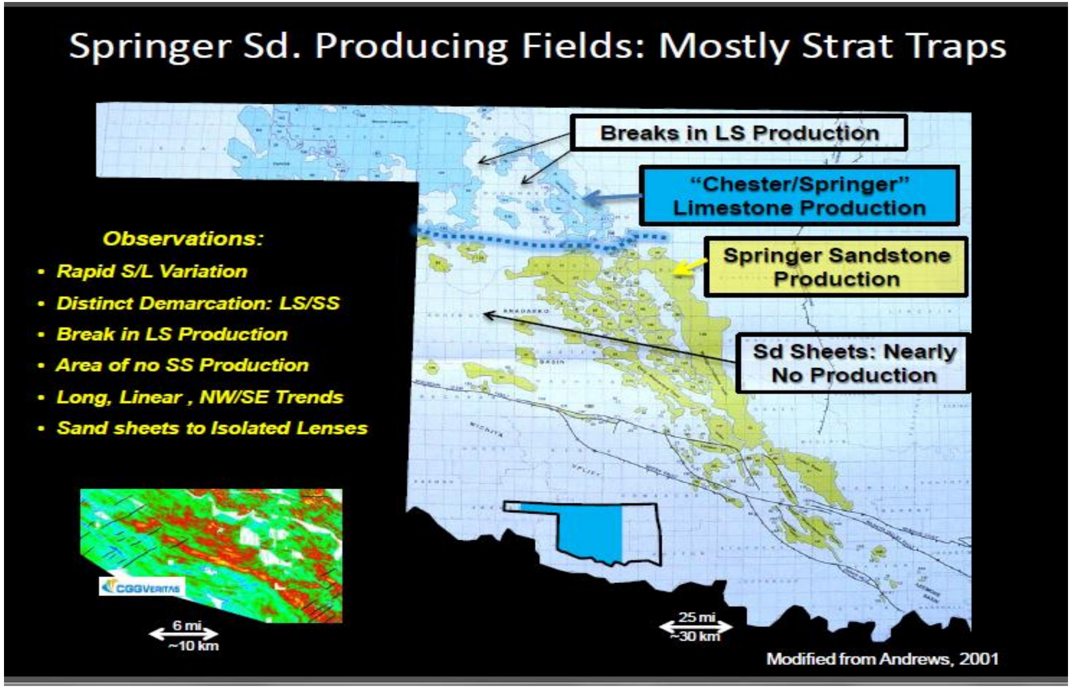
- Mississippian-Pennsylvanian boundary
- Highly heterogeneous
- Pressure variations

Graphics: Continental Resources



Traditional View: Strat Traps

- Most studies look at lenticular units
- Stratigraphic traps
- New view? (look for the shale and silty sections, and not the sand bodies)



Key Questions - 1

- Source & Migration
  - Truly self-sourced? Or, combined with Woodford?
    - TOC for Springer tends to be somewhat low (according to early work)
  - ID / fingerprint the oil and gas?
    - Where the Woodford & the Springer HC's are trapped together (areas of relative accessible porosity & permeability) = super-sweet spots
  - Provenance Matters (migration along faults, fracture networks, along unconformable surfaces)
    - How are the migration pathways mapped by the USGS relevant to the Springer?
    - Can we propose something completely different?

Historical Springer Production

Springer sand:

  but now we have

  Springer shale

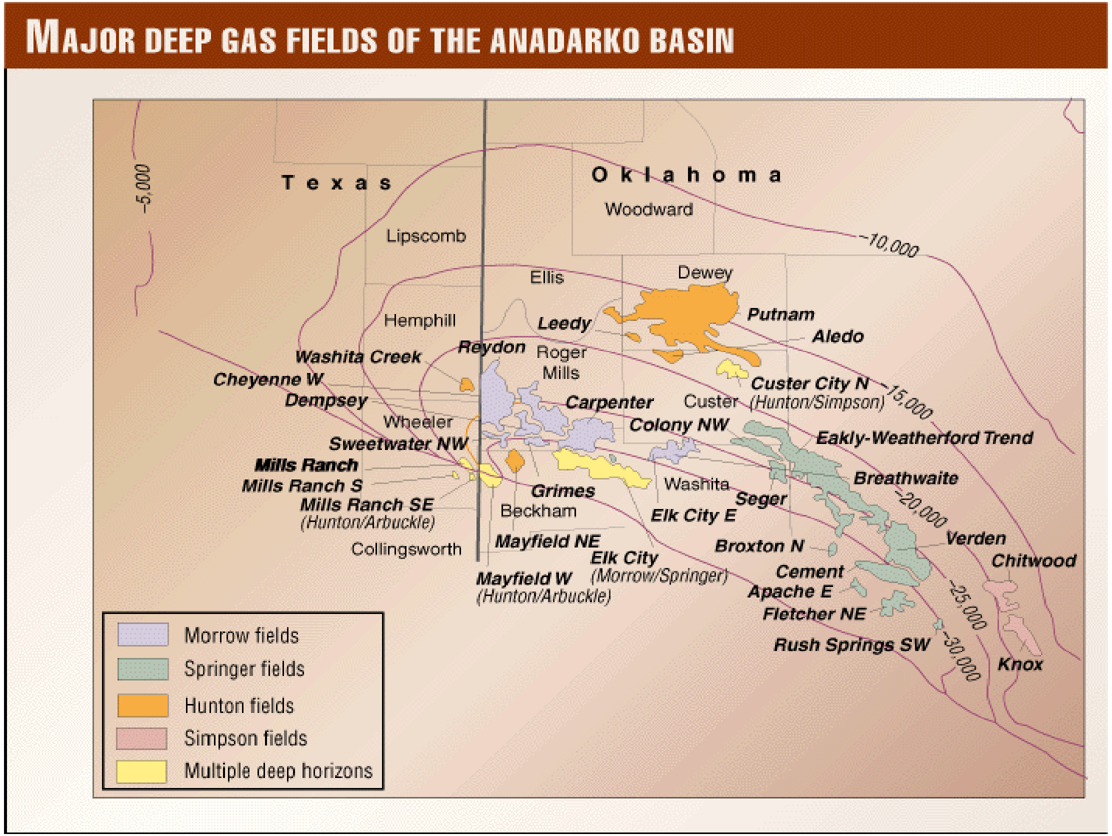
Stacked pay potential (in

  multiple Springer zones)

Key issues:

- *identify the lenses / sweet spots*
- *reservoir optimization (drilling & completion techniques)*

Graphics: Continental Resources



Mississippian-Pennsylvanian Boundary

- Springer units
- Unconformity
- Implications & key questions
  - How are the deposits at the unconformity different than the ones lower in the section?
  - Intercalated siltstones?
  - Any unconformity deposits (like Misener)? If so, how / what?

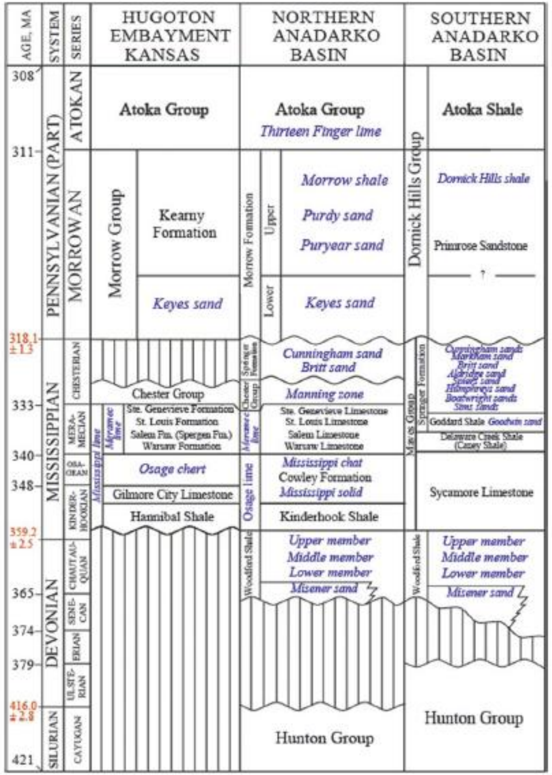


Figure 2. Generalized stratigraphic columns of the Mississippian and portions of the Silurian through Pennsylvanian sections. Italics (blue text) and lower case names indicate informal status. Modified from Bebout et al. (1993) and Henry and Hester (1995). Ages in millions of years from Haq and Van Eysinga (1998), and Gradstein et al., (2004) (red text). Fm., formation; Mbr., Member; Ste., Sainte; St., Saint.

Key Questions -- 2

- What is the nature of the Mississippian / Pennsylvanian boundary?
  - Unconformable / erosional surface
  - Implications:
    - Fluid movement long the boundary, when tilted, and when there are porous lenses
    - Diagenesis – implications for brittleness & also grains
    - Pockets / lenses of finer- or coarser-grained deposits

Initial Strategies

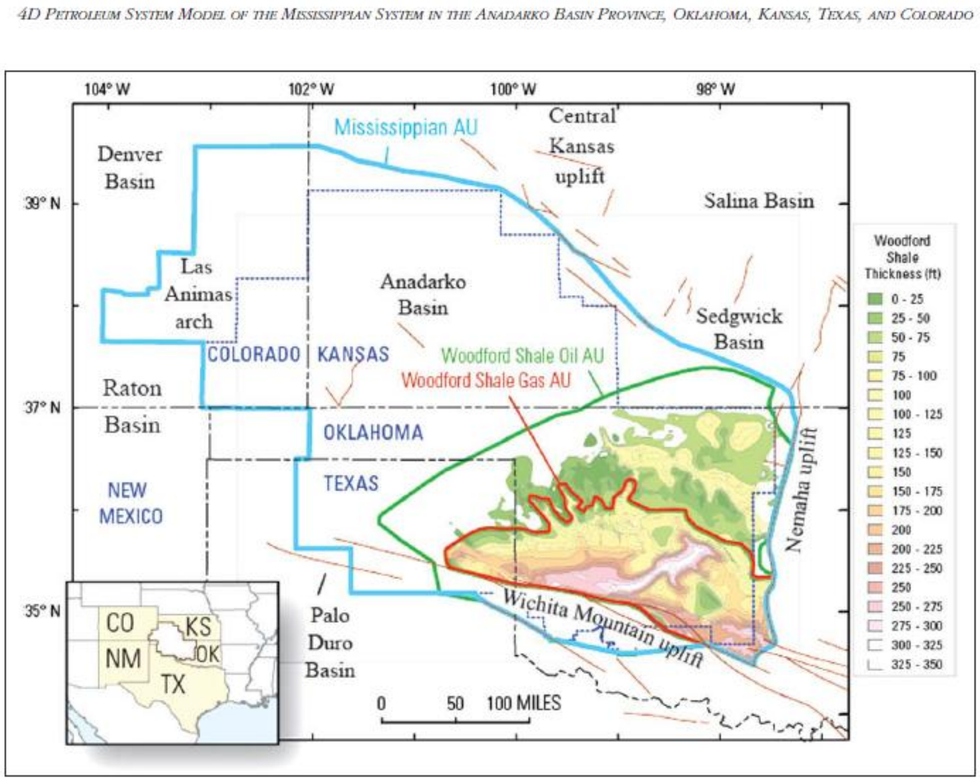
Fluid flow mapping

Depositional environment:

instead of using sequence stratigraphy for stratigraphic traps, look for the migration pathways

How to identify the pathways?

- Geochemical fingerprinting
- Image logs
- Fracture networks / heat flow



- Graphics: Higley (USGS)

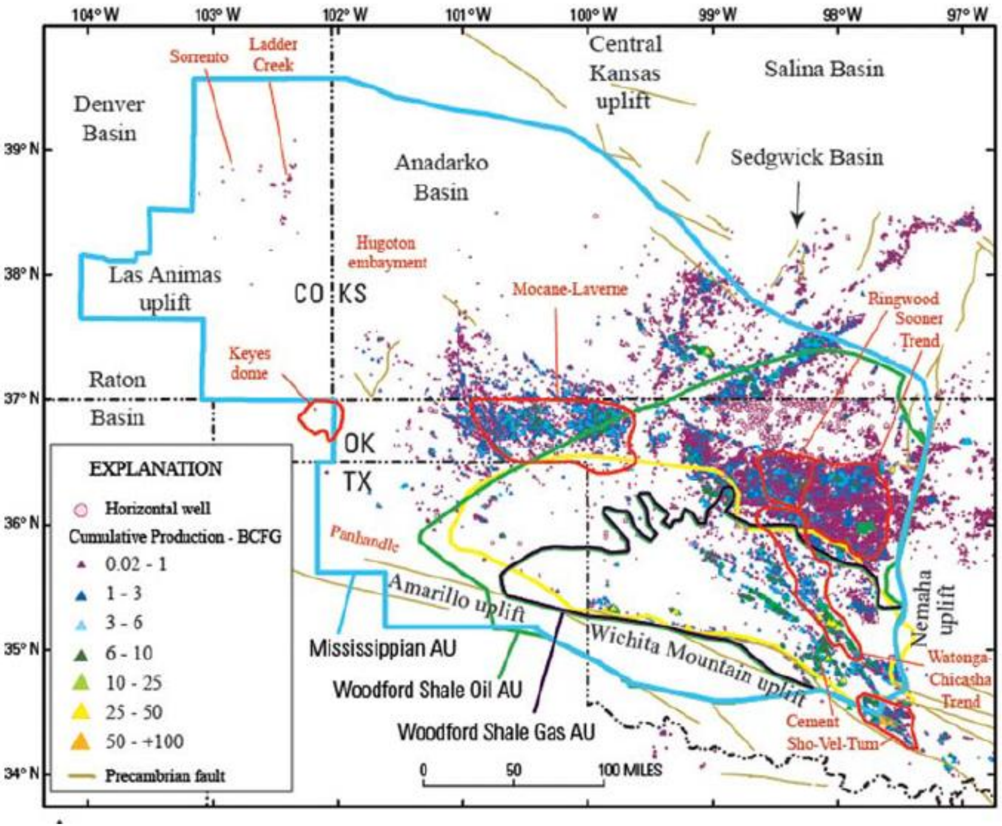
Production

USGS study of Springer & Woodford production (Higley, 2013)

Questions:

- Reservoir quality of the Springer sands
- The nature of the Springer "shale" – which units is it producing from?

- Graphics: Higley (USGS)



Thickness

USGS map depicting the thickness of the Mississippian (Where Woodford would go (Woodford Devonian & early Mississippian)

Graphics: Higley (USGS)

Debra K. Higley

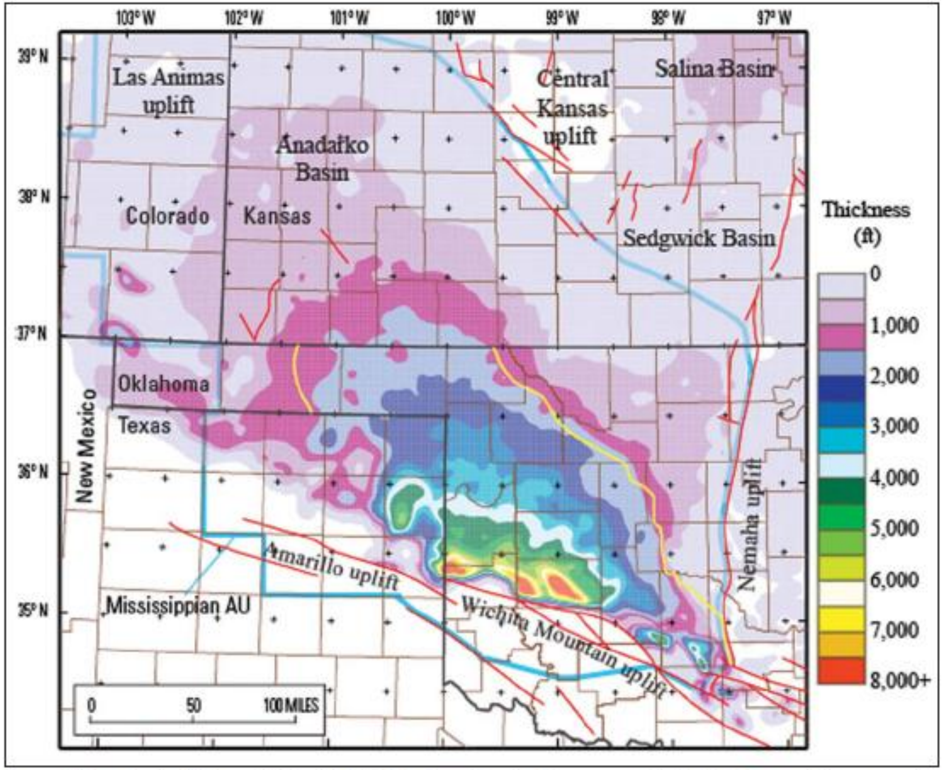


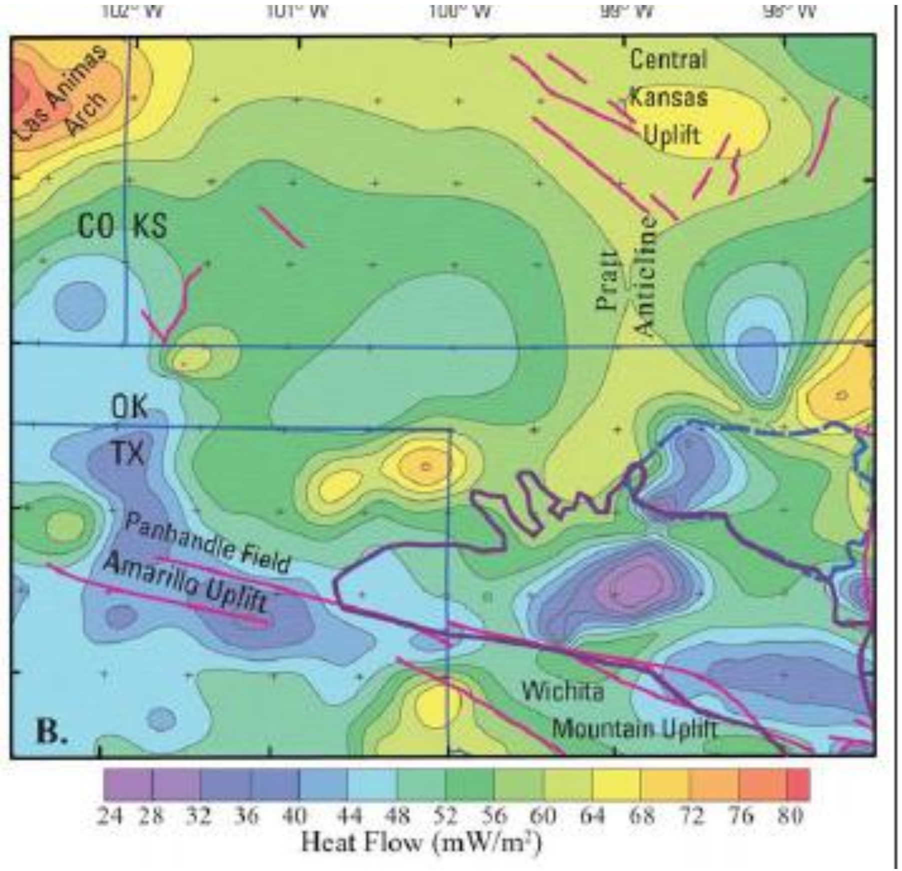
Figure 4. Maps showing thickness (in feet) of the Mississippian section (Fig. 2), as represented by the Springer model layer across the Anadarko Basin Province. The Oklahoma portion of the basin incorporates faults and elevations on the top of the Springer Formation from Andrews (2001, Plate 5); yellow lines delineate the extent of the Springer within the Oklahoma portion of the basin. Eastern extent of Chesterian strata in the Oklahoma portion of the basin is approximated by the 1,500-ft elevation contour. Also evaluated were formation data derived from more than 220 well logs located north of the Wichita Mountain and Amarillo Uplifts, as well as modified formation elevations from IHS Energy (2009, 2010a). Displayed Precambrian fault lines (red) are from Adler et al. (1971).

Heat Flow

Why does it matter?

- Maturation
- Diagenesis
- Pressure
- Conduits & migration pathways
- Determining faulting and fracture networks if heated fluid present

Graphics: Highley (USGS)



Migration Pathways

- Flow paths and accumulations
- Springer (with Woodford
- Yellow line: oil/gas generation boundary

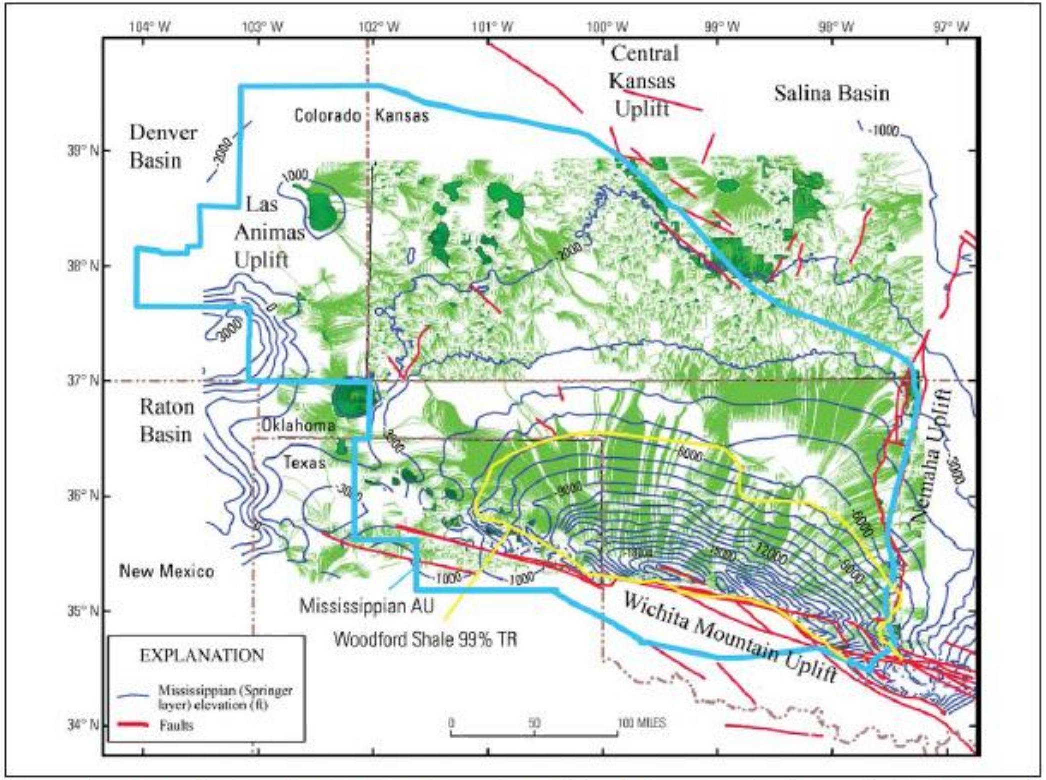
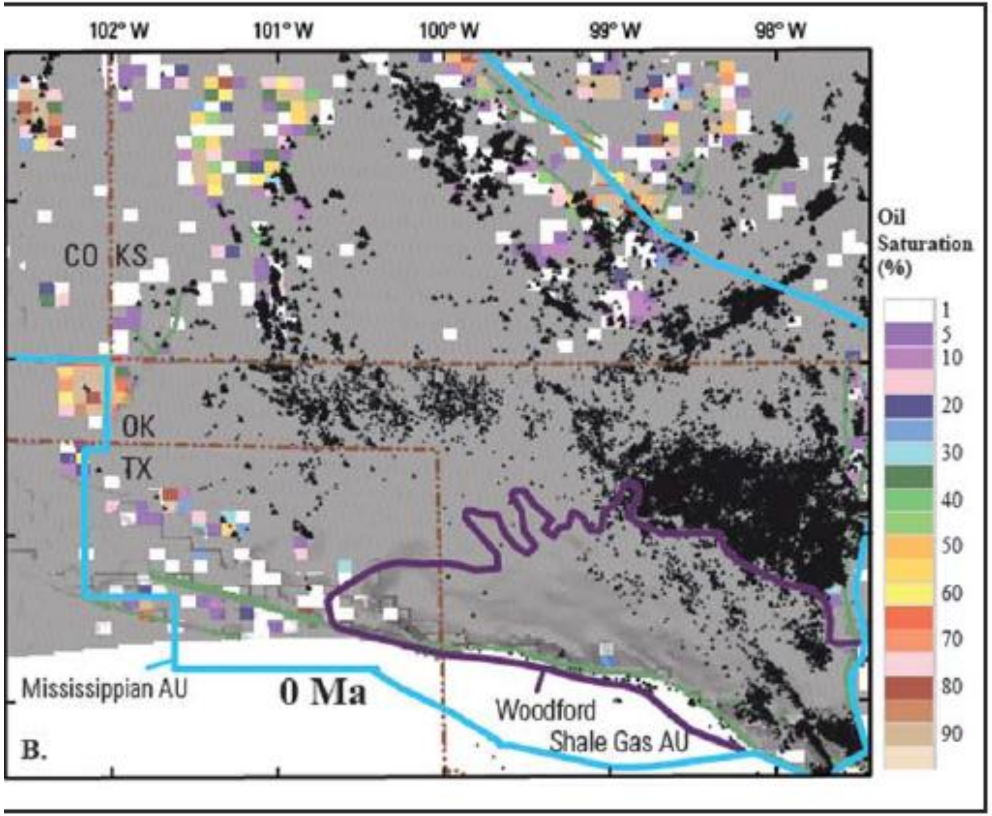


Figure 9. Present-day oil-migration flow paths (green lines) and accumulations (dark green) on the Springer (Mississippian) layer and sourced from the Woodford layer. Contours are elevations relative to sea level on top of the Springer layer based on Andrews (2001, Plate 5), IHS Energy (2009, 2010a), and evaluation of well logs from more than 200 wells. The yellow line is the oil/gas generation boundary of the Woodford Shale based on the 99% transformation ratio (TR). This line approximates the southern boundaries of the Mocane-Lavern Field and the Sooner Trend areas (Fig. 3A). Faults (red) are modified from Adler et al. (1971) and Andrews (2001, Plate 5). Contour interval is 1000 ft.

Oil Saturation

Woodford Shale Gas / Mississippian (Higley, USGS)



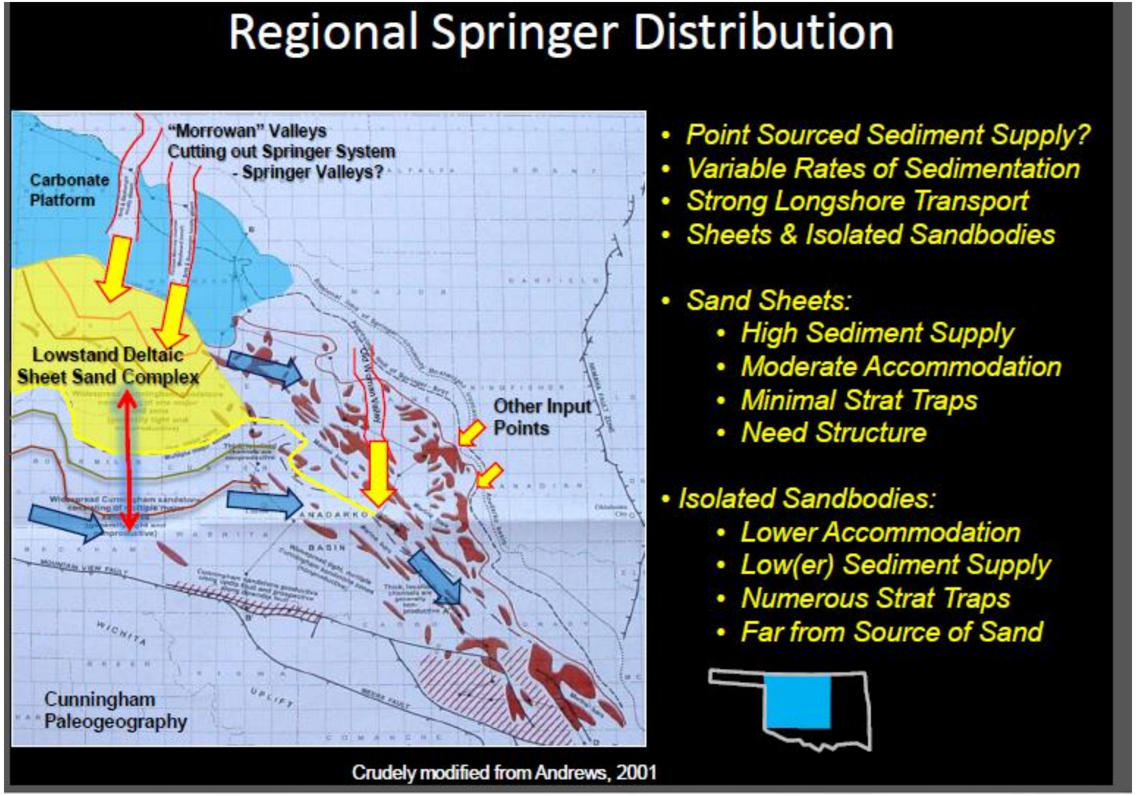
Key Questions - 3

- Springer stress regimes and pore pressure
- Migration / mechanical flow
- Springer Cation Exchange Capacity – how "sticky" is the shale?
- Chemical flow / adsorption factors (salinity / CEC makes it easier for the generated or migrating oil to travel

Depositional Environment

Toward a strategy of what to prospect for … looking at the seismic & sequence stratigraphy (Krystinik)

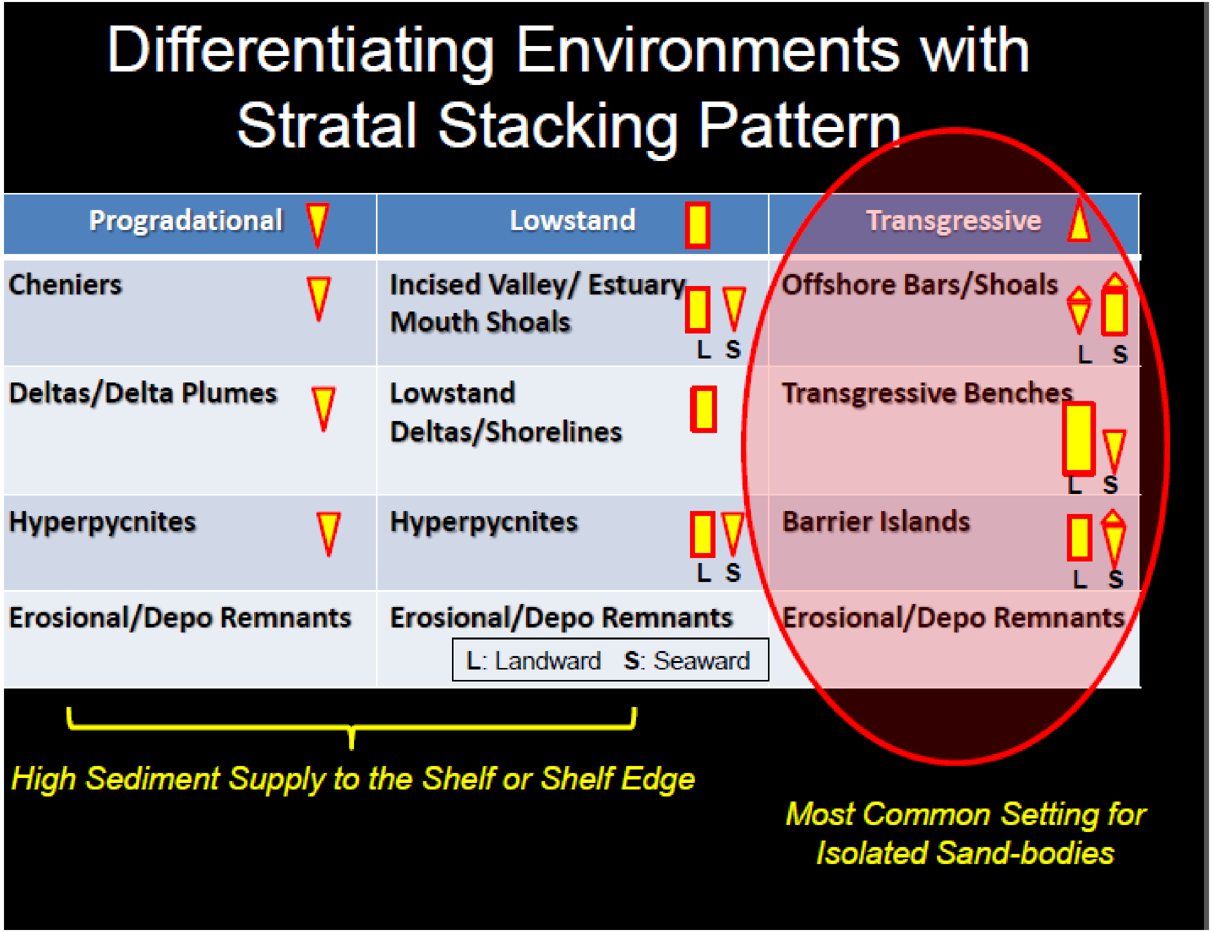
Graphics: Lee Krystinik



Springer Shale

Instead of looking for lenticular units (point bars, benches, islands, look for silty shale with hard streaks (highly intercalated) shale / silt sequences

Graphics: Lee Krystinik



Differentiating Environments with Stratal Stacking Pattern

Progradational	Lowstand	Transgressive
Cheniers	Incised Valley/ Estuary Mouth Shoals (L S)	Offshore Bars/Shoals (L S)
Deltas/Delta Plumes	Lowstand Deltas/Shorelines	Transgressive Benches (L S)
Hyperpycnites	Hyperpycnites (L S)	Barrier Islands (L S)
Erosional/Depo Remnants	Erosional/Depo Remnants	Erosional/Depo Remnants

L: Landward S: Seaward

High Sediment Supply to the Shelf or Shelf Edge

Most Common Setting for Isolated Sand-bodies

From Continental Resources: Many Potentially Viable "Stealth Plays"

Numerous formerly unproducible zones in the Anardarko Basin

*Derisking
- Geochemistry
- New techniques
- Stacked pays
- Whipstocking laterals?

Investor and Analyst Day 2012 Active Exploration Projects

Project	Expected Product	CLR Net Acres
Stealth A	Gas/Oil	5,000
Stealth B	Gas/Oil	8,970
Stealth C	Oil	30,500
Stealth D	Oil/Gas	17,200
Stealth E	Oil	25,000
Stealth F	Gas/Oil	23,500
2012 Total Leasehold		110,170

2014 Active Exploration Projects

Project	Expected Product	CLR Net Acres
Stealth 1	Oil	30,000
Stealth 2	Gas/Oil	140,000
Stealth 3 (New)	Oil/Gas	130,000
Stealth 4 (New)	Oil	15,000
Stealth 5	Oil	153,000
Stealth 6 (New)	Gas/Oil	54,000
Stealth 7	Oil	17,000
2014 Total Leasehold		539,000

Reservoir Optimization of the Springer Shale

- Use same pad as for Woodford Shale
- Determine the best locations for intercalated siltstone / shale
- Be very selective with the Springer laterals – only use them for the sweet spots
- In some cases, use the depleted Woodford laterals and whipstock up (if it makes sense to do so)
- Follow the microseismic monitoring results & see if there has been potential impact in the Springer (if so, one may economize on completions – specifically hydraulic fracturing
- Do extreme geochemical testing to determine origins of hydrocarbons, accessible porosity, migration pathways, and also transformation

Springer Shale Play

- Fingerprint the hydrocarbons (oil, gas, condensate)
- Extreme depositional environment modeling
- Migration pathways (deposition, tilting, geomechanics – need tectonic activity + heat flow)
- Physical & chemical accelerants to migration
- Sweet spots – transcending the stratigraphic trap concepts (reprocess 3D seismic)
- Whipstocked laterals (post-decline) – particularly important with Springer – go in and offset / whipstock to drain discrete lenticular units

Thank you

Debra Higley
Lee Krystinik
Paul Smith
Younane Abousleiman
Roger Slatt