

# THE LEWIS SHALE, SAN JUAN BASIN: APPROACHES TO ROCKY MOUNTAIN TIGHT SHALE GAS PLAYS

## BOTTOM LINE

As production from conventional reservoirs in the continental U.S. is decreasing, gas from the Lewis and similar unconventional reservoirs will become increasingly important for future gas supply. Significant Lewis Shale gas reserves may be commercially accessible in old and new wells within the San Juan Basin. Key features for successful development and exploitation include lithofacies (coarser-grained, quartz-rich intervals are best), presence of natural macro- and micro-fractures, number of treatments, type of stimulation, and optimal completion techniques.

## KEY WORDS:

Lewis Shale  
San Juan Basin  
Natural Fractures  
Frac Treatment  
Completion  
Technique

## PROBLEM ADDRESSED

The Lewis Shale can be successfully completed in a large number of old wells in the San Juan Basin where significant tight gas reserves remain. Completions in the Navajo City and First and Second Otero intervals of the Lewis Shale have a good track record in this basin. Characterization of reservoir properties can be integrated with reservoir simulation and hydraulic fracture models to high grade the Lewis, both regionally and within the nearly 1,500 ft thick vertical column. Although an optimal completion technique is still being developed for the Lewis, more than one stage of frac treatment is currently cost prohibitive and may be ineffective. Water-based stimulation fluids and frac fluid retention within the formation reduces relative permeability to gas and should be minimized. A type-curve model provides a practical and simple method to evaluate Lewis Shale reserves.

## TECHNOLOGY OVERVIEW

Historically, most San Juan Basin production has been from naturally fractured, low permeability, Cretaceous sandstones such as the Dakota, Mesaverde and the Pictured Cliffs, or from the Fruitland Coal. In the past the Lewis was completed only in the few wells where

large Lewis flow rates were encountered while air drilling for deeper targets. Prior to 1990 the Lewis was not a completion target. However, the Lewis is accessible between the Mesaverde and the Pictured Cliffs formations in thousands of existing wells across the San Juan Basin. A Burlington Resources study has shown that the Lewis has commercial gas potential throughout much of the San Juan Basin and could be completed in many new and existing wells. The New Mexico Oil Conservation Division has included the Lewis Shale within the Mesaverde pool definitions, which should simplify the regulatory issues when completing Lewis wells.

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### SPEAKERS:

*Geological & Production Features of Lewis Shale*  
S.R. Bereskin, Tesseract Corporation

*Reservoir Characteristics of Lewis Shale*  
H. Dube, Burlington Resources

*Reservoir Characterization and Log Model Development*  
G. Christiansen, Burlington Resources

*Evaluating Fractured Gas Shale*  
J. Frantz, Schlumberger Holditch-Reservoir Technologies

**Lewis Characterization.** The Lewis Shale is a 1,000 to 1,500 ft thick, layered reservoir composed of shale, siltstone, and minor sandstone that should be considered for completion and production purposes as a sandy siltstone rather than true shale. It was deposited during the final transgressive-regressive cycle of the Cretaceous Interior Sea. The Lewis is composed of four members that include, from top to bottom, the

Ute, Navajo City, First bench of the Otero, and Second Bench of the Otero. Generally mudstone and laminated sandstone comprise most of the Ute and Navajo City intervals, while bioturbated and laminated sandstone comprise most of the Otero intervals.

Average matrix porosity and permeability are 1.72% and 0.0001 md respectively. Low matrix permeability therefore requires natural fractures and stimulation to make a well economical. Water saturation ranges from 20% to 100%. Storage capacity for the Lewis interval is approximately 22 bcf per 160 acres. Adsorptive capacity ranges from 13-38 scf/ton. Total organic carbon (0.45-1.59 wt. %) is relatively low compared to other shale gas reservoirs. The Lewis is sub-normally pressured at 0.22 psi/ft, which is similar to pressures observed in the Mesaverde. Within the San Juan Basin the coarser-grained, quartz-rich intervals comprise most of the play. These intervals are also the most prone to natural fractures, particularly in laminated sequences. Thus, matrix quality appears to be important relative to economic production.

Most of the Lewis Shale appears to contain some natural microfractures-although occurrence of macro-scale natural fractures is limited. Fractures are typically vertically isolated and steeply dipping with a dominant fracture set striking along a north-northeast azimuth, and an infrequent sub-perpendicular set. Both larger conventional macrofractures and microfractures within the matrix are present within the Lewis. Fractures tend to have limited vertical extent, and truncate at subtle lithologic boundaries. The degree of connection between the microfractures is poorly understood, but certainly must increase bulk permeability. Both the layered and fractured nature of the Lewis is reflected by substantial vertical and lateral variation of permeability and reservoir pressure.

Reservoir characteristics of the Lewis Shale are analogous to many mud-rich intervals throughout the world. Therefore, many previously overlooked intervals may have commercial potential, particularly if these formations already exist "behind pipe." The Lewis is intermediate between hydrocarbon-bearing shales and "tight" gas sands.

**Optimizing Lewis Completions.** The optimal stimulation procedure for the Lewis is still being developed. It is suspected that fluid type and number of stages

are the most important factors. At this time nitrogen foam/linear gel is considered the optimal stimulation fluid. During 2000 there was a \$25-35K cost difference between one-stage and two-stage treatments. It is possible that one-stage treatments could show comparable results to two-stage treatments. It is likely that the hydraulic fracture propagates down the natural fractures once they intersect. Larger stimulation treatments may not benefit production depending on the natural fracture anisotropy and the fracture fluid retention in the natural fractures. However, long-term production will ultimately determine the optimal number of stages. Sub-normal pressure within the Lewis should also be considered when designing hydraulic fracture stimulation.

At this time (February 2001), Burlington Resources offers the following completion practices:

- **Perforations should be concentrated in the quartz-rich intervals**, which have the best reservoir storage potential and are the most prone to natural fractures.
- **Perforating method:** 10 ft. intervals at 1 shot/ft, or 1 shot/2 ft; five to six 10 ft perforated intervals per fracture stage to reduce multiple fracture generation as much as possible, while still treating the entire interval.
- **Perforation breakdown methods:** Bridge plug & packer; isolating 10 ft to 20 ft perforations per setting improves the chance that all intended intervals will be treated.
- **Number of stages:** 2 stages have the greatest chance of treating the entire (600-900 ft) intended treatment interval.
- **Fluid type:** 75-80 quality nitrogen foam/20# linear gel minimizes the amount of fluid put into the formation. This reduces the amount of liquid that can imbibe into the natural fracture system, which may reduce the relative permeability to gas.
- **Sand volume:** 80-100K lbs. per stage for a 2 stage treatment. Pumping additional sand may have little effect.
- **Pad volume:** 5K gals (10%) 80 quality nitrogen foam/20# linear gel per 100K lb sand stage. Due to water retention observed in the Lewis, pad volumes should be minimized to keep as much water out of the formation as possible.
- **Sand laden treatment volume:** 45K gals 75 quality nitrogen foam/20# linear gel per 100K lb sand stage - following 5K gals pad, pump 10K gals with 1 ppg,

15K gals with 2 ppg, and 20K gals with 3 ppg.

- **Flowback:** 24hr-48hr flowback per stage, increase choke based on time rather than pressure. Within an hour after the treatment is pumped, start flow-back on a 10/64 choke and increase every 2-3 hours up to a 32/64-in choke over a 24-hour period. The goal is to remove the maximum amount of stimulation fluid from the reservoir in the shortest period of time.

**Estimating Reserves.** Incremental analysis is necessary to determine production rate and estimated ultimate recovery. Existing production data indicates that T30N-R8W, T30N-R7W, T30N-R6W, T29N-R7W, and T29N-R6W are the better areas tested to date (late 2000). For these areas the average Lewis production rate will vary between 100-130 Mscfd with average estimated ultimate recoveries between 300-500 MMscf. Total storage capacity for the Lewis in this fairway is 24 tcf and this value will increase as the play area is expanded.

Hyperbolic decline of the Lewis was not considered when estimating ultimate recovery and production rate from the spinner survey wells. Using incremental decline curve analysis for estimated ultimate recovery is preferred over using the spinner survey data. However, estimated ultimate recovery from incremental decline curve analysis contains uncertainty due to the large variation in initial hyperbolic decline and "n" exponent (hyperbolic constant), and the inherent uncertainty of the base forecast. A Microsoft Excel™/Access™-based type curve model was developed and provides a practical and simple method to

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evaluate Lewis Shale reserves.

**Future Work.** To better understand the Lewis resource and to maximize profitability associated with its continued development, the following areas of future work are suggested:

- Perform additional desorption analysis to confirm adsorption isotherms
- Perform additional production testing to quantify recoverable resources
- Acquire additional geoscience input to identify naturally fractured areas
- Continue to improve completion methods to increase recovery factors.

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