A Detailed Lithologic Analysis of a (Mississippian) Barnett Shale Core from the Northern Forth Worth basin Cooke Co., Texas

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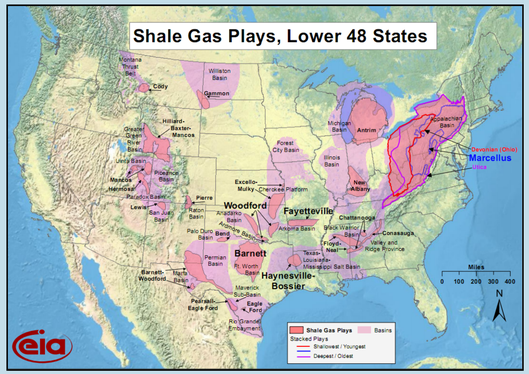
Abstract

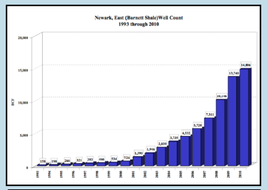
The Barnett Shale (Mississippian) in the Forth Worth basin is one of the most prolific unconventional gas plays in North America. Successful economic wells in this low permeability reservoir result from application of innovative drilling and completion techniques such as horizontal drilling and hydraulic fracturing. Until recently production has been mainly from areas of the basin that yield only dry gas. Declining gas prices have caused operators to shift exploration to areas of the basin that produce natural gas liquids and oil addition to gas. The organic-rich shale serves as the source, reservoir, and seal for the hydrocarbons. The conventional wisdom considers deep-water marine shales such as the Barnett to be homogeneous and lack lithologic variation. Understanding lithologic variation is an important key for locating hydrocarbon-rich areas (sweet spots) in the Barnett Shale and other shale gas reservoirs. Only a few detailed studies of Barnett Shale core describing lithology, diagenetic, and depositional histories are available in the public domain. All these work cores have also been from the gas generating window and there have been no such analyses of a Barnett core from the oil generating window available to the public. A clear understanding of the lithology and the sedimentological processes of the Barnett Shale in the oil-generating portion of the basin is necessary for efficient production of oil and gas from this typically tight homogeneous reservoir.

Introduction

Unconventional reservoirs containing both oil and/or gas are the center of attention in several basins all across the United States. It was the pioneering success of completion and drilling techniques (water fracturing and horizontal drilling) by Mitchell Energy and Devon Energy that paved the way for a world-class unconventional gas play, the Barnett Shale of the Forth Worth basin. In order to extract commercial liquids from a tight (low permeability and porosity) formation , understanding the diagenetic and depositional history of this unconventional reservoir in the oil generating window is imperative. Recent activity suggest companies are targeting shale reservoirs in the oil generating window from the Barnett Shale with success. It will be necessary for detailed studies of core taken from the oil generating window and the insight gained will be important to the Fort Worth basin and other basins alike. Improved understanding of the lithology, diagenetic and depositional history of the Barnett will be the essential for the exploitation of oil and gas from this petroleum rich source rock (Breyer et al., In Press).



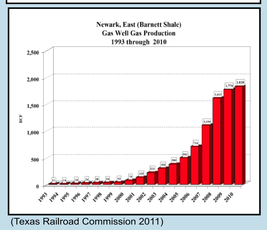
• The figure above demonstrates and overview of shale-gas plays in the United States. The Barnett shale is currently one of the most active plays in the United States



• As of March 7, 2011 there has been 14,886 wells producing from the Barnett Shale

• Currently there are a total of 247 operators in the Newark East (Barnett Shale) field

• Since hydraulic fracturing and horizontal drilling the number of wells drilled in the Barnett Shale have increased tremendously



(Texas Railroad Commission 2011)

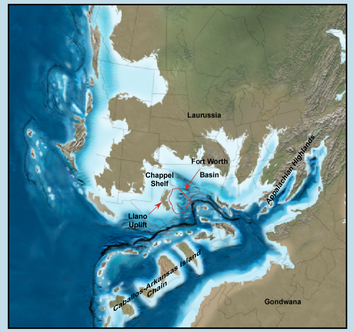
• Discovered by George Mitchell in 1981, the Newark East Field is the largest gas field in the United States

• Since 1993, 7 TCF (trillion cubic feet) of natural gas has been discovered

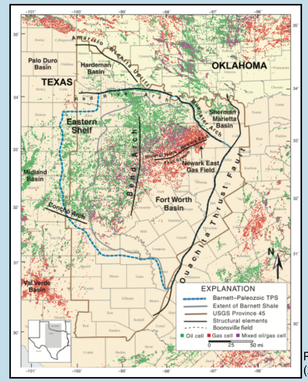
• Created opportunity and interest for developing oil and gas from similar type unconventional reservoirs

Geographic and Geologic Setting

The Fort Worth basin, located in North-Central Texas, is a north-south elongated basin covering approximately 15,000 mi^2 (Montgomery et al., 2005). The basin is limited structurally to the West by the Bend Arch, to the south by the Llano uplift, to the east by the Ouachita thrust belt, and to the north by the Red River and Muenster arches (Reference). The Llano uplift is a circular domal structure exposing Precambrian and Paleozoic rocks (Pollastro et al. 2007). The axis of the Fort Worth basin is oriented parallel to the Muenster arch and bends south to parallel to the Quachita structural front (Jarvie et al., 2007). The Fort Worth basin is wedged shaped where it thickens and deepens to the northeast where the Barnett juxtaposes against the Muenster arch and reaches a maximum thickness of 12,000 feet (Montgomery et al., 2005). Westward, the Fort Worth basin thins and shallows against the Bend arch (Pollastro et., 2005).



• Regional paleographic map of the southern mid continent during the late Mississippian. The Fort Worth Basin is outlined in red. (Blakey 2010)



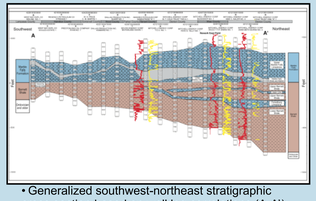
• USGS map of the Fort Worth Basin with major structural features pertaining to the Barnett Shale

• Oil and gas distribution throughout the Fort Worth Basin indicated by the green and red cells.

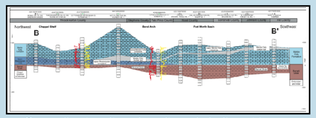
• The extent of the Barnett Shale is outlined in gray and the total petroleum system is outlined with blue dashes

Pollastro et al. (2007)

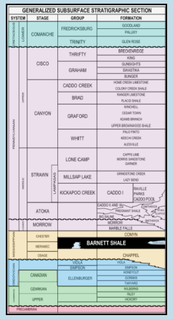
Stratigraphic and Structural Elements



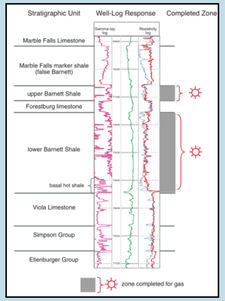
• Generalized southwest-northeast stratigraphic cross section based on well log correlations (A-A')



• Generalized northeast-southwest stratigraphic cross section based on well log correlations (B-B')



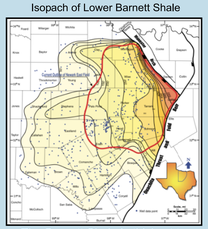
Stratigraphic Column of the Fort Worth Basin (Modified from Pollastro 2007)



• Type well log and stratigraphic section with gamma ray and resistivity log curves

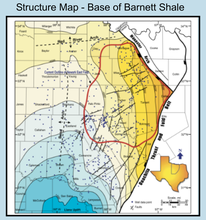
•The Barnett can be recognized by a high gamma ray and high resitivity values

Isopach of Lower Barnett Shale



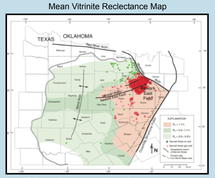
• The Barnett Shale is thickest to the northeast towards the Muenster arch and Ouachita thrust and fold belt (CI=50 ft)

Structure Map - Base of Barnett Shale



• The Barnett Shale is shallowest in the southwest and deepest in the northeast towards the Muenster Arch and Ouachita thrust and fold belt (CI=1000 ft)

Mean Vitrinite Reclectance Map

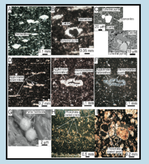


• Oil and gas production can be determined from the Barnett Shale in the Fort Worth Basin from vitrinite reflectance (R_o).

• R_o values are indicative of thermal maturity and establish oil and gas windows.

Previous Work

- Loucks and Ruppel - Defined three different facies from four cored samples
  1. Laminated Siliceous Mudstone
  2. Laminated Argillaceous Mudstone
  3. Skeletal Argillaceous Mudstone
- Papizis - Recognized and defined five different lithologies
  1. Black shale
  2. Silt rich black shale
  3. Coarse-grain accumulations
  4. Calcite-rich mudrock grading into limestone
  5. Concretions
- Hickey and Henk - Recognized six lithofacies based on thin section interpretation
  1. Organic rich shale with micopeloidal texture
  2. Fossiliferous shale
  3. Phosphatic shale
  4. Dolomite rhomb shale
  5. Dolomitic shale
  6. Concretionary carbonate
- Slatt, Singh, and Coffey - Constructed a detailed stratigraphic analyses and identified nine lithofacies
  1. Siliceous non-calcareous mudstone
  2. Siliceous calcareous mudstone
  3. Micritic/Limy mudstone
  4. Bottom current laminae deposit
  5. Fossiliferous deposit
  6. Silty-shaly interbedded depost
  7. Phosphatic deposit
  8. Dolomitic mudstones
  9. Concretions



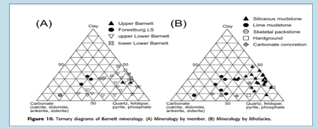


Figure 19. Ternary diagrams of Barnett mineralogy. (A) Mineralogy by member. (B) Mineralogy by lithofacies.

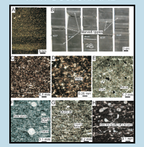
Objectives

A detailed analysis of a Barnett core extracted from the oil generating window of the Fort Worth Basin will be conducted. The core is provided to TCU by EOG from a well near the Muenster Arch in Cooke Co. Texas. The core is 772 feet in length and is the lower interval (below the Forestburg Limestone) of the Barnett. Analytical and quantitative methods of study will be used to define the depositional and diagenetic history of the Barnett Shale in the northern part of the basin. The structural framework and a reservoir model will also be defined to help understand oil production from this petroleum rich unconventional reservoir.

Barnett Shale Core

• Macroscopic description of core will note color, grain size, sedimentary structures, diagenetic features and fractures

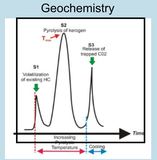
Thin Section/XRD



• Modal analysis of thin sections will provide quantitative data on composition and grain size

• Selected samples will undergo XRD analysis to determine clay mineralogy

Geochemistry



• Rock Eval Pyrolysis will determine total orgainc carbon, source rock type, maturity, and quality

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