The Pennsylvanian Gothic Shale Gas Resource Play of the Paradox Basin

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The Gothic Shale represents the maximum flooding surface for the third cycle of the Paradox Member of the Pennsylvanian Hermosa Formation and is found across the entire Paradox Basin. The thickest Gothic Shale section is located in the southeastern portion of the basin and appears to be the associated prodelta of the Silverton Delta. At the distal and central portions of the prodelta, elevated carbonate percentages are observed in the shale from XRD data where the marine environment (Type II kerogen) dominates the lithology. Observed full core from the proximal side of the prodelta contains increased silica content, humic matter and woody-plant fragments as expected in addition to the carbonate presence (Type II & III kerogen mix). All of the horizontal wells are located on the distal portion of the prodelta. The prodelta is the target area for the Gothic Gas Shale Play.

The steep learning curve associated with completing the Gothic Shale began with small hydraulic fracture stimulations and has led to the larger type frac treatments currently being pumped in other shale plays. The complication with brine flowback, generated by the presence of salt in and below the shale, has caused interruptions in gas flow by plugging the tubing and increasing the bottom hole flowing pressures. These issues have been solved with modifications to normal production practices.

Good gas content, acceptable TOC, extremely brittle rock and an overpressured reservoir in the Gothic Shale have contributed to the excellent development of system permeability created by the completion. Production rates have ranged from 1.5 to 4.9 MMCF/D with some associated condensate and the current cumulative production is 1.16 BCF. As observed with other successful gas shales, the proper completion is the key. A small frac treatment on a tight rock yields a small gas well. In contrast, the larger the frac treatment, the shallower the decline curve, the larger the reserves.

Achieving the maximum surface area at the lowest cost will eventually make the play commercial. Calculating and adjusting the following elements for a slickwater frac treatment to take advantage of the particular attributes for a given shale are as follows: length of lateral, number of stages, injection pump rate, volume of treatment, sieve size and volume of proppant used, proppant concentrations, number of sweeps and the flowback rate.

The thermal maturity of the Gothic Shale increases from the southwest, in the oil window, to the northeast portions of the basin where dry gas is present. This is clearly observed on regional Hydrogen Index and Production Index maps compiled from various vintages of Rock-Eval data. TOC corresponds to this trend and decreases towards the more mature northeast portions of the basin as more organic material has converted to gas. All of the anomalously thick Gothic Shale prodelta deposition is located in the gas window.

Natural fractures in the Gothic Shale play a large part in the deliverability of the natural gas. From image log interpretation, these near vertical fractures are healed, partially healed and open. The presence of all of these fractures provide zones of weakness for the fracture stimulation to gain rapid access to the shale and contribute to the complex network of rubblization needed to maximize surface area to yield maximum gas production. A fairly consistent averaged density of natural fractures is observed spanning twelve miles from four wells where image logs were run in the lateral section.

These wells have averaged 5.6 to 7.2 feet per natural fracture but, numerous “sweet spots” of natural fracture clusters are present.

Post depositional movement of Pennsylvanian Paradox Salt below the Gothic Shale may be the cause of the natural fractures. Most of the target area is located on an anticlinorium consisting of the Dolores and Dove Creek anticlines. These structures are not basement derived but are controlled by increased salt thickness and may actually be failed diapirs with salt movement occurring at the end of the Pennsylvanian into Early Permian time.

The Mass Spectrometer has been used on all of the horizontal wells in this project to direct the placement of completion stages by using various ratios of light-end vs. heavier-end gases to indentify “like rock” compartments. This is an attempt to avoid not stimulating portions of the lateral due to varying permeability or brittleness caused by variable natural fracture density.

To date, four vertical science wells have been drilled with full core in the Gothic Shale. Core evaluation included canister gas samples (sorbed gas data) and a complete CoreLab evaluation as used in the Gas Shale Core Consortium. The Schlumberger FMI, Sonic Scanner, ECS ELAN, Well Montage Shale Gas Evaluation and Triple Combo logs and a mudlog were also used for the evaluation of the Gothic Shale.

Nine horizontal wells have been completed with mud logs, mass spectrometer, radio active tracers for the perforations and chemical tracers with the treatment to monitor flowback water. Natural gas from heal to toe has been observed in every well and every well has recorded relatively high production rates. Microseismic has been conducted on five of the wells. All of the horizontal wells have been drilled on two 3D seismic surveys of approximately twenty squares each.

Currently this project is in the phase of determining the correct set of stimulation variables that all gas shale plays experience. With four years invested in the Pennsylvanian Gothic Shale Gas Resource Play, perseverance has been key to this point and will be critical to reach the goal of commercial viability.