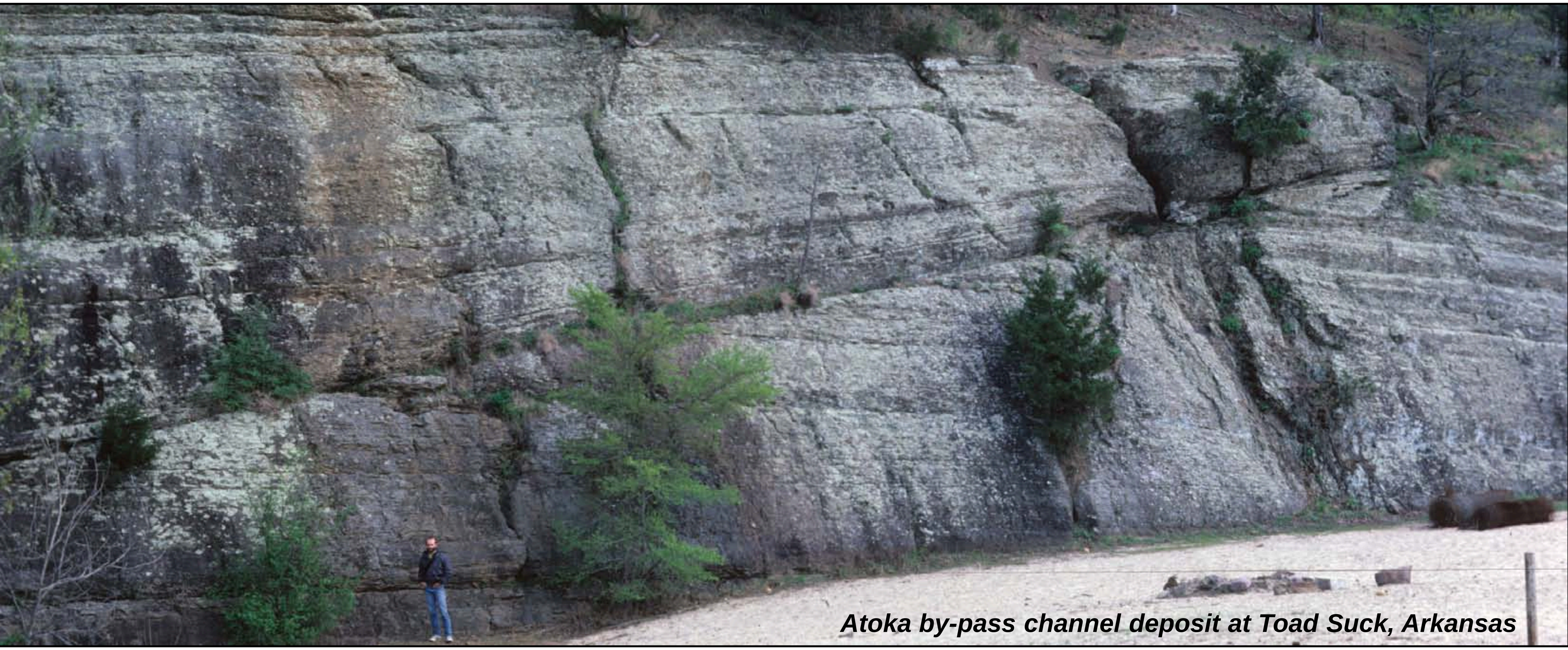
Natural Gas Assessment of the Arkoma Basin, Ouachita Thrust Belt, and Reelfoot Rift

Arkoma Basin Shelf and Deep Basin Plays

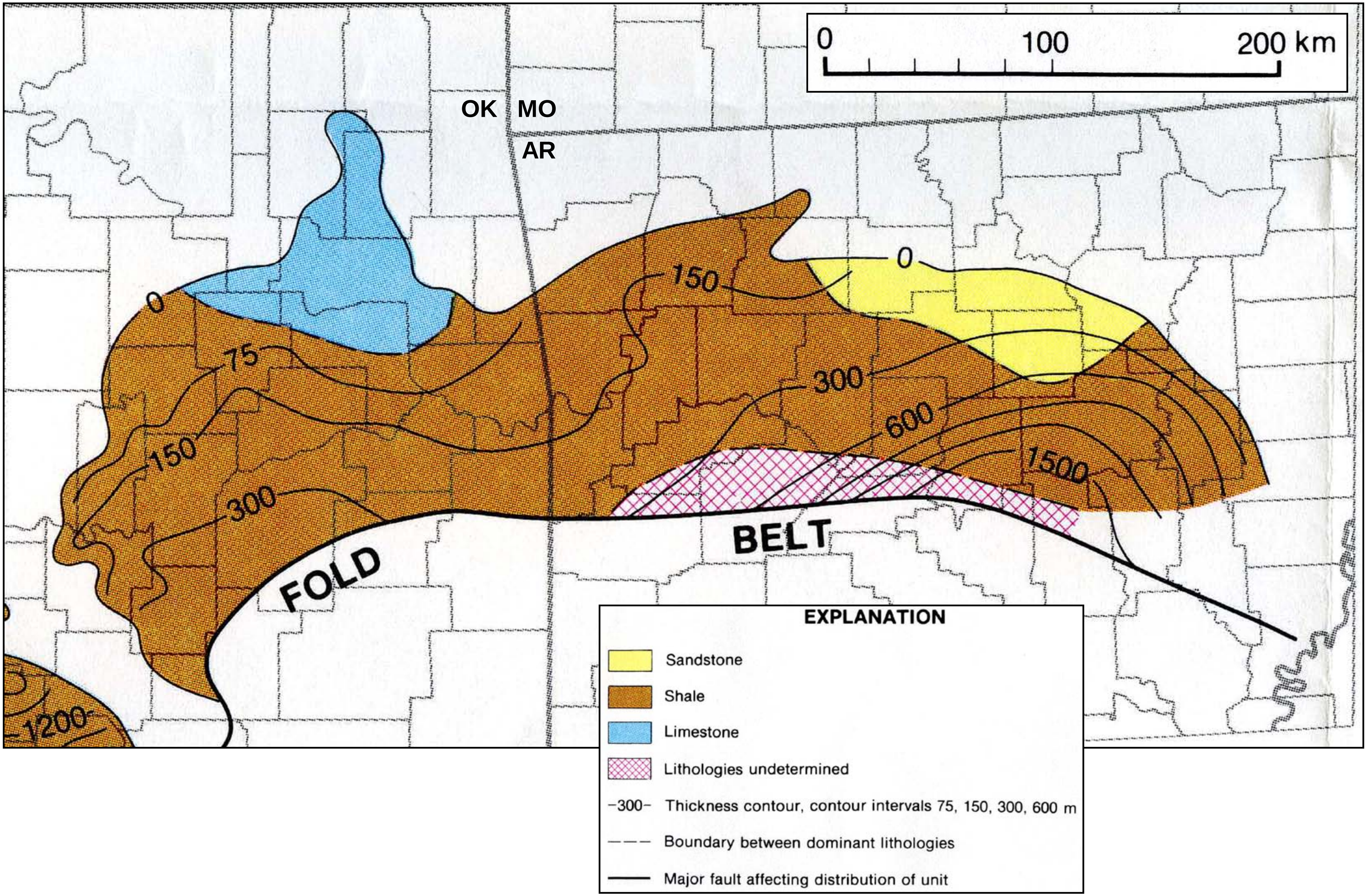


Atoka by-pass channel deposit at Toad Suck, Arkansas

Dave Houseknecht

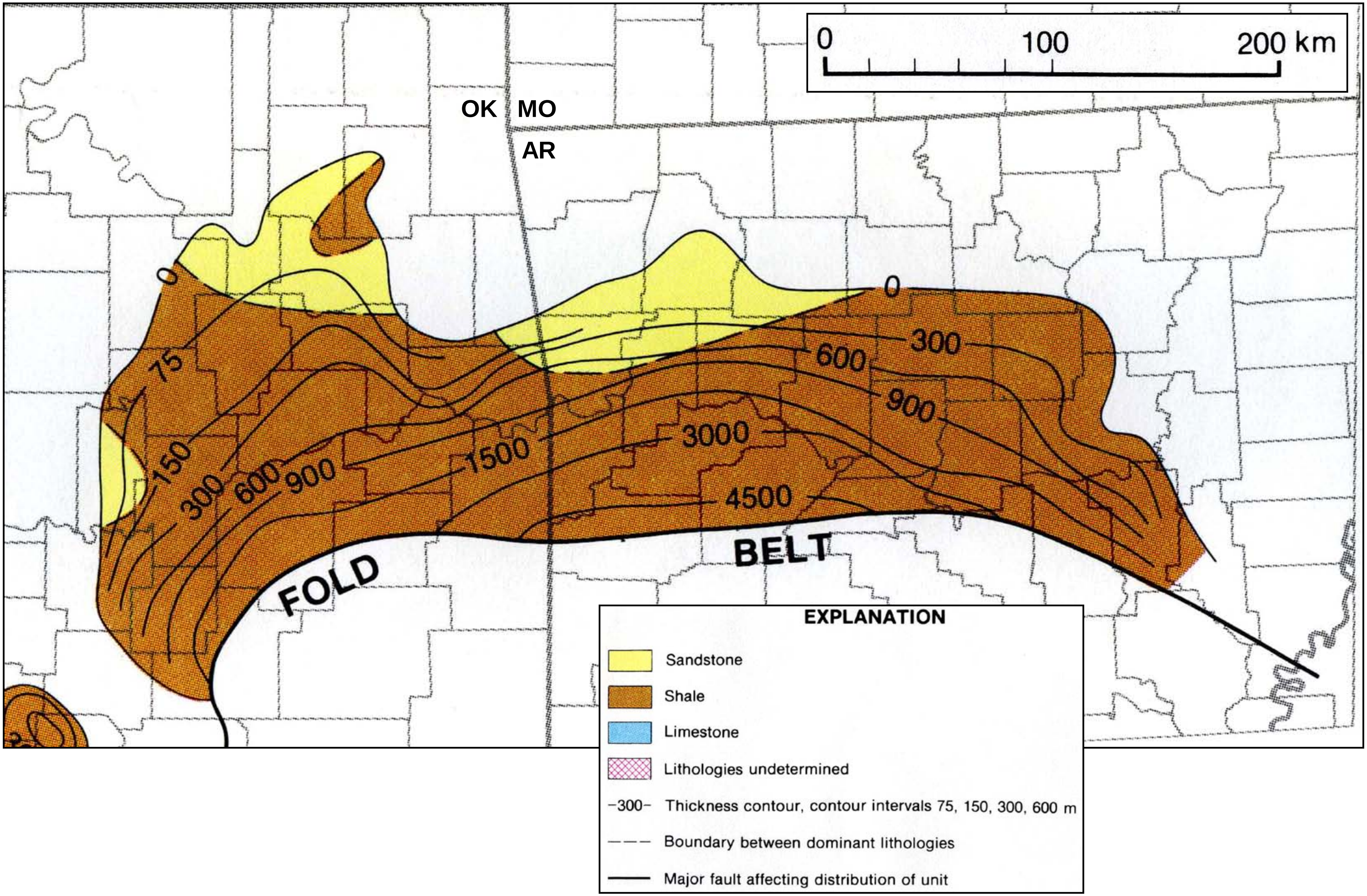
U.S. Department of the Interior
U.S. Geological Survey

Morrowan Series – *Thickness & Dominant Lithology*



Rascoe & Johnson, 1990; mod. From Adler et al., 1971 and McKee et al., 1975

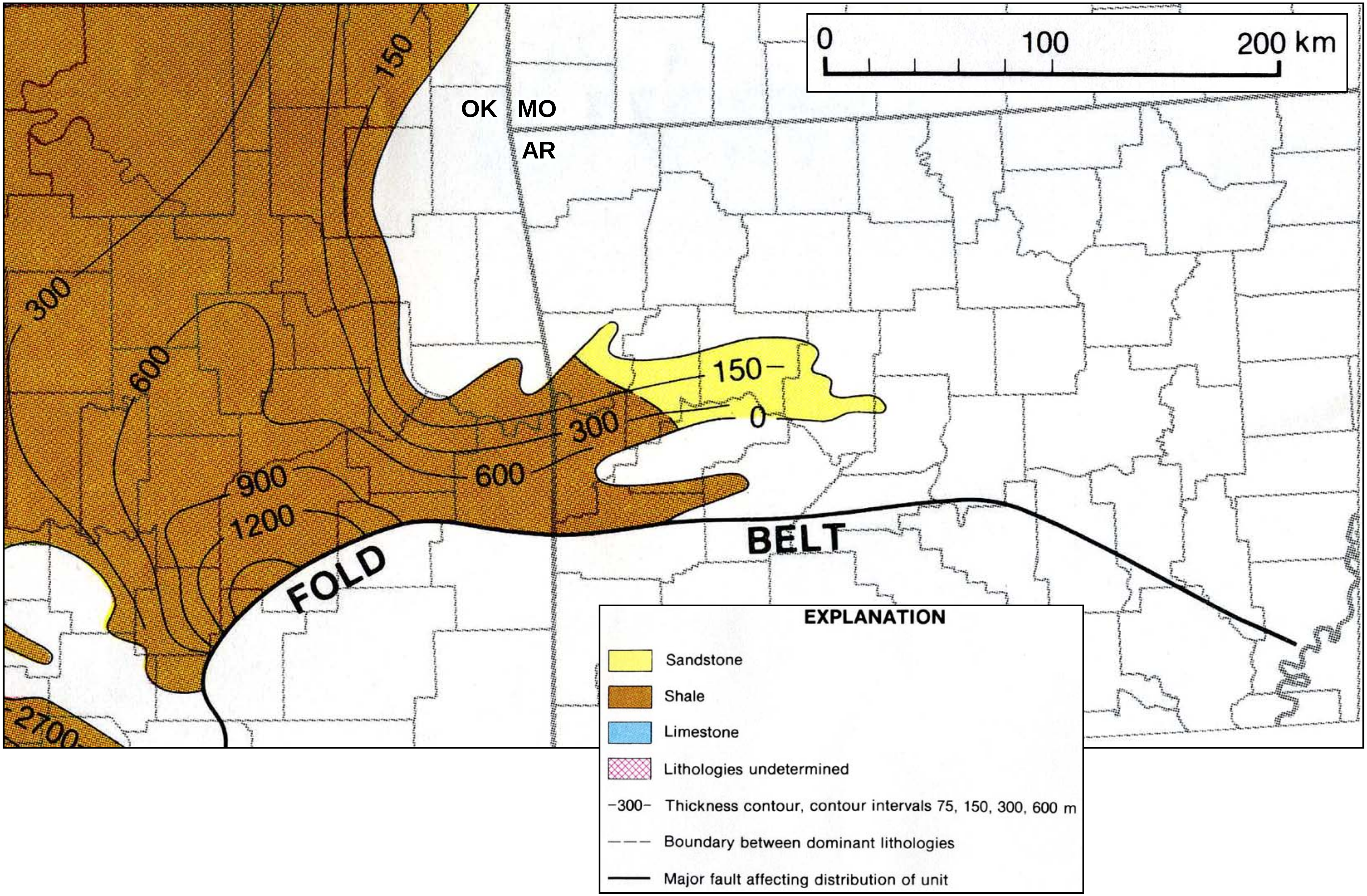
Atokan Series – *Thickness & Dominant Lithology*



USGS

Rascoe & Johnson, 1990; mod. From Adler et al., 1971 and McKee et al., 1975

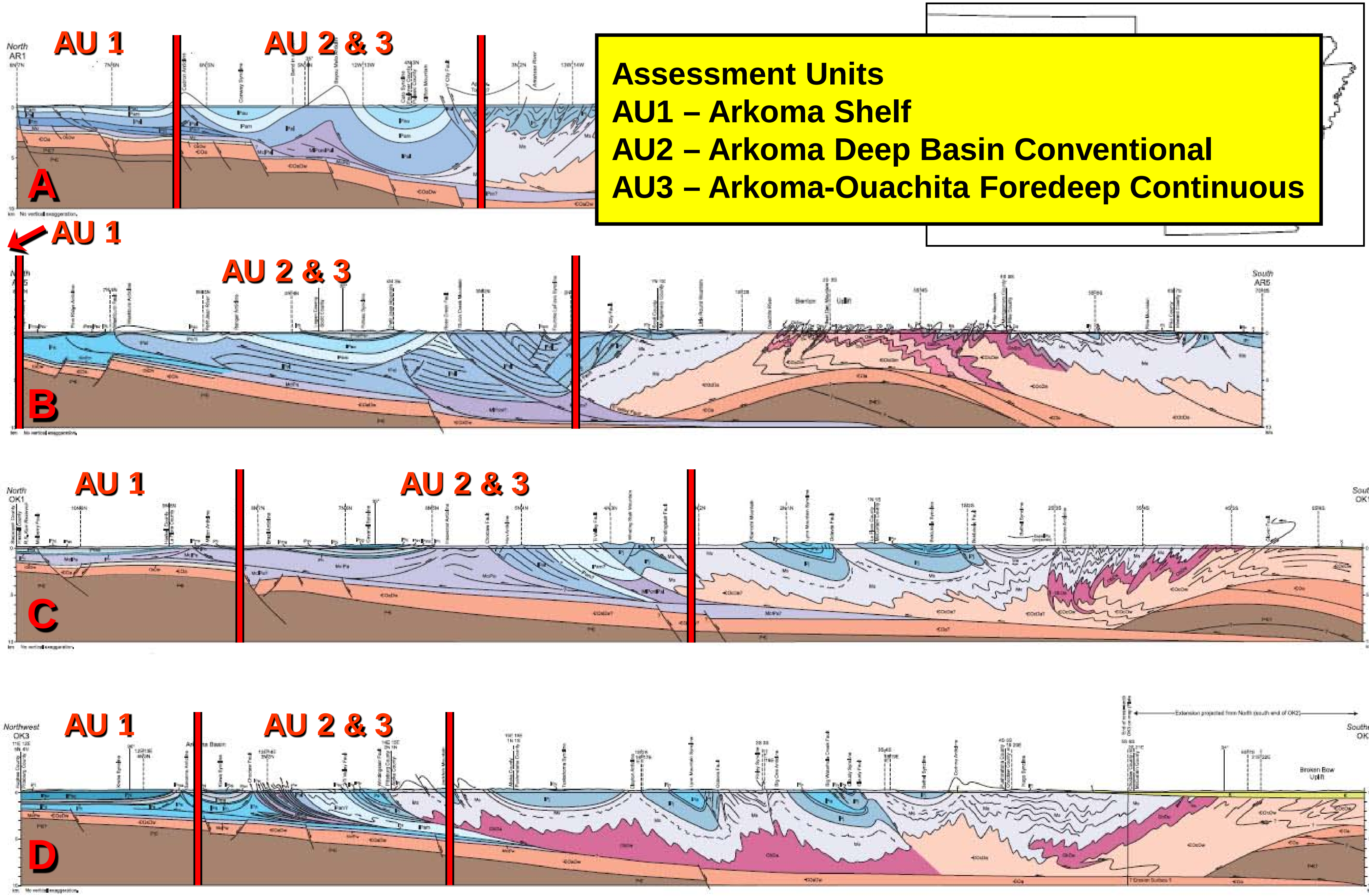
Desmoinesian Series – *Thickness & Dominant Lithology*



Rascoe & Johnson, 1990; mod. From Adler et al., 1971 and McKee et al., 1975

Structural Cross Sections – *Southern Arkoma Basin & Ouachitas*

Definition of Assessment Units



Assessment Units
AU1 – Arkoma Shelf
AU2 – Arkoma Deep Basin Conventional
AU3 – Arkoma-Ouachita Foredeep Continuous

USGS

Arbenz, 2008

Stratigraphic Cross Section in Western Arkansas

Arkoma Basin Growth Fault Systems

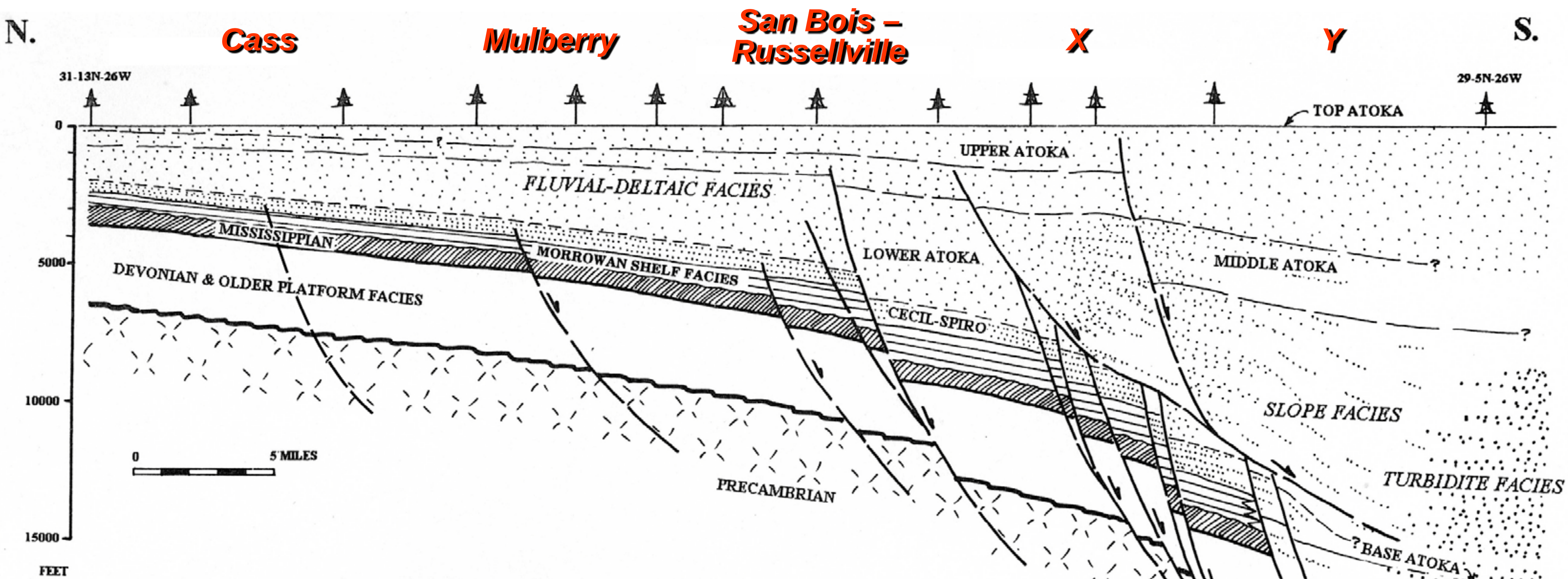


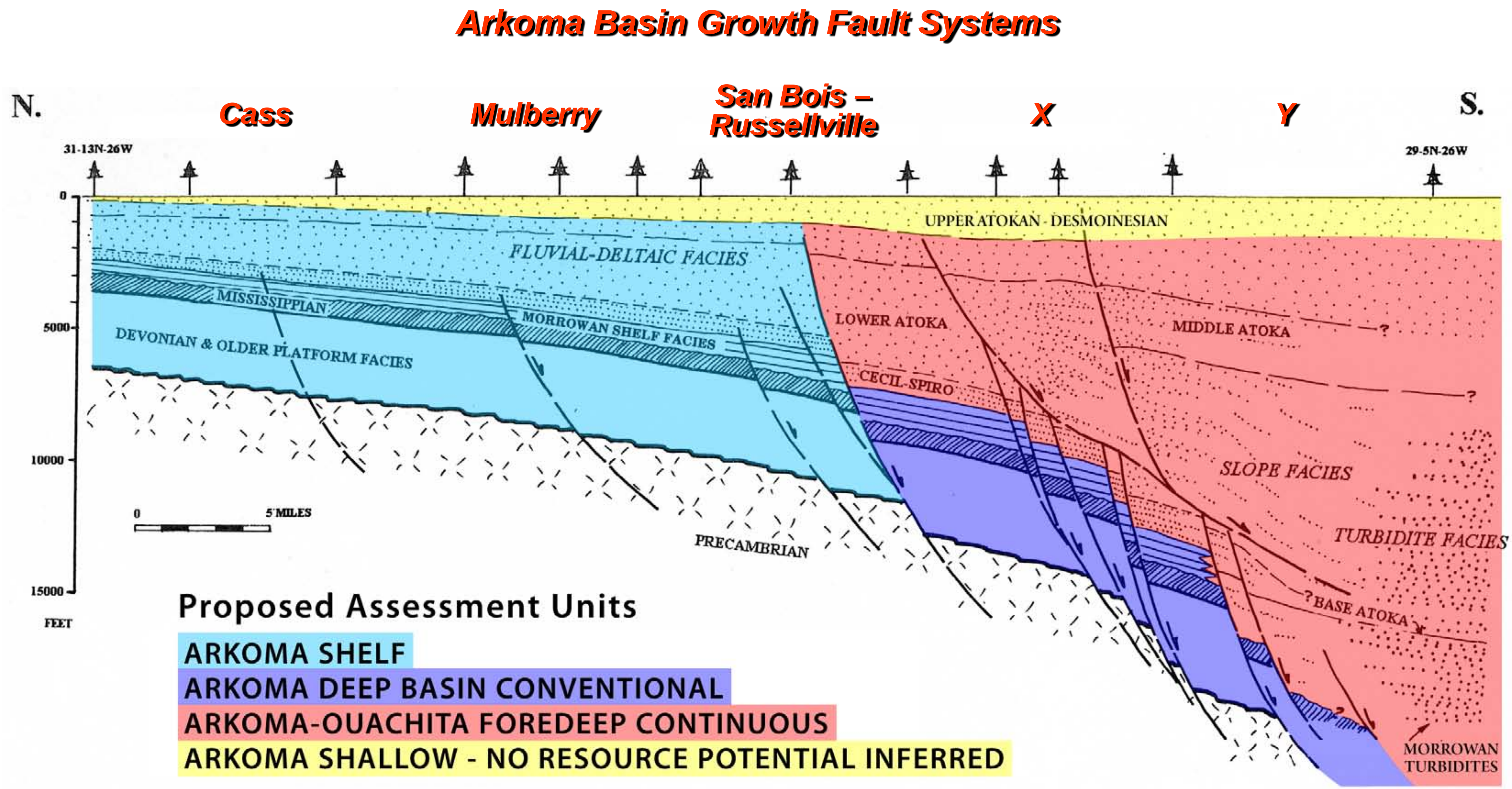
Figure 11. Stratigraphic cross section, Arkoma Basin, western Arkansas, at end of deposition of the Atokan. Morrowan and lower Atokan units change from shelf and fluvial-deltaic to deep-water facies from north to south, with the transition occurring about 30–35 mi south of the Mulberry fault zone (constructed from data in Haley, 1982).

Approximate location shown by A on subsequent map.

USGS

Cross section modified from Roberts, 1994
Fault designations from Houseknecht et al., 1989

Proposed Assessment Units – *Shelf-Foredeep Boundary*



Approximate location shown by A on subsequent map.

Cross section modified from Roberts, 1994
Fault designations from Houseknecht et al., 1989

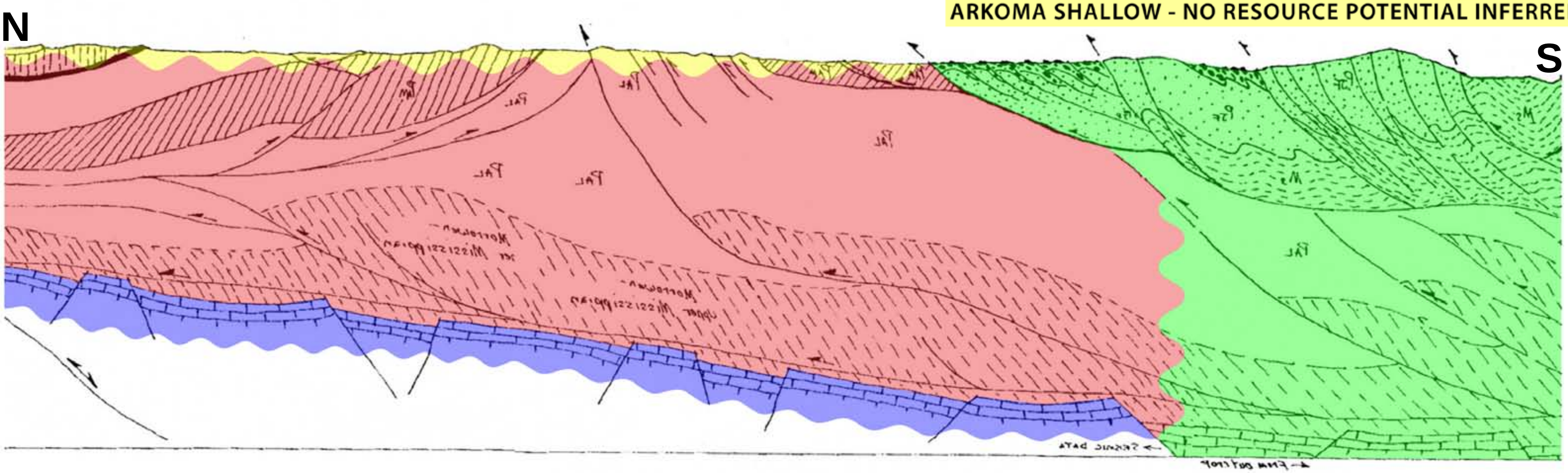
USGS

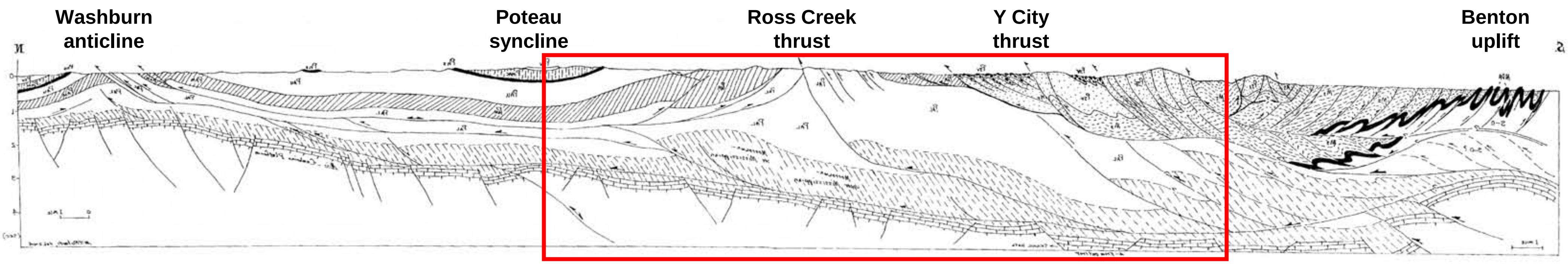
Structural Cross Section in Western Arkansas

Foredeep-Thrust Belt Boundary

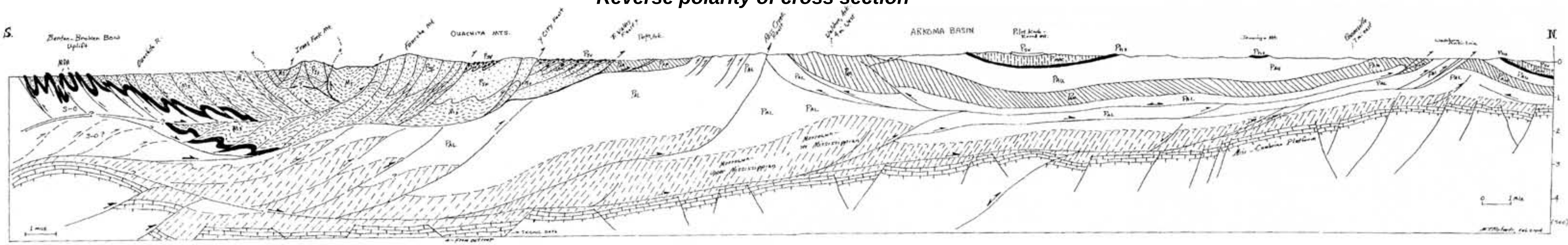
Proposed Assessment Units

- ARKOMA DEEP BASIN CONVENTIONAL
- ARKOMA-OUACHITA FOREDEEP CONTINUOUS
- OUACHITA THRUST BELT
- ARKOMA SHALLOW - NO RESOURCE POTENTIAL INFERRED





Reverse polarity of cross section



USGS

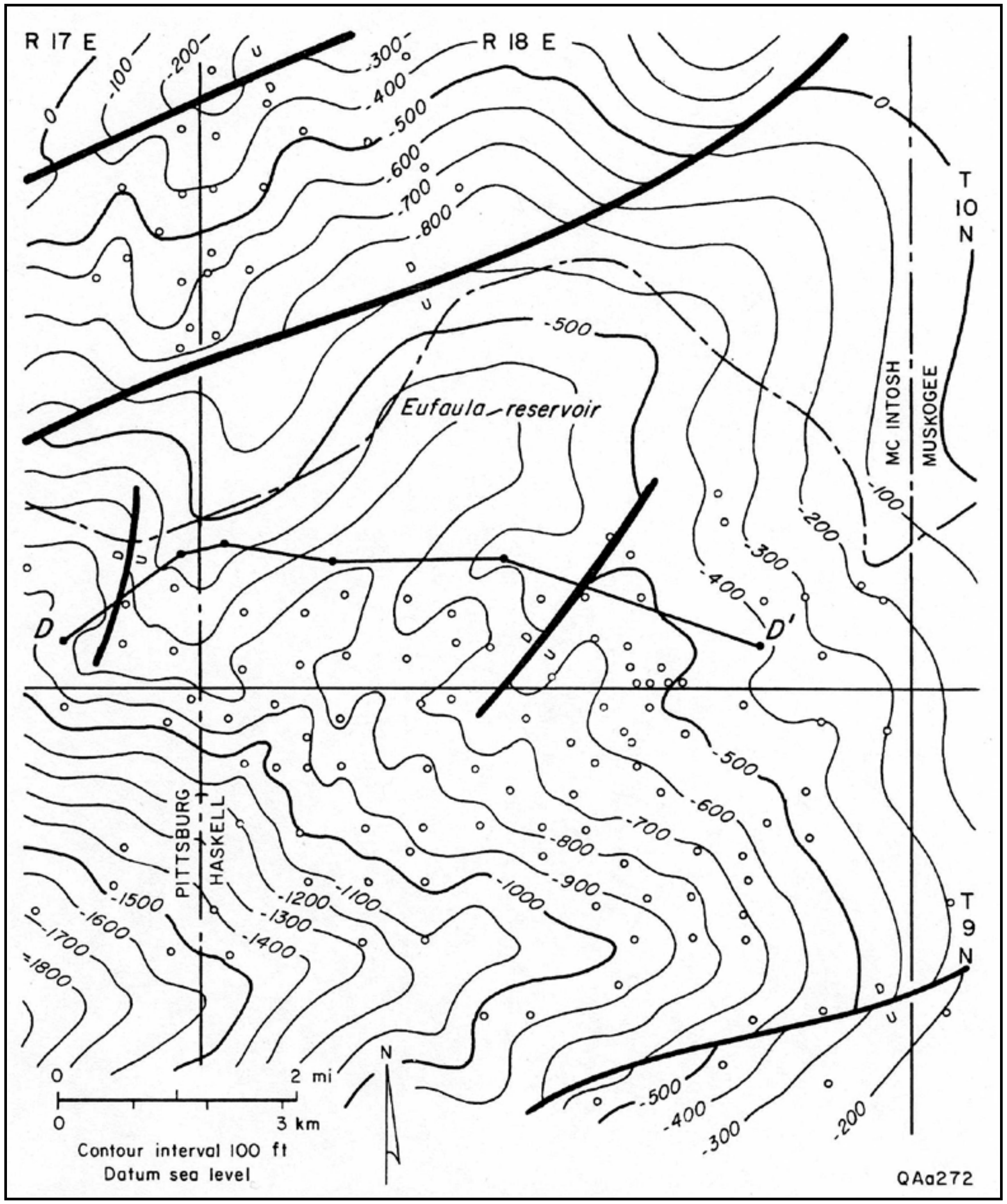
Approximate location shown by B on subsequent map.

Cross section modified from Roberts, 2005

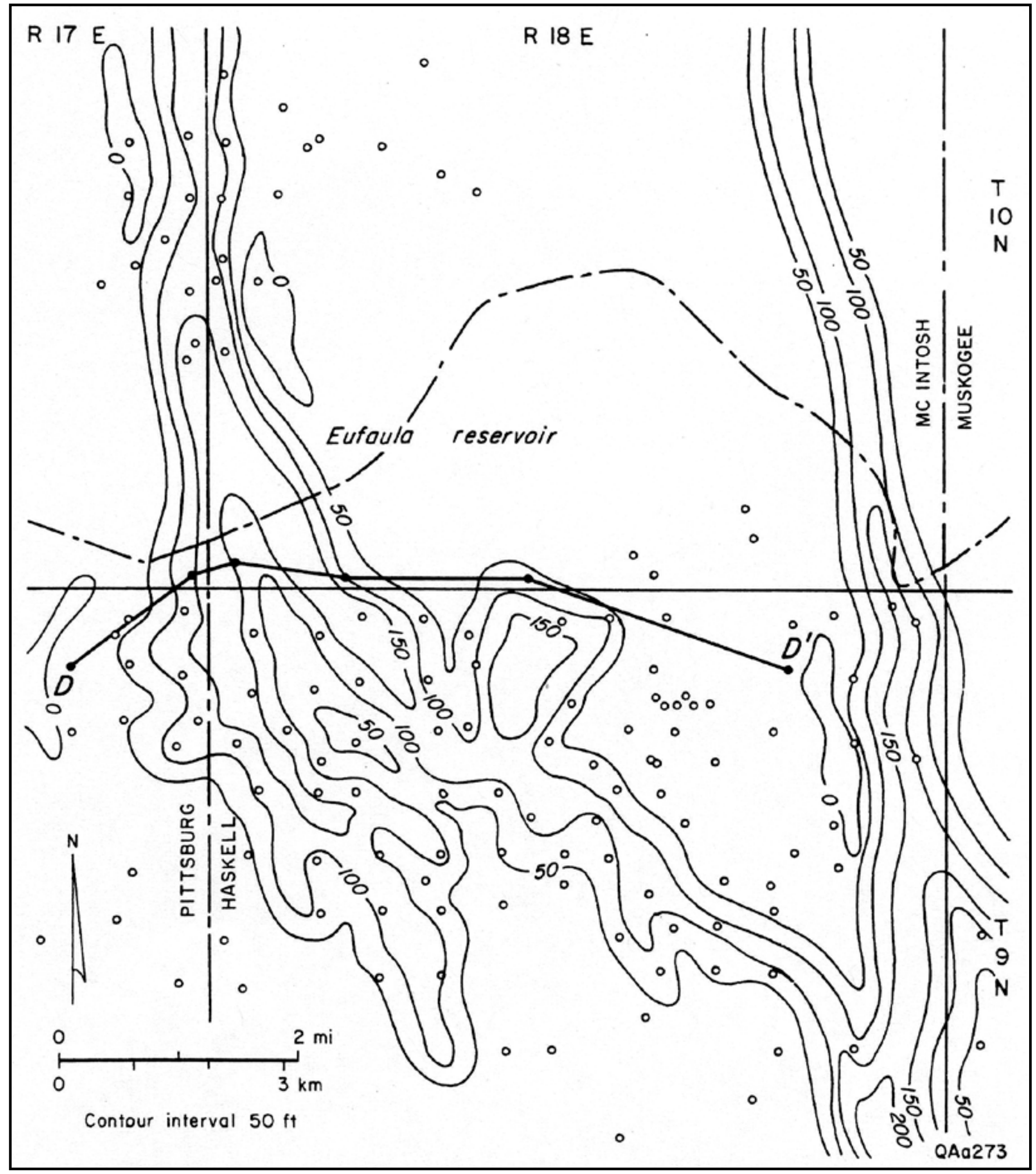
Arkoma Shelf Assessment Unit – *Key Characteristics*

- **Mostly structural and structural-stratigraphic traps**
- **Reservoirs include both sandstone and carbonate strata**
    - **Basal Atoka (Spiro) & older shelf strata**
    - **Atoka & Demoinesian foreland-basin strata**
- **Water legs predominant to common**
- **Mostly normally pressured; locally under-pressured**
- **Example fields: Kinta, Altus-Massard trend, Brooken, Quinton, White Oak, Bonanza**
- **Production histories indicate finite accumulation volumes**
- **Conventional accumulations**
- **Maturely explored – modest potential for new discoveries of the minimum size (3 BCFG ~ 0.5 MMBO)**

Brooken Field – Middle Booch Sandstone



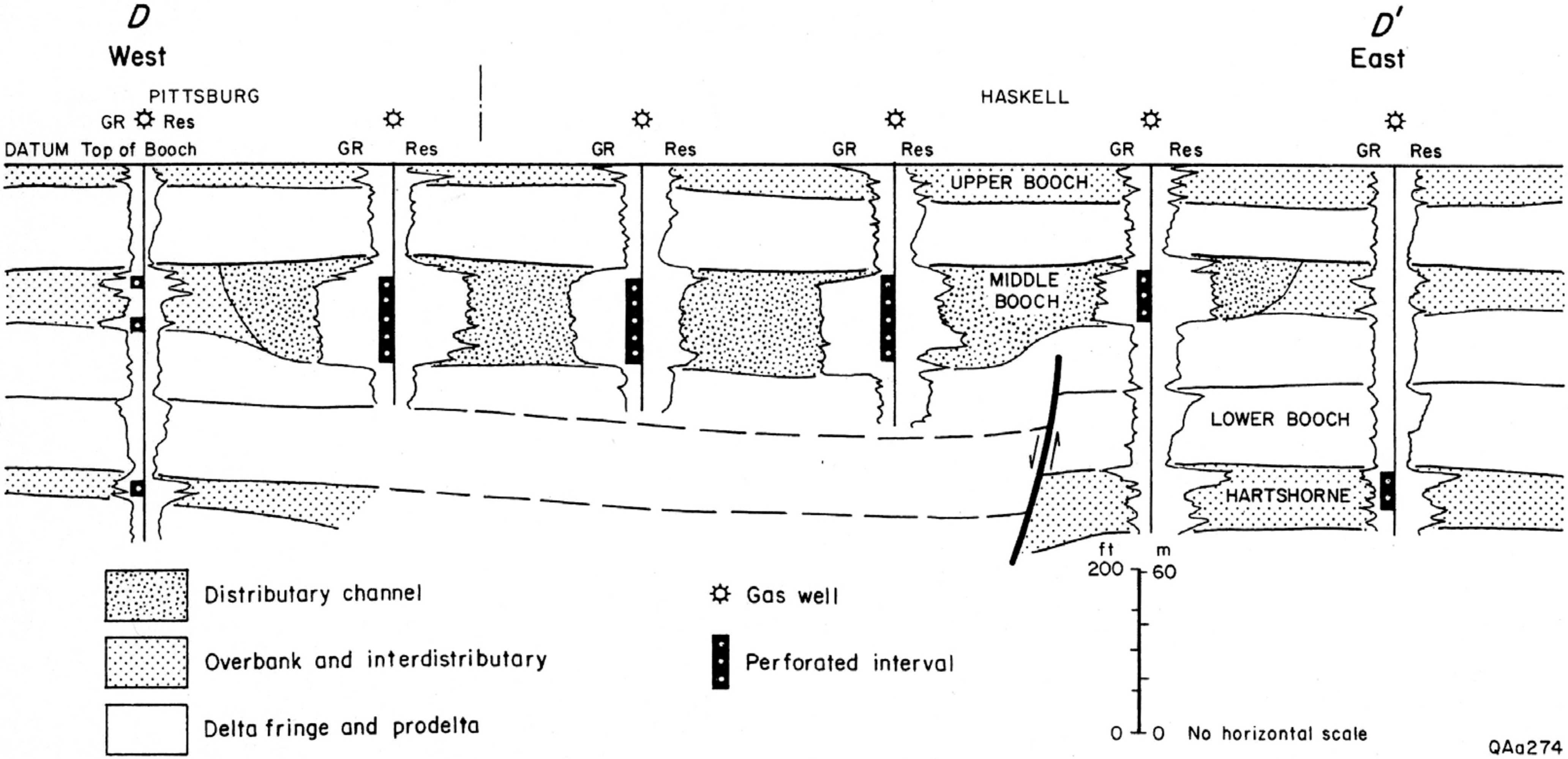
Structure contour map



Net sandstone isopach map

Brown & Parham, 1993 from Bowker & Seale, 1985

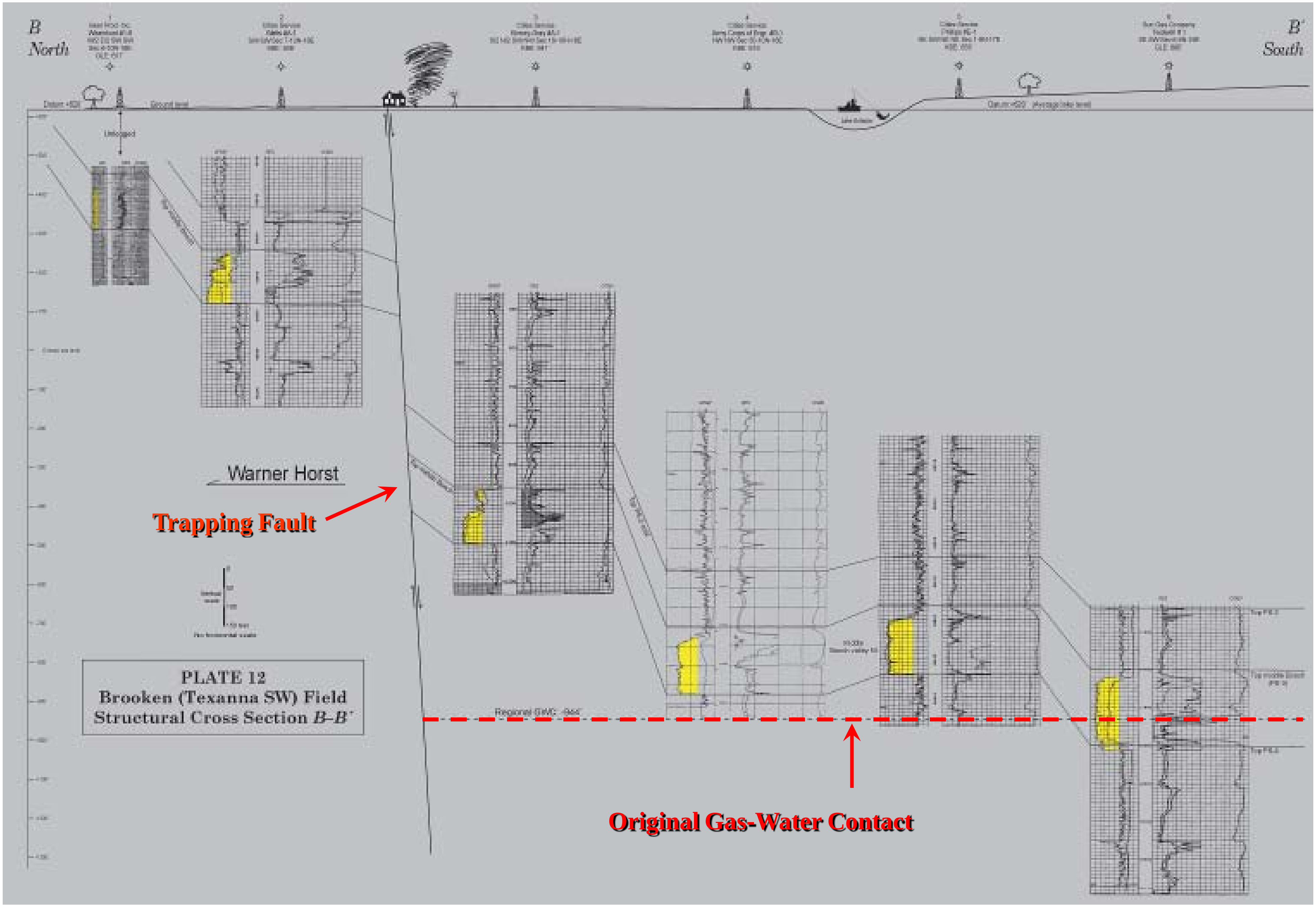
Brooken Field – Stratigraphic Cross Section
Booch & Hartshorne Sandstone Facies



Brown & Parham, 1993 from Bowker & Seale, 1985

Brooken Field – Structural Cross Section

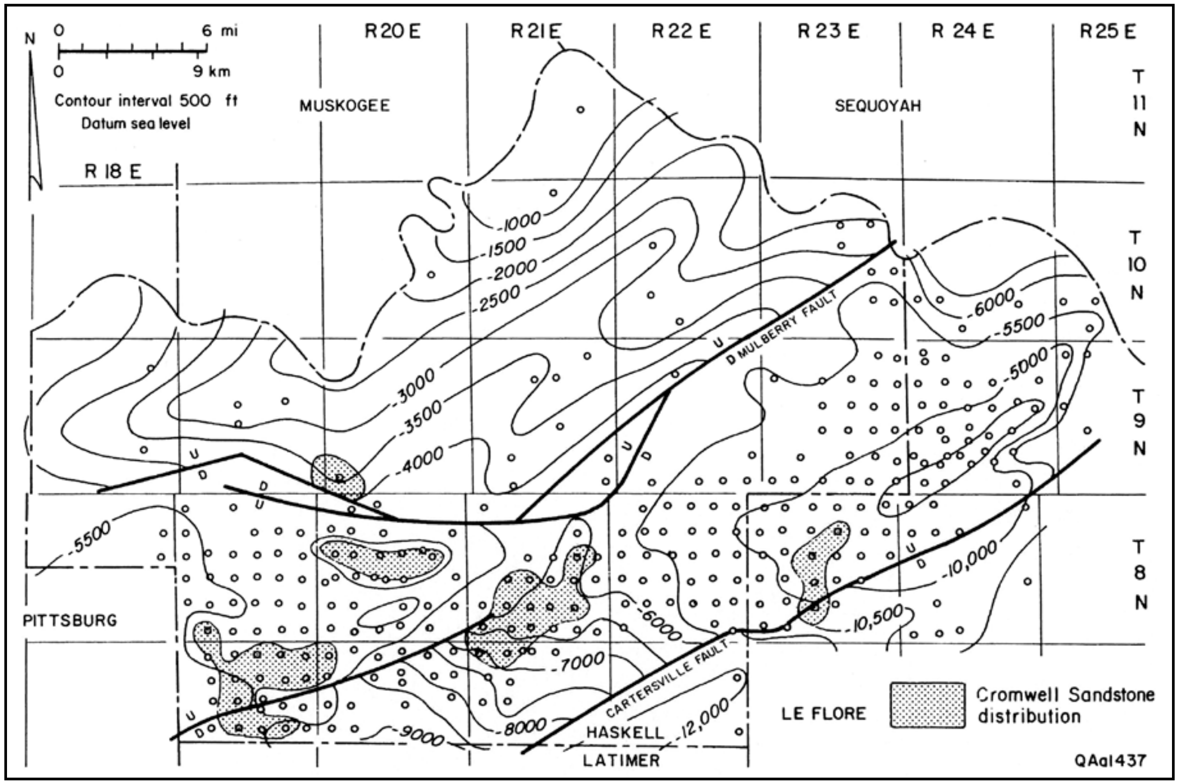
Trapping Fault & Original Gas-Water Contact in



Boyd, 2005, 2008

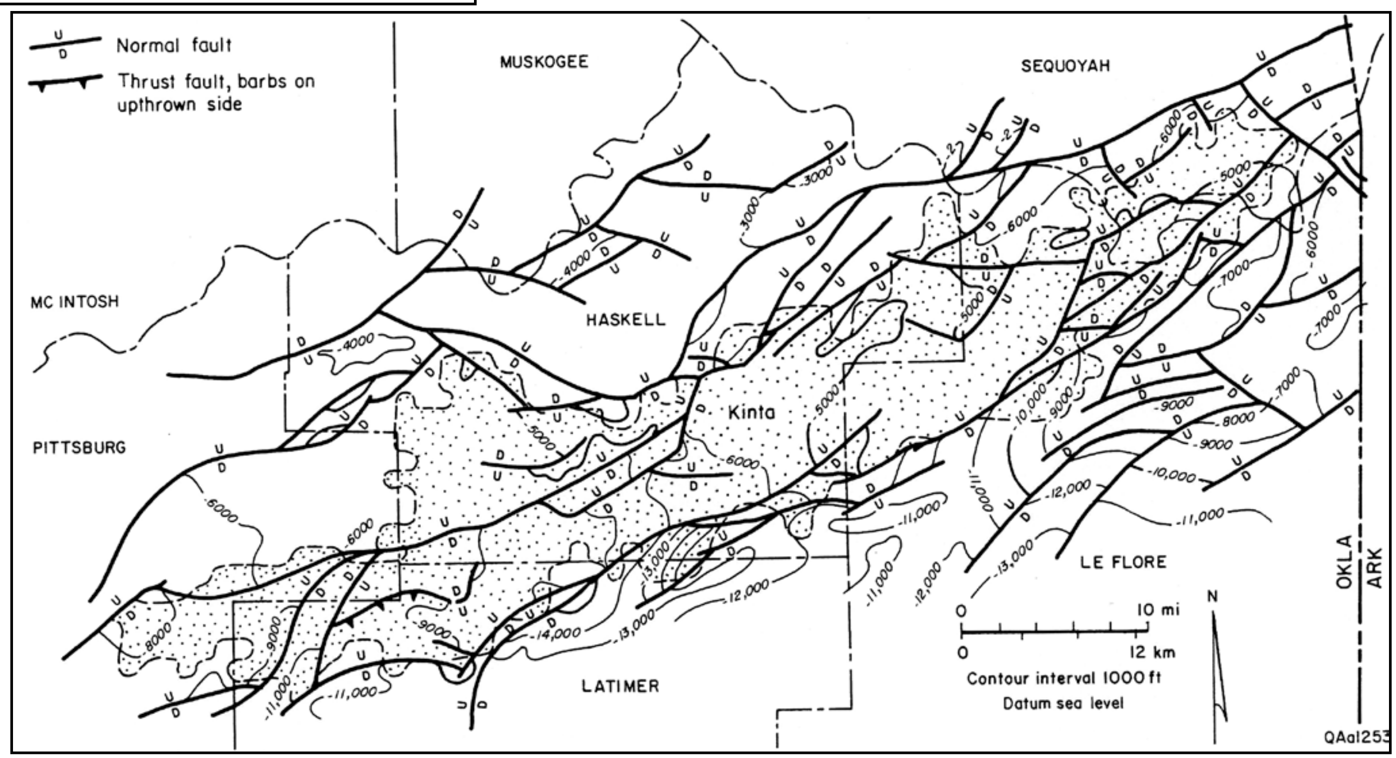
USGS

Kinta Field – Transition from Shelf to Foredeep



Wapanucka limestone structure contour map

Bingham & Woodward, 1993 from Woncik, 1968

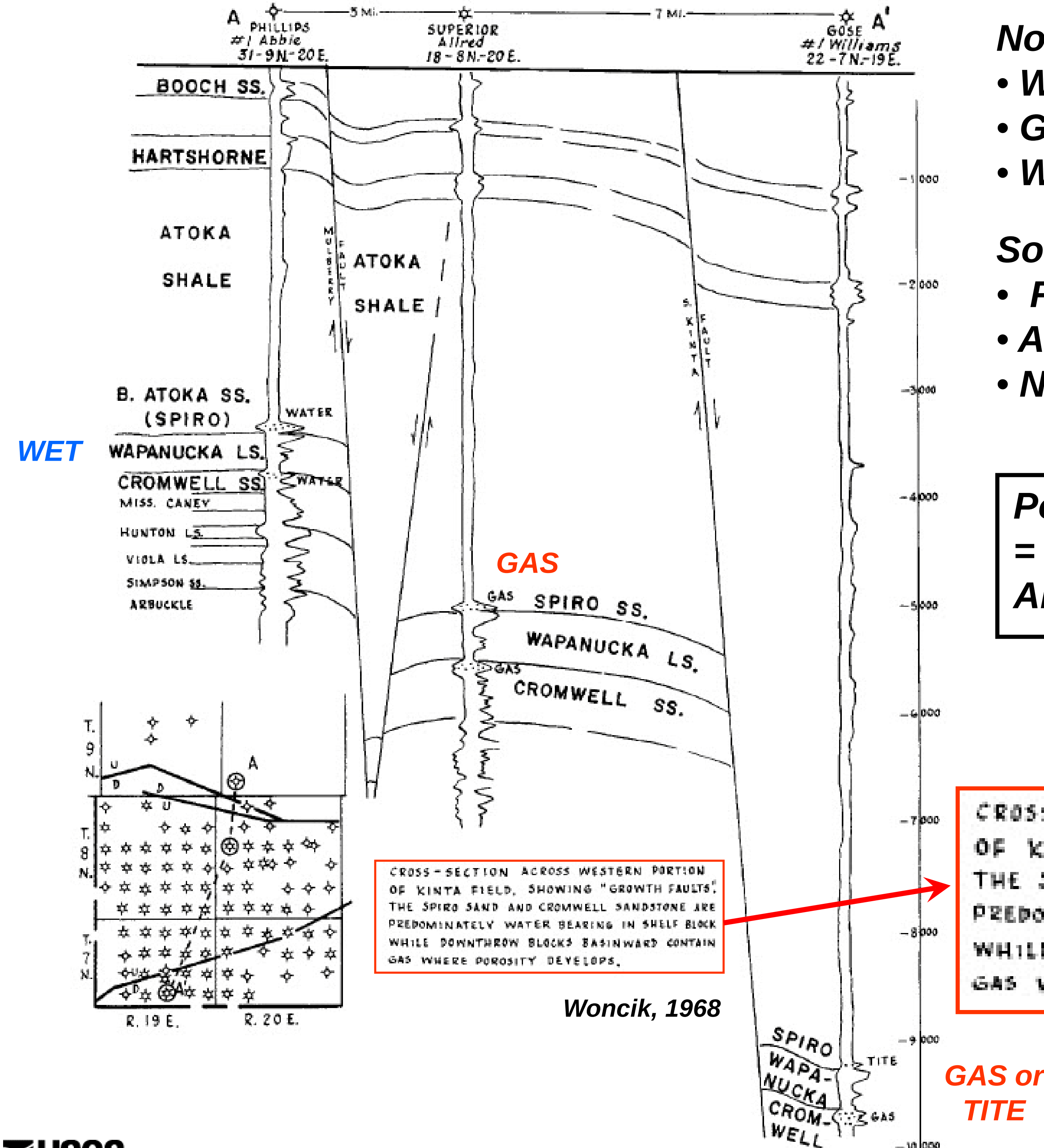


Spiro sandstone structure contour map

Brown & Woodward, 1993 from Wylie, 1988

USGS

Kinta Field Cross Section – *Transition in Character of Reservoir & Formation Fluid*



Woncik, 1968

North
- ***Widely Porous Reservoirs***
- ***Gas Accumulations on Structure***
- ***Water Legs***

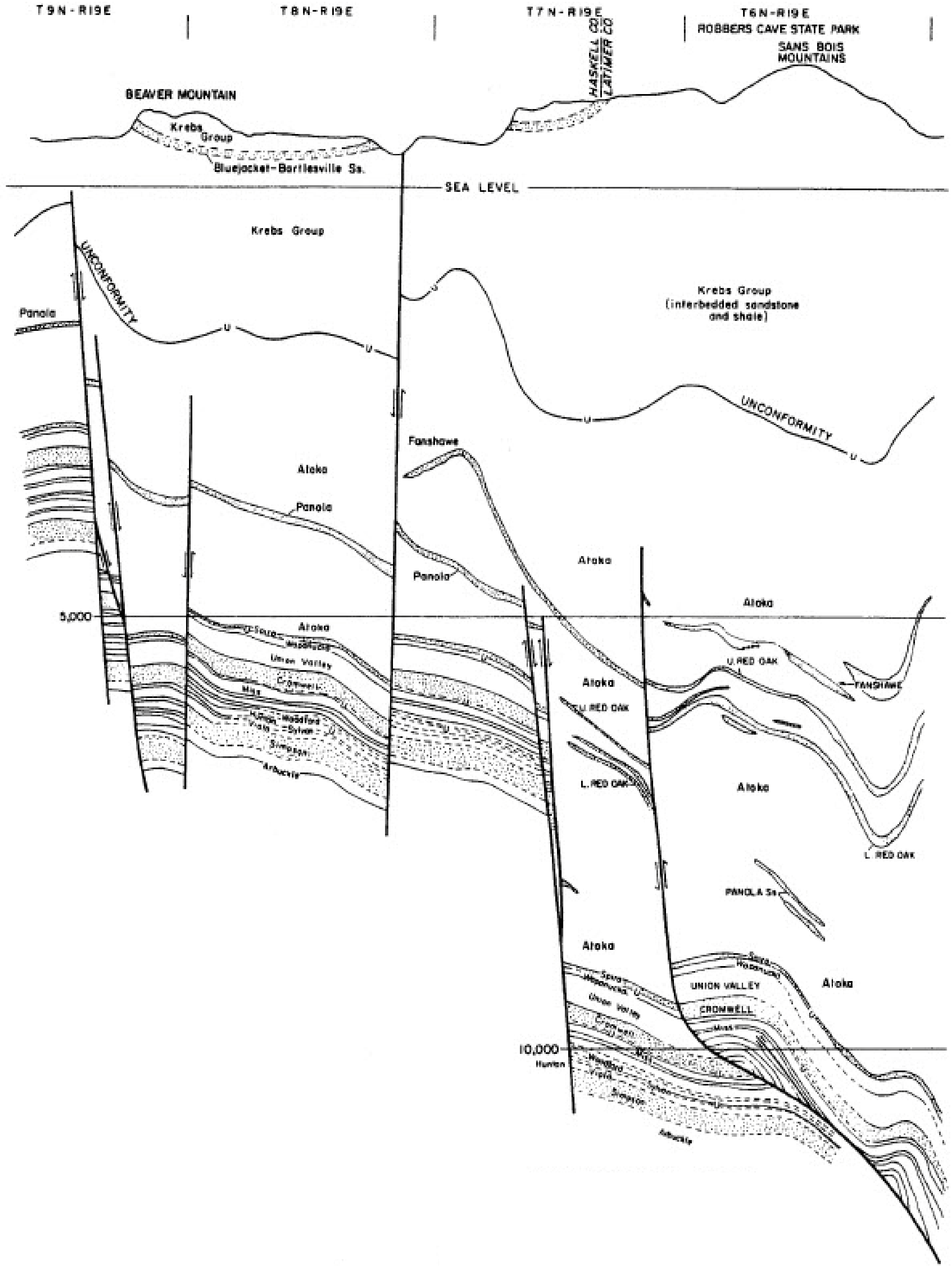
South
- ***Reservoirs Units Locally Porous***
- ***All Porosity is Gas Saturated***
- ***No Water Legs***

Porous & Gas Charged vs. Tite = Distinctive Characteristic of Arkoma Deep Basin - Foredeep

CROSS-SECTION ACROSS WESTERN PORTION OF KINTA FIELD, SHOWING "GROWTH FAULTS". THE SPIRO SAND AND CROMWELL SANDSTONE ARE PREDOMINATELY WATER BEARING IN SHELF BLOCK WHILE DOWNTHROW BLOCKS BASINWARD CONTAIN GAS WHERE POROSITY DEVELOPS.

USGS

Kinta Field Cross Section



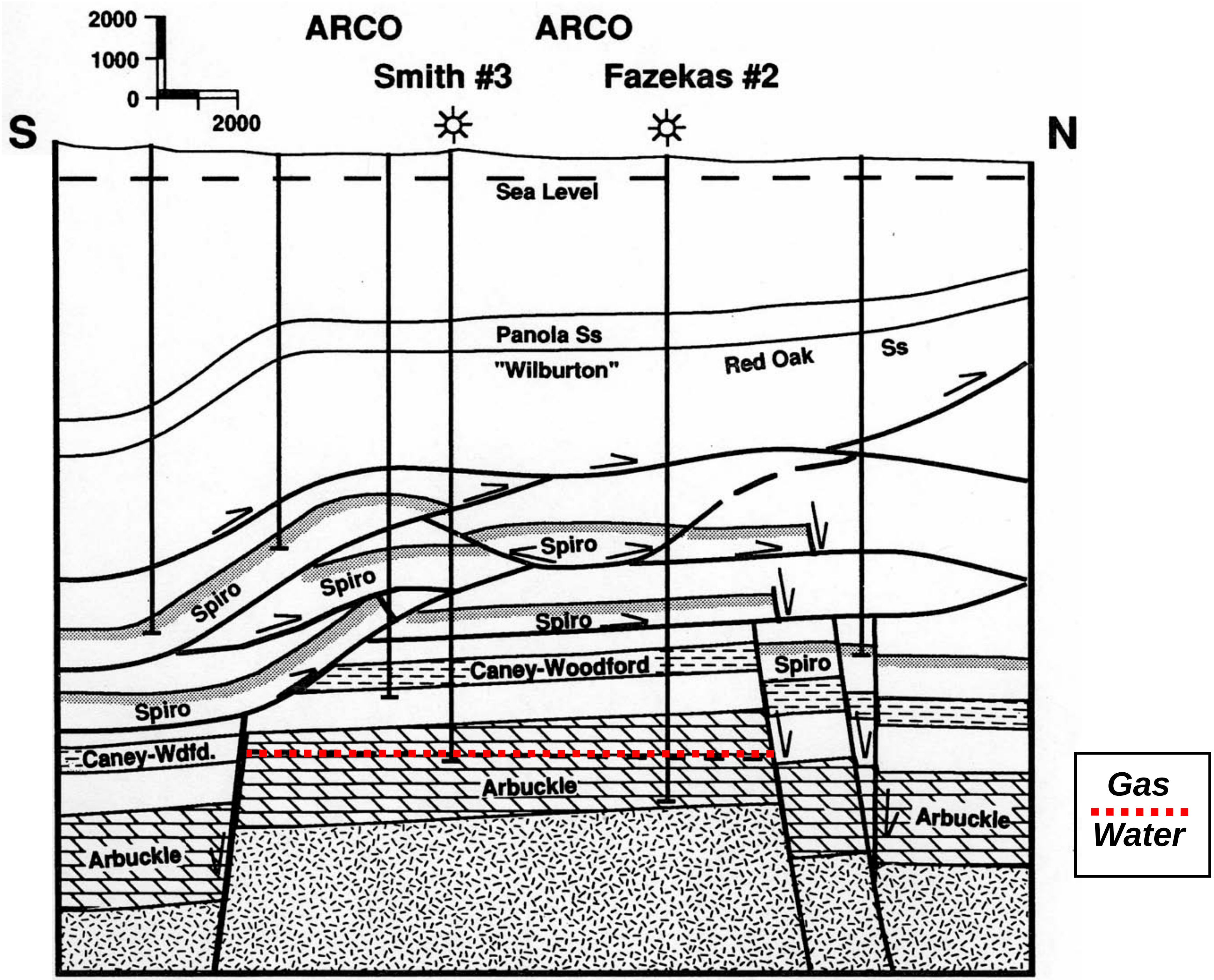
USGS

Northcutt & Brown, 1994
From Wylie, 1988

Arkoma Deep Basin Conventional Assessment Unit – *Key Characteristics*

- **Mostly structural and structural-stratigraphic traps**
- **Reservoirs include both sandstone and carbonate strata**
  - **Basal Atoka (Spiro) & older shelf strata**
  - **Arbuckle Group considered oldest potential reservoir**
- **Evidence that accumulations are discrete**
  - **- Water legs present in west (lowest thermal maturity)**
  - **- “Fossil” water legs present elsewhere**
- **Normal or abnormal (both over & under) pressured**
- **Example fields: Wilburton deep, Red Oak deep, Caulksville deep**
- **Production histories indicate finite accumulation volumes**
- **Assessed as conventional accumulations**
- **Moderately explored – potential for new discoveries of the minimum size (3 BCFG ~ 0.5 MMBO)**

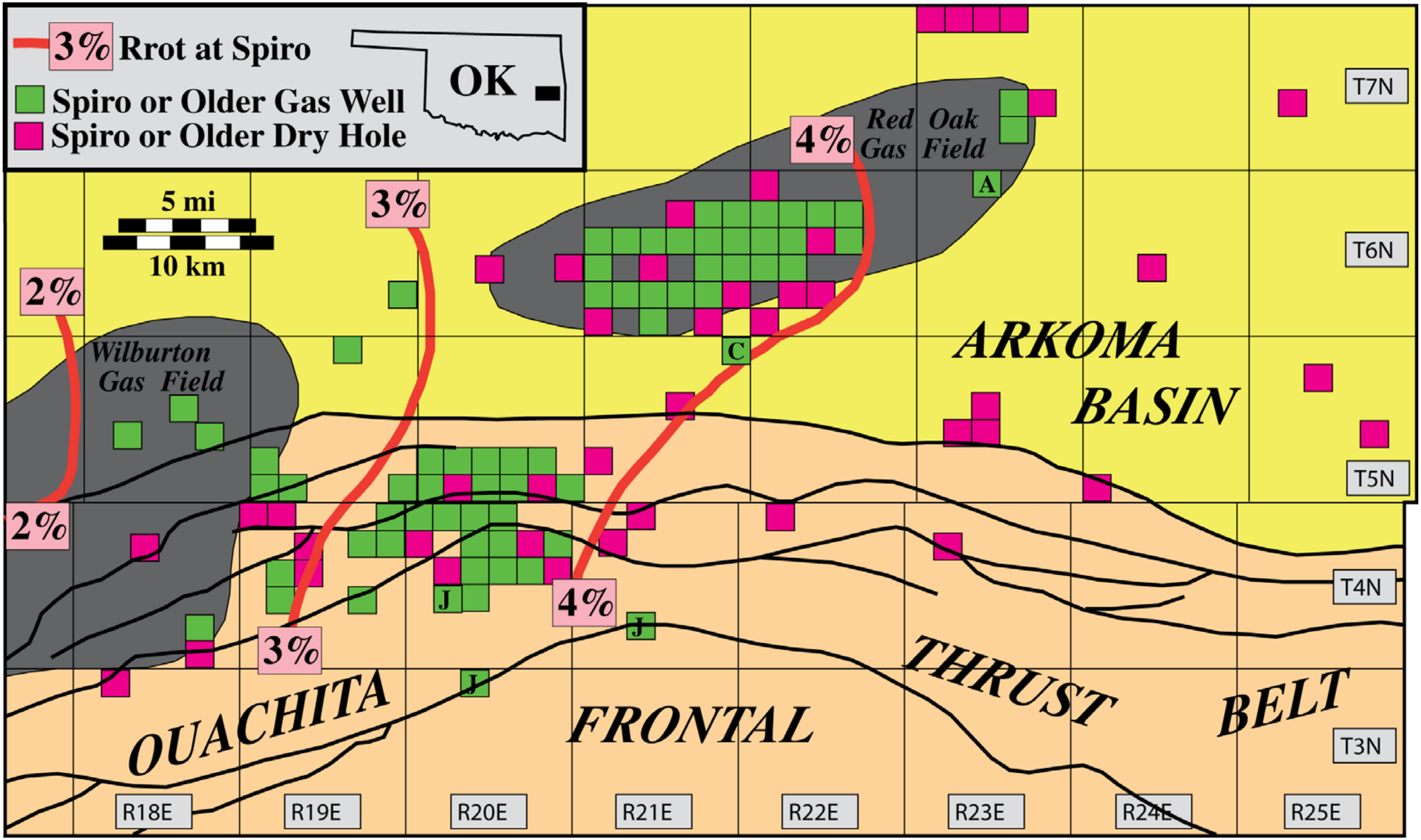
Wilburton Field – *Cross Section Showing Water Leg in Arbuckle Reservoir*



USGS

Mescher and others, 1993

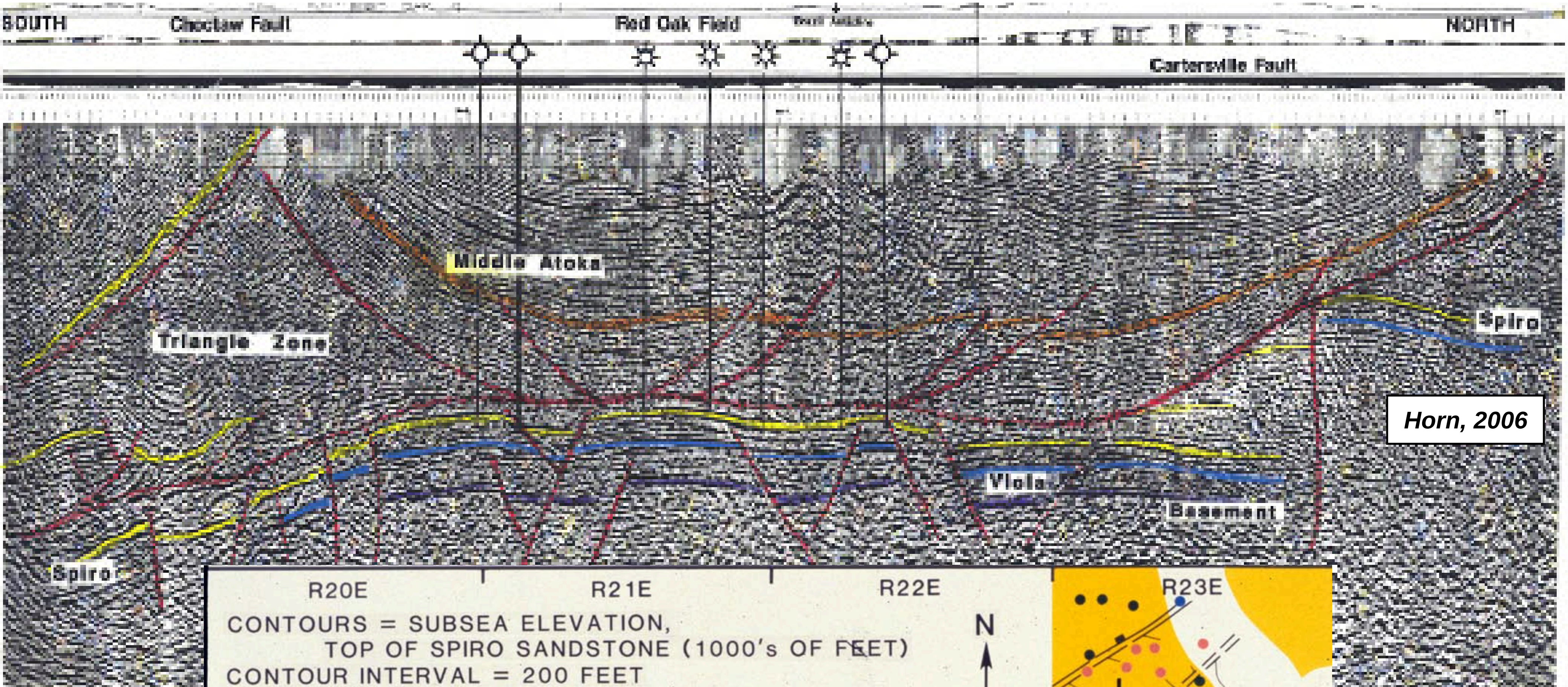
Thermal Maturity of Spiro Horizon – Wilburton and Red Oak Fields



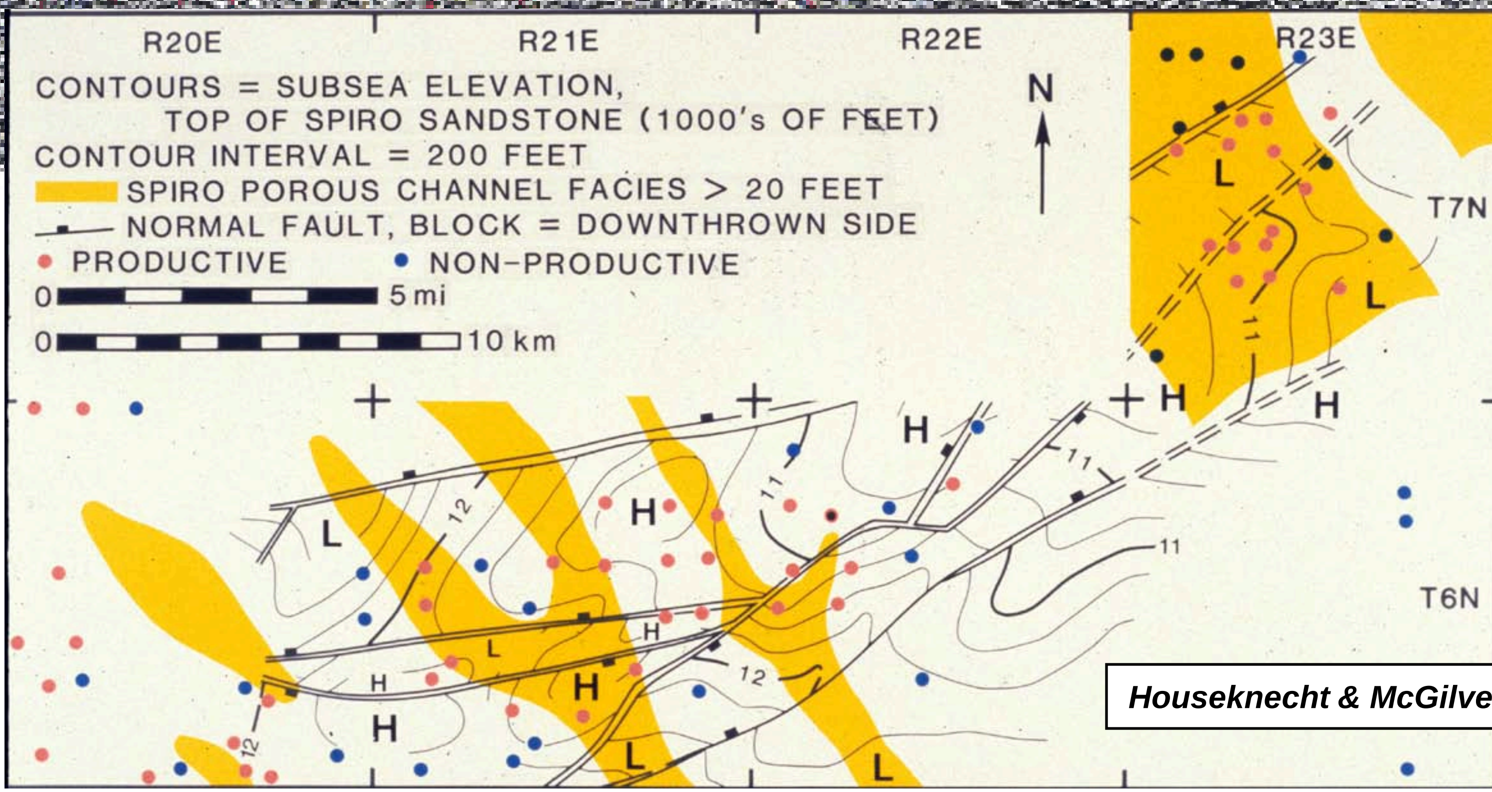
USGS

Houseknecht & Spötl, 1993

Arkoma Basin – *Seismic Expression & Spiro Structure in Red Oak Field*

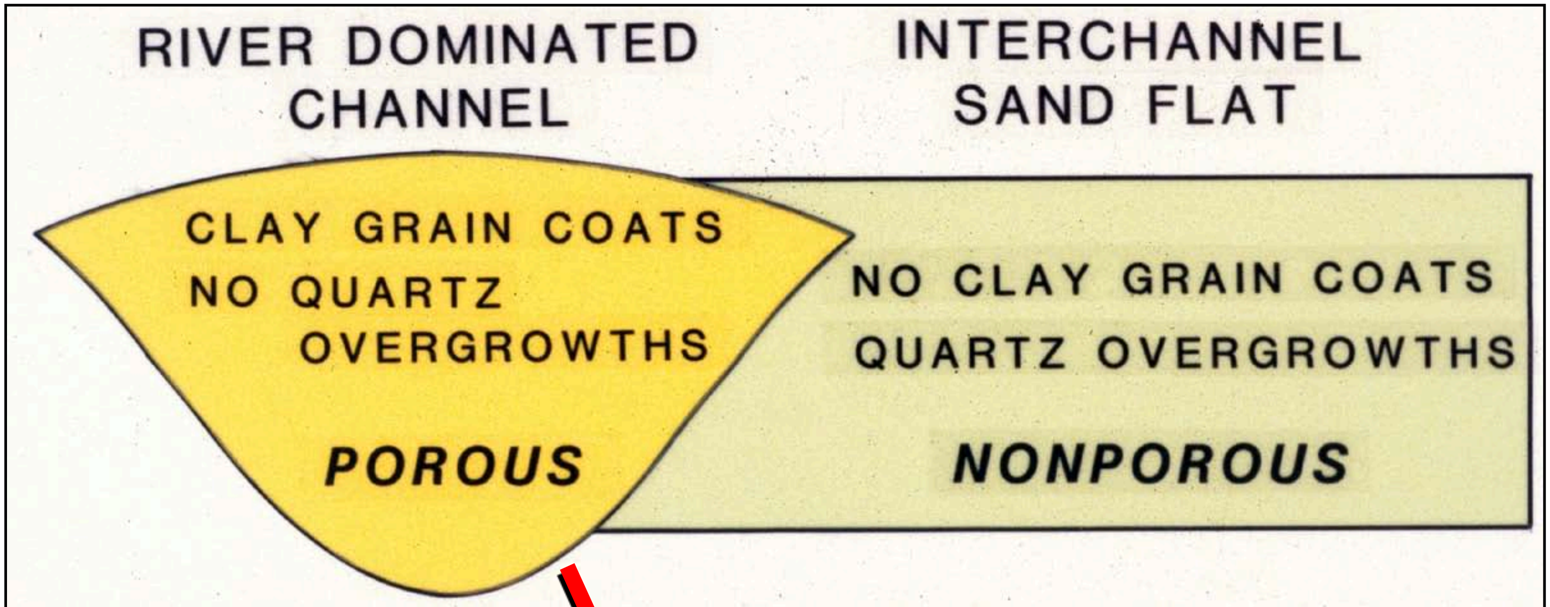


Horn, 2006



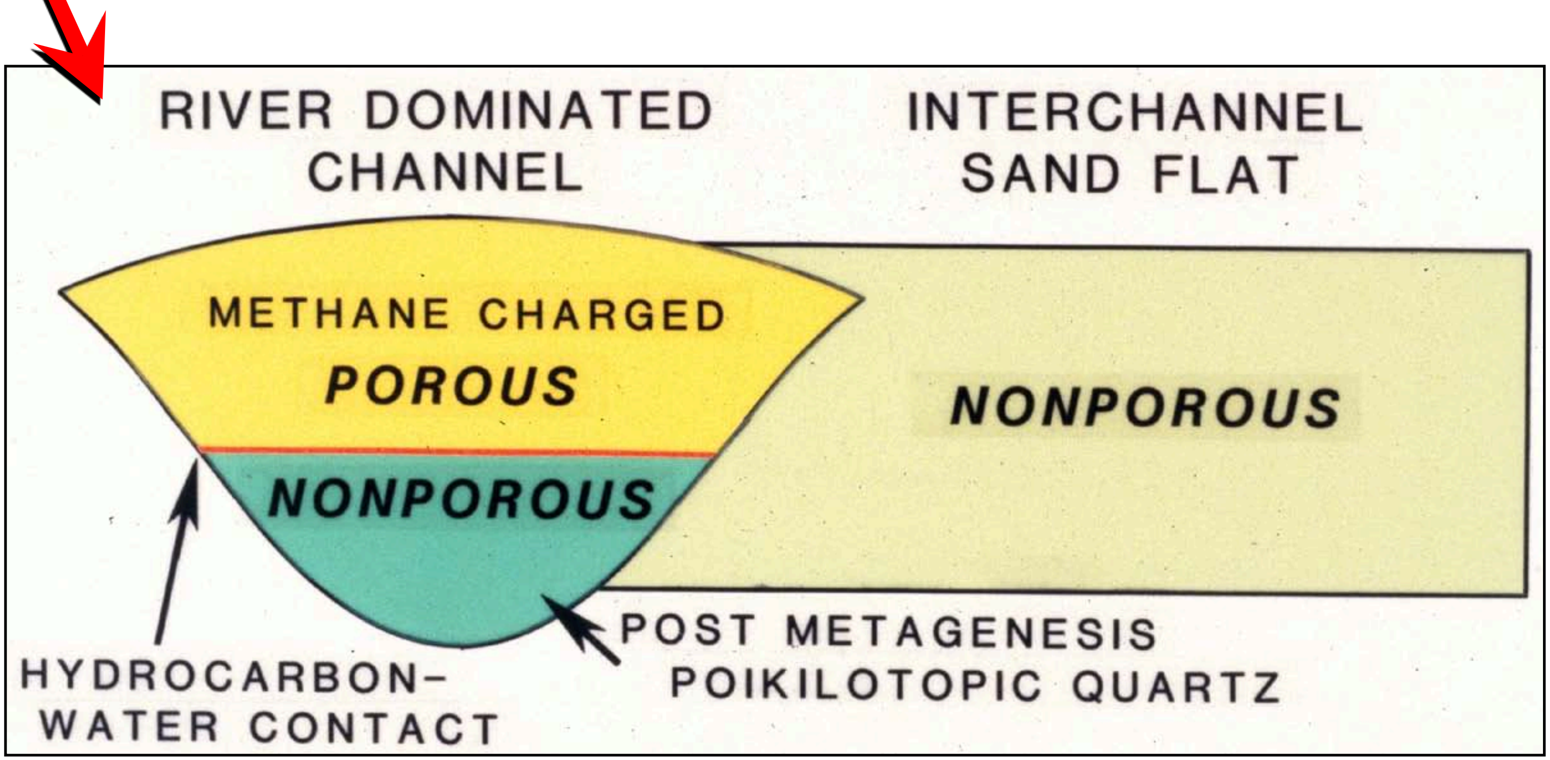
Houseknecht & McGilvery, 1990

Spiro Diagenesis in Red Oak Field – “Fossil” Water Leg



Early, Low-Temperature Diagenesis

Later, High-Temperature Diagenesis



USGS

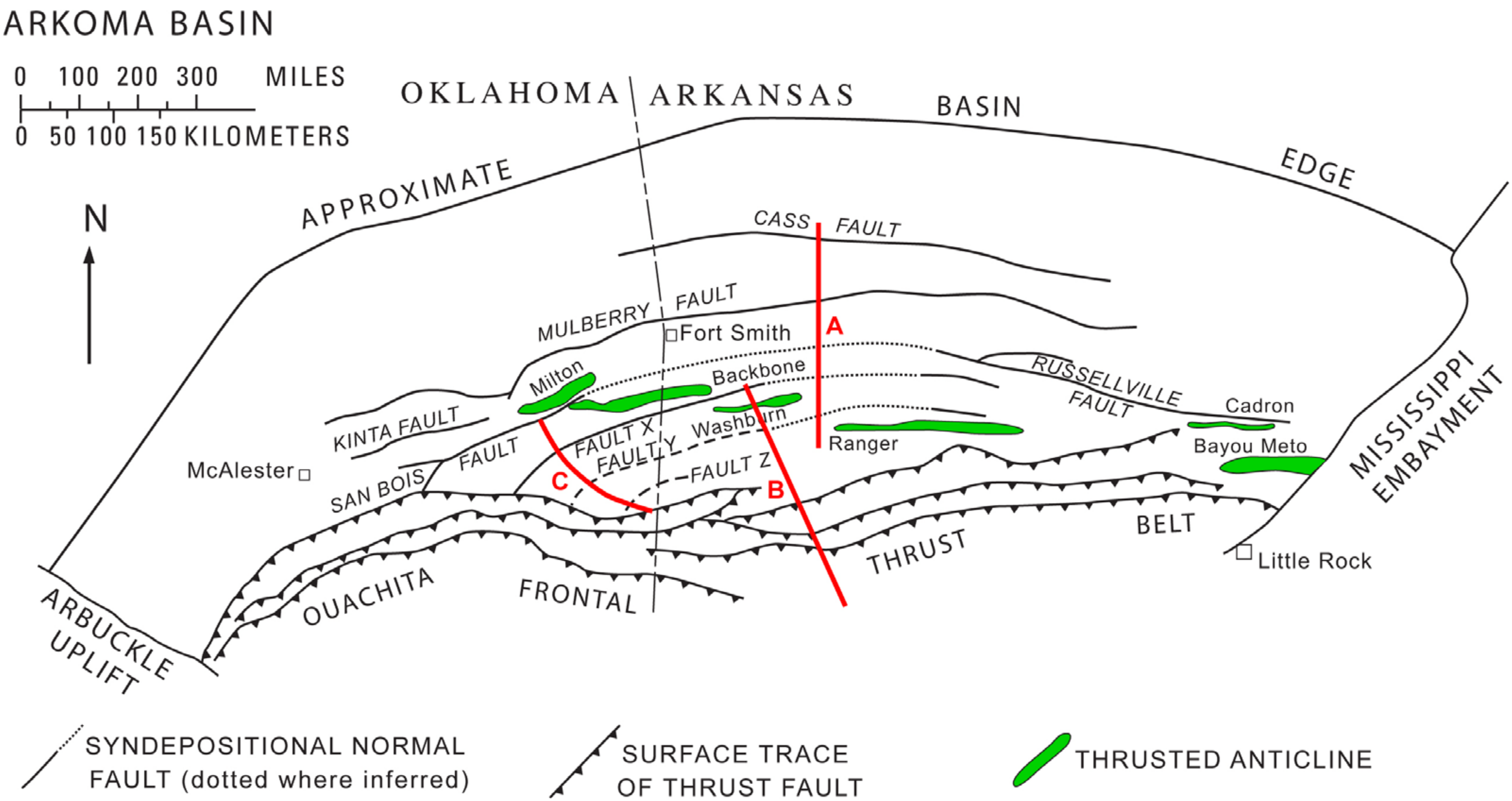
Houseknecht & McGilvery, 1990; Houseknecht & Spőtl, 1993; Spőtl et al., 1994, 1996, 2000

Arkoma-Ouachita Foredeep Continuous Assessment Unit – *Key Characteristics*

- **Vast, gas-saturated volume – strong stratigraphic component**
- **Reservoirs are mostly low P&P sandstone**
- **Little or no free water; no water legs; no "fossil" water legs**
- **Abnormal pressure common (over > under)**
- **Example fields: lower-middle Atoka reservoirs in Red Oak, Wilburton, Gragg, Witcherville, Booneville, Panola, Chismville, Waveland, Rich Mountain**
- **Sweet spots defined by channelized sandstone facies & local fracture-enhancement of permeability**
- **Production histories indicate vast & non-discrete accumulation volumes**
- **To be assessed as continuous, basin-centered accumulation with tight sandstone reservoirs**
- **Maturely explored *as conventional accumulations on structure***
- **Moderately developed as *continuous accumulation* – significant potential for reserve additions off structure**
- **Resource play!**

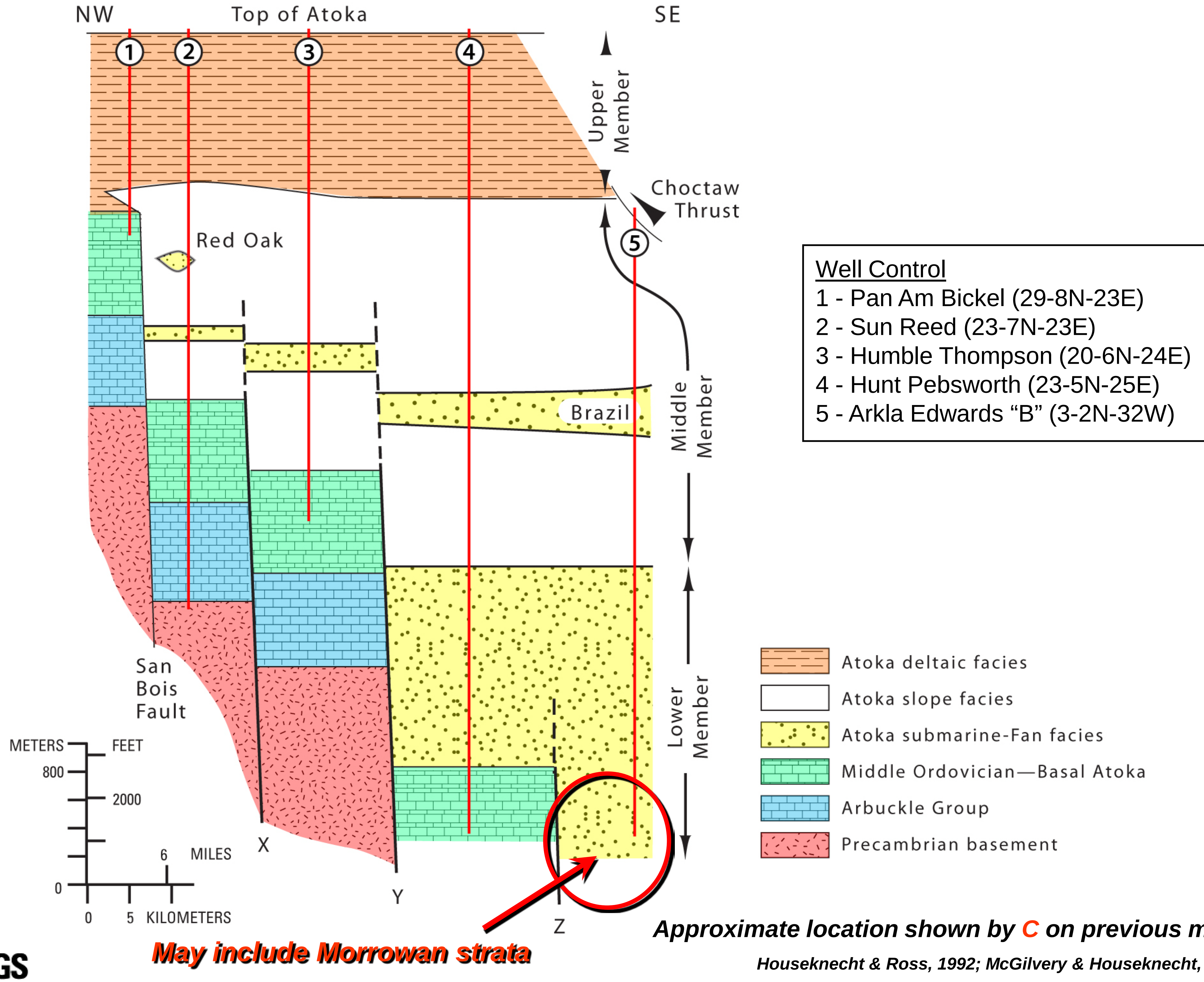
USGS

Arkoma Base Map – *Distribution of Major Growth Fault Systems*



Houseknecht, 1986; McGilvery & Houseknecht, 2000

Generalized Cross Section of Atokan "Growth Faults" in Oklahoma

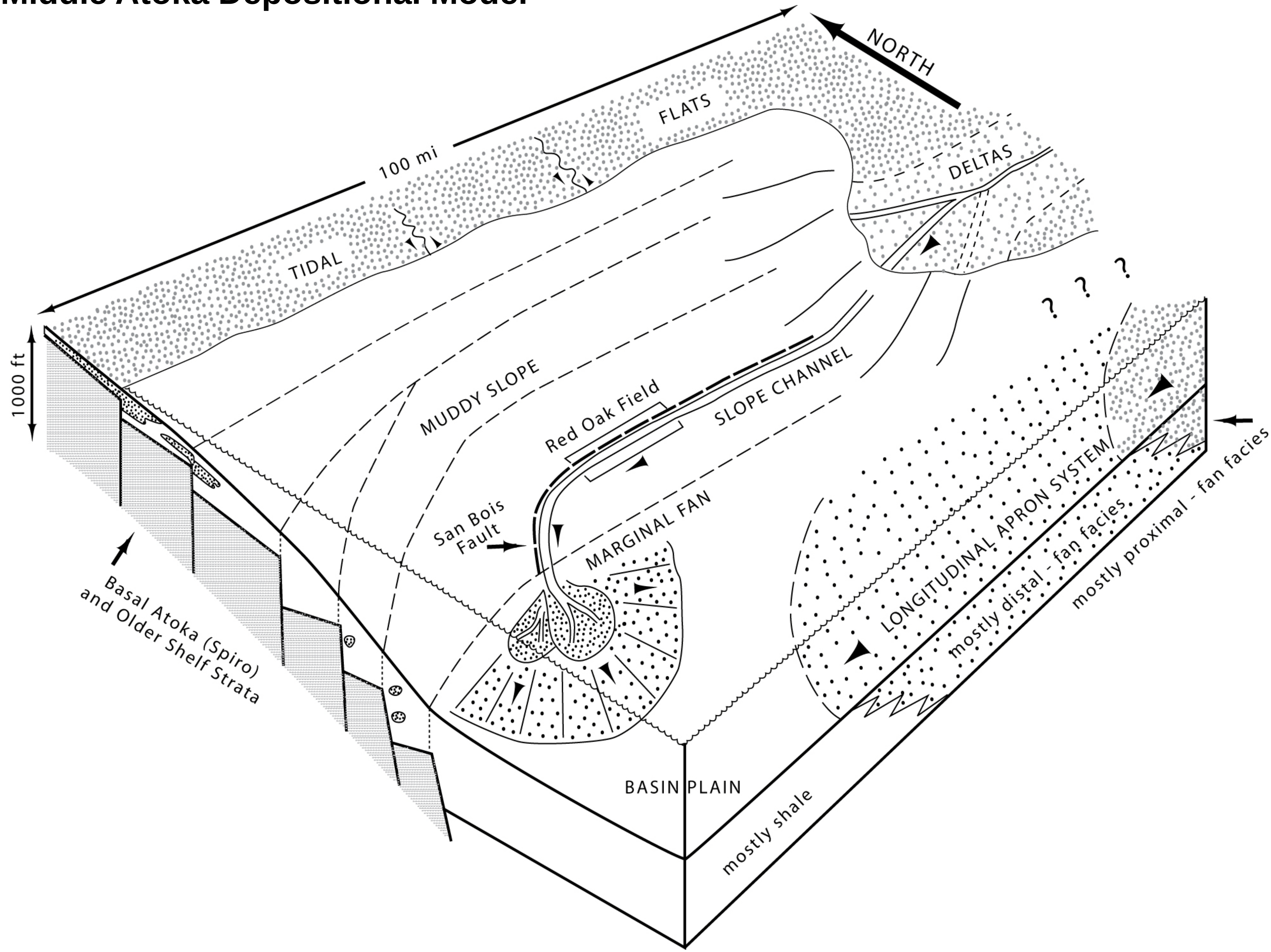


Approximate location shown by C on previous map.

Houseknecht & Ross, 1992; McGilvery & Houseknecht, 2000

USGS

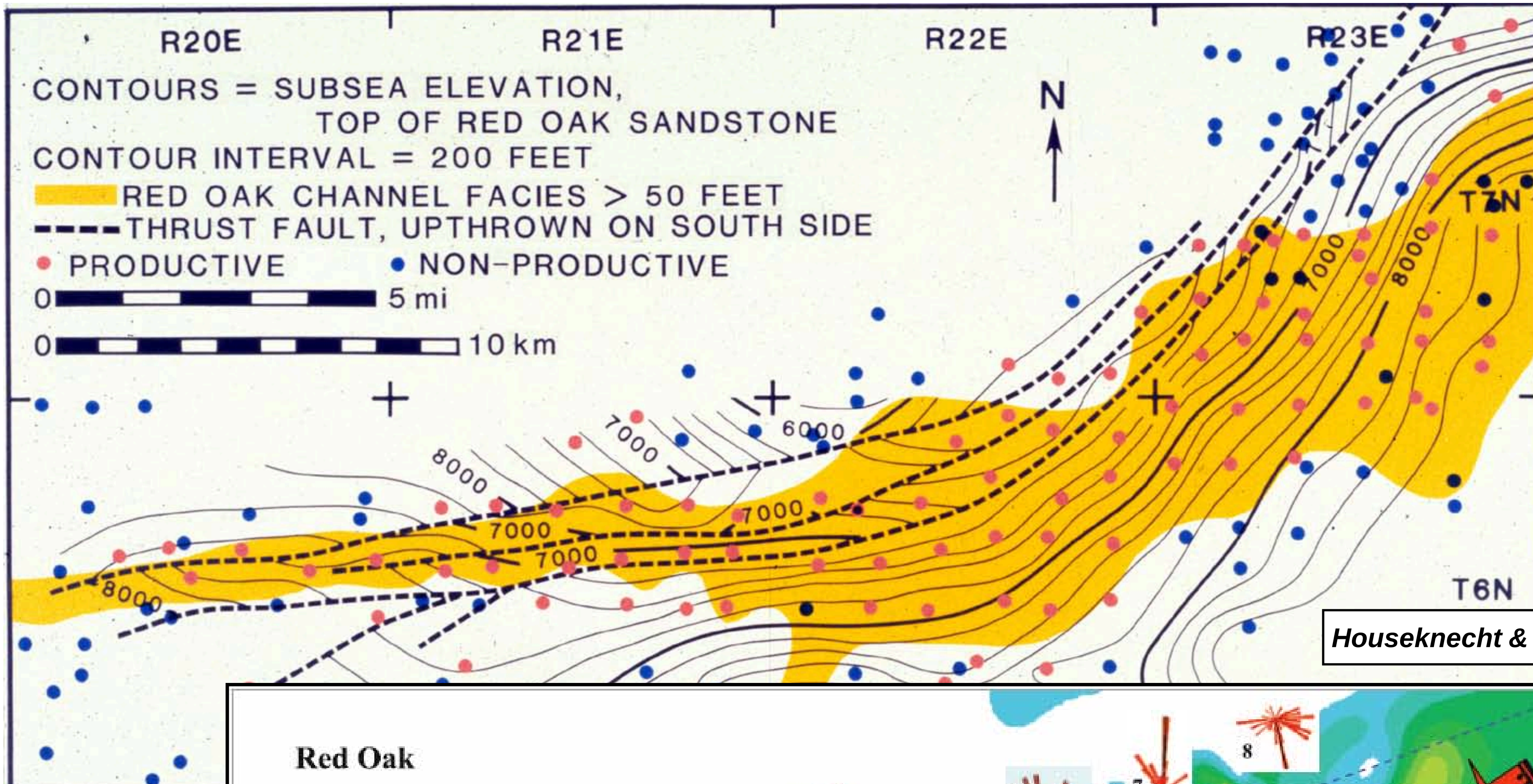
Middle Atoka Depositional Model



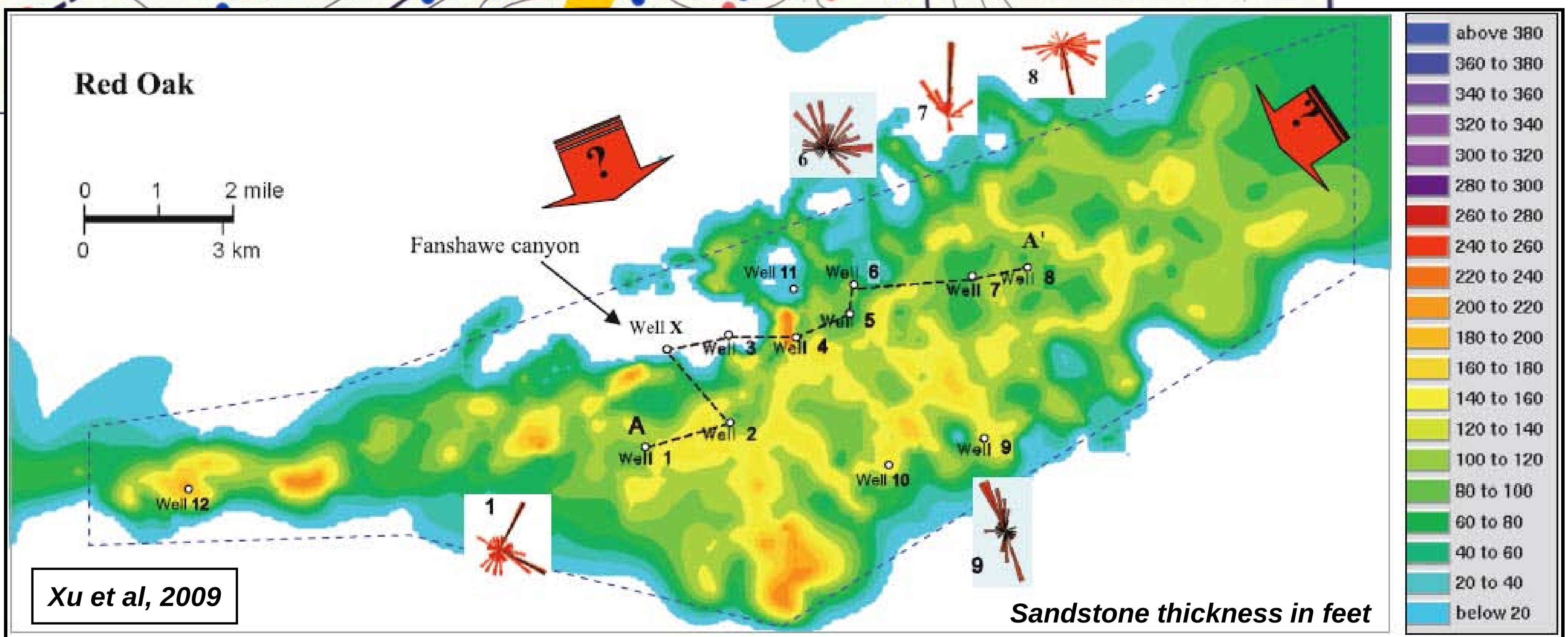
USGS

Houseknecht, 1986; McGilvery & Houseknecht, 2000

Red Oak Field – Red Oak Structure & Channelized Sandstone Facies



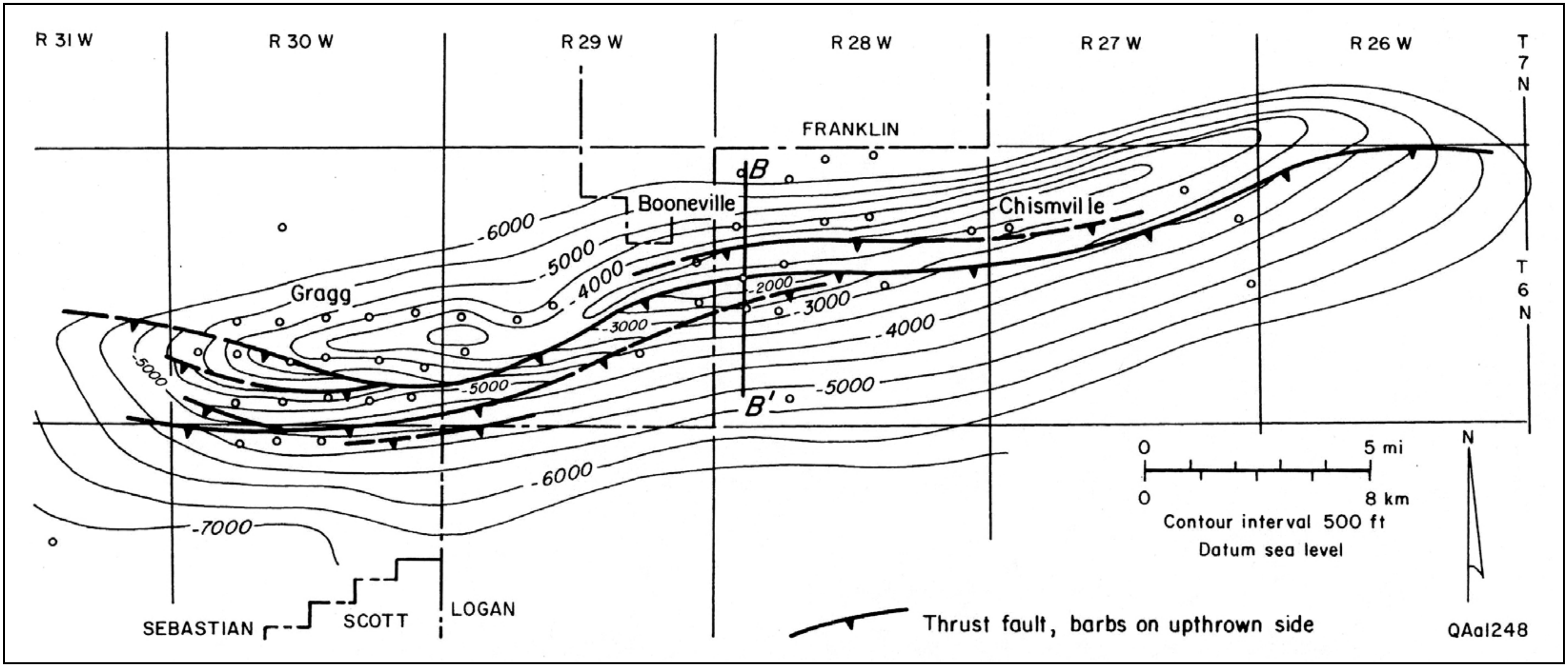
Houseknecht & McGilvery, 1990



Xu et al, 2009

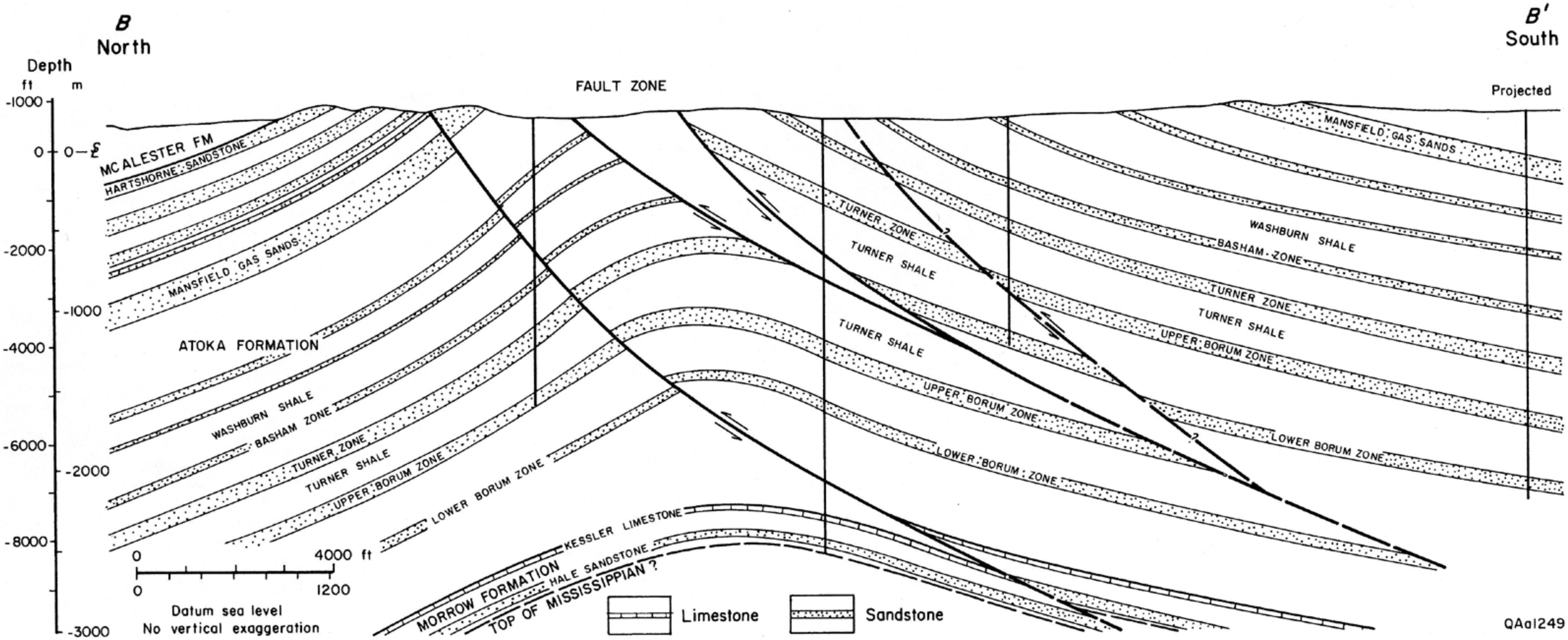
Sandstone thickness in feet

Washburn Anticline – *Structure Map, Top Upper Borum Sandstone*



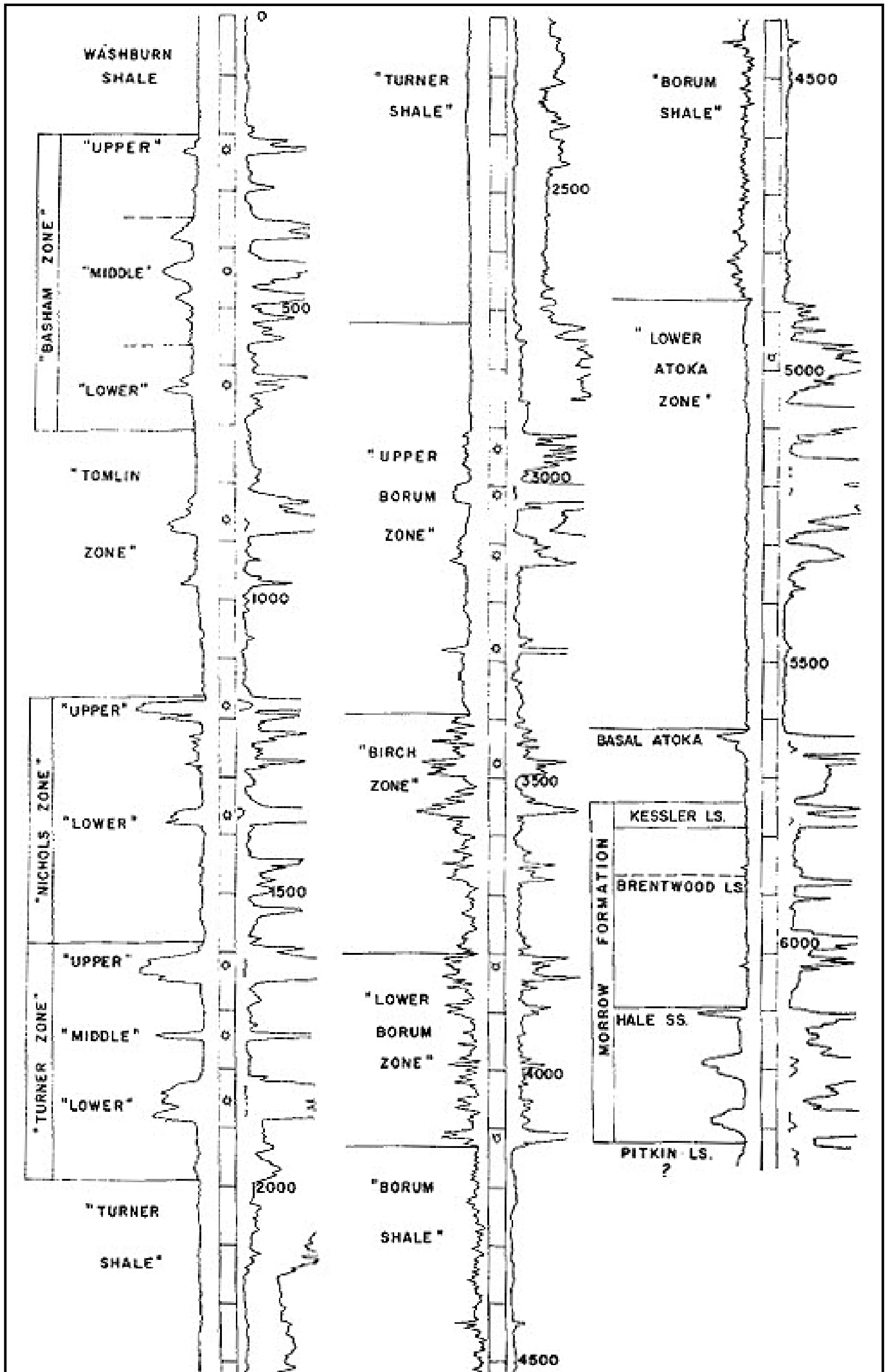
Gragg-Witcherville, Booneville, Chismville, Rich Mountain "fields"

Washburn Anticline – Cross Section

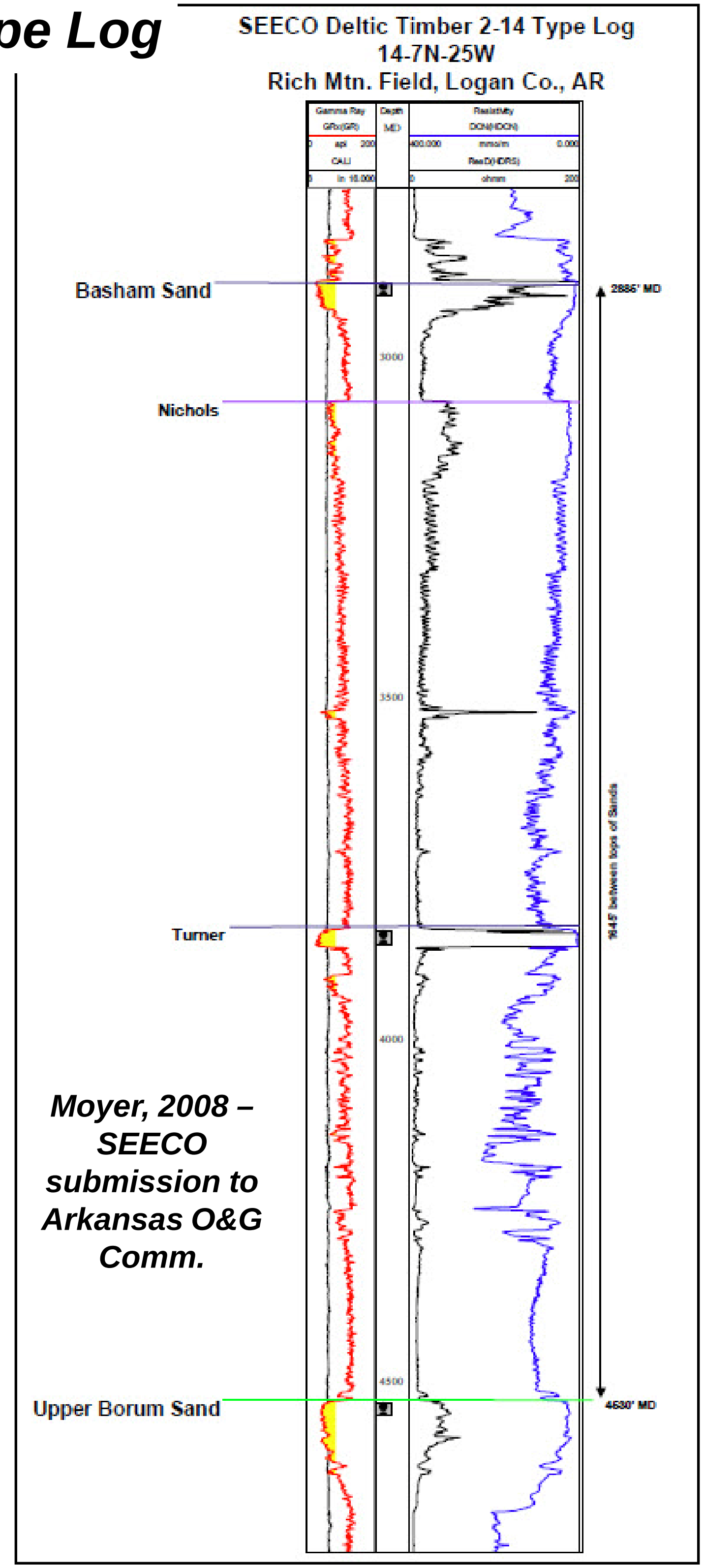


Brown & Woodward, 1993 from Bartlett, 1968

Washburn Anticline – *Composite Log & Rich Mtn. Type Log*



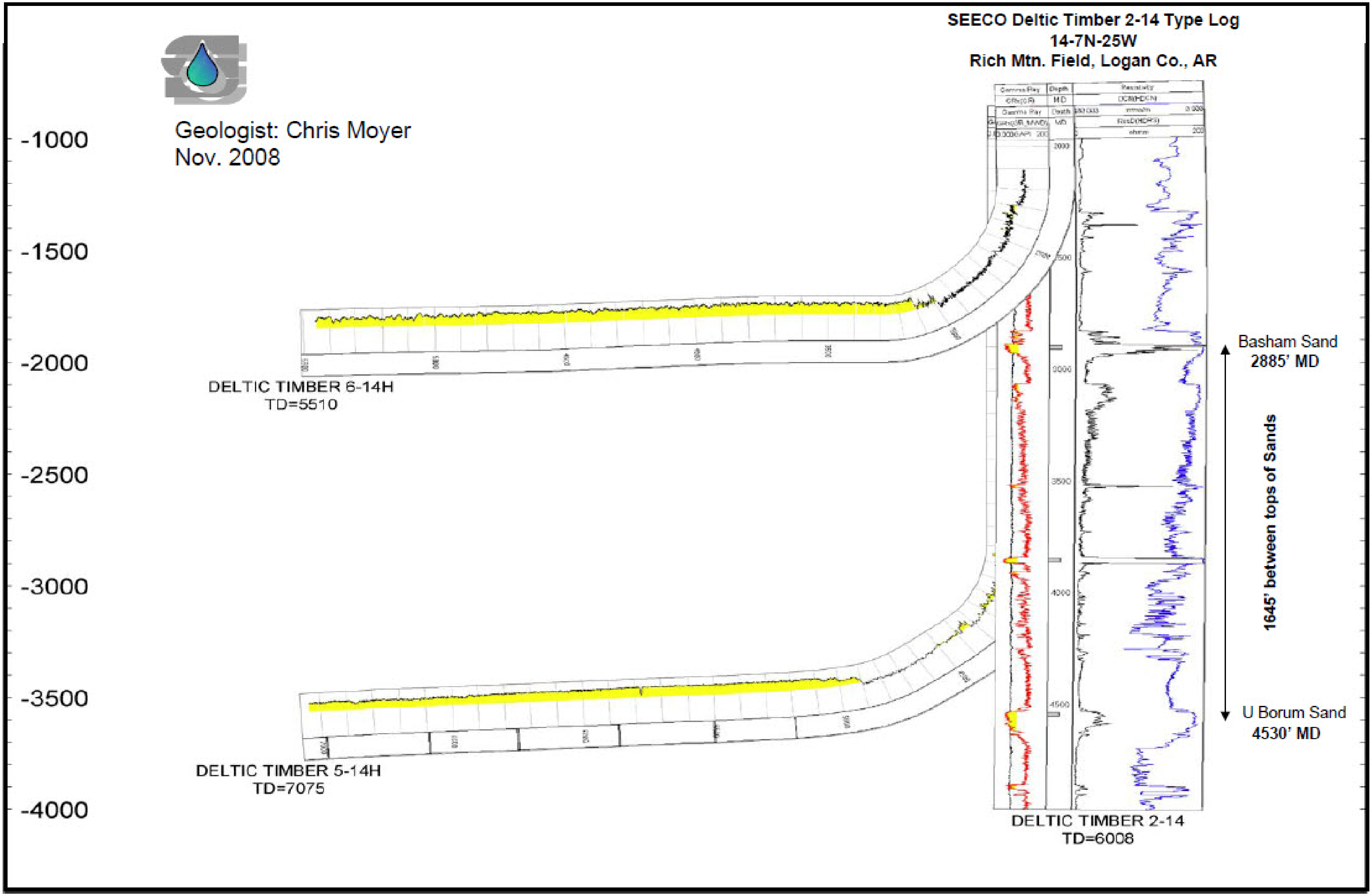
Bartlett, 1968



Moyer, 2008 – SEECO submission to Arkansas O&G Comm.

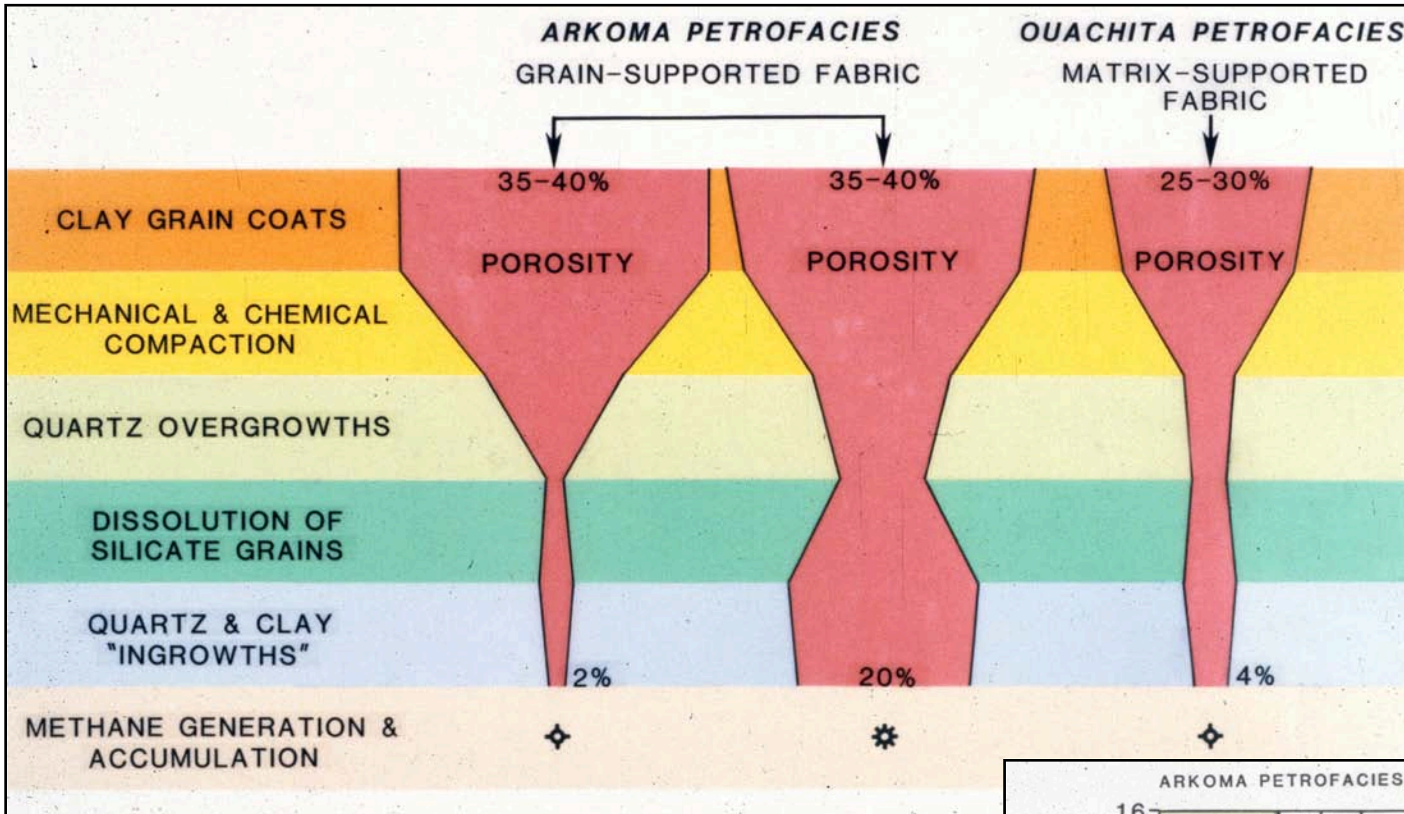
USGS

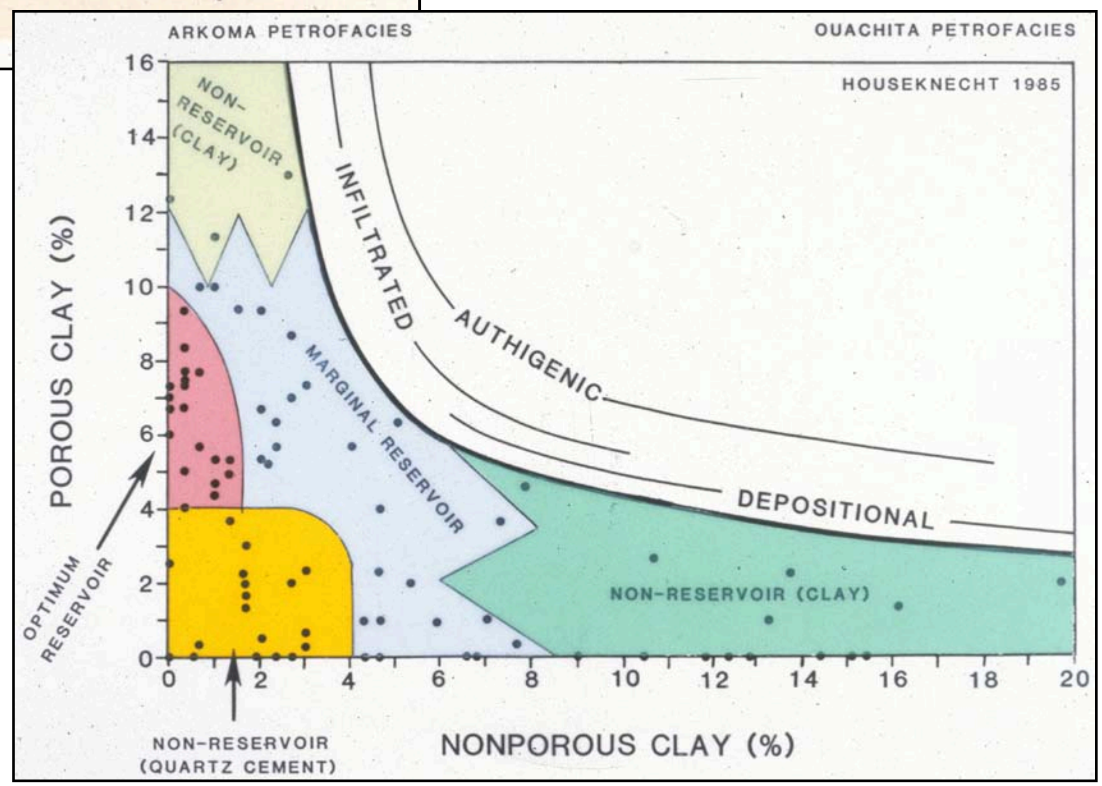
Rich Mountain Field – *Development of Continuous, Basin-Centered Gas with Tight Sandstone Reservoirs - Are Horizontal Well Completions the Future?*



From SEECO submission to Arkansas O&G Comm., Nov. 2008

Petrofacies and Reservoir Quality in Atoka Sandstones





The presence, volume, and distribution of clays – many emplaced during or immediately following deposition – significantly influenced diagenesis and represent a primary control of reservoir quality.

Houseknecht, 1987; Houseknecht & McGilvery, 1990; Houseknecht & Ross, 1992; McGilvery and Houseknecht, 2000

USGS