A SYMPOSIUM OF

OIL & GAS FIELDS

THE ROSWELL GEOLOGICAL SOCIETY

1950

OF

SOUTHEASTERN NEW MEXICO

1995

Reservoir Characteristics and Petrophysical Analysis of the Upper Brushy Canyon Sandstones, East Livingston Ridge Delaware Field Lea County, New Mexico

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INTRODUCTION

The East Livingston Ridge Delaware field is located in extreme west central Lea County, New Mexico. The field is currently wholly contained within sections 9, 15, 16, 21 and 22 of township 22 south and range 32 east (figure 1). This field is approximately 3 miles due east of the prolific Delaware reservoirs of the Livingston Ridge field in Eddy County, New Mexico. Production is from lower Guadalupian Brushy Canyon formation of the Delaware Mountain Group. Strata Production and Yates Petroleum are the major operators in the East Livingston Ridge Delaware field.

The first well in the East Livingston Ridge area was drilled in 1954. The Union Oil of California #1 Gilmore in Section 21 reached a TD of 8770' and was abandoned as a dry hole. A DST was attempted in the Upper Brushy Canyon but failed as a result of stuck drill pipe. John Trigg drilled the #1-22 Federal-Red Tank Unit in 1964 to a TD of 7313'. Several cores were taken in the Upper Brushy Canyon, however, there were not any shows reported and the well was declared D&A. The first productive well in the area was the Mercury Exploration #1 Connally Federal in Section 15. This well is currently classified as a gas well and production is from Pennsylvanian.

Oil production from the Brushy Canyon formation was first established in East Livingston Ridge Delaware Field in January of 1992 with the completion of the Strata Production #1 Cercion Federal in Section 21. The field now contains 23 producing wells. As of September 1994, cumulative production was 885 MBO, 865 MMCFG. The 1994 production totaled 124 MBO and 194 MMCFG.

The main pay in the East Livingston Ridge Delaware Field is the Upper Brushy Canyon "D" sand. The name for this interval is informal, as used by Strata Production. Other operators in the field may or may not use this nomenclature.

GEOLOGIC SETTING

Regional Geology

The Delaware Basin is a broad, asymmetrical, block-faulted basin that developed as a separate structural depression in the late Paleozoic and contains approximately 40,000 cubic miles of sediment within an area of more than 13,000 square miles (Hills, 1984). Epeirogenisis along preexisting lines of weakness during early Pennsylvanian resulted in the formation of the Central Basin Platform. The formation of this structural positive divided the Tobosa Basin into the relatively shallow Midland Basin and the deeper Delaware Basin (Hills, 1984). Late Mississippian-early Pennsylvanian block faulting resulted in the present structural outline of the Delaware Basin (Payne, 1973, 1976). Tertiary age tectonism uplifted the western side of the basin and resulted in a gentle eastern tilt. This rotational tilting combined with the updip evaporite seals provided the necessary trapping mechanisms for many of the Delaware Basin oil fields. Most of the sediment filling the basin during the Guadalupian was probably from older reworked sediments on the shelf. During Guadalupian time, the basin was tectonically quiescent with no uplifting occurring; however, continued subsidence allowed the basin to fill as fast as it subsided (Hills, 1984). Water depths may have reached 1800 feet by late Guadalupian (Harms, 1974).

Cyclicity was a major factor in the deposition of the Brushy Canyon. This is evidenced by the interbedded organic rich siltstones, or "shales," and very fine clastics. Changes in relative sea level was the most likely control on cyclicity. Massive carbonate buildups along the margins of the basin during high stands of sea level created a sediment-starved condition in the distal parts of the basin by trapping sediment on the shelf. Pelagic sedimentation was the prevalent type of deposition during these periods of sediment deprivation. Low stands of sea level allowed the influx of clastics from the shelf (sediment bypassing) throughout the basin and deposition of the vast sandstone and siltstone units.

in order to operate properly. Pre-processed dipmeter data could also be used for the same purpose, but the raw data would be difficult to interpret in the field.

Quantitative log analysis in the Brushy Canyon (the entire Delaware Mountain group for that matter) has, by some operators' accounts, been tenuous at best. The fine grain size, residual oil saturations and authigenic clays can, in varying degrees, contribute to the difficulty in evaluating well logs run in the Brushy Canyon. The fact that the Brushy Canyon reservoirs are transitional type reservoirs, without distinguishable "oil-water" contacts, adds to the interpretative difficulties.

Log analysis in the Brushy Canyon should be based on qualitative rather than quantitative methods. The analysis should combine all aspects of formation evaluation, such as mud log shows, shows in rotary sidewall cores and wireline log analysis. If all of the methods listed do not agree (i.e., zone is productive or nonproductive), then the anomaly should be scrutinized more closely. Traditional shaly sand analysis is not necessary by virtue of the low volume of clay. The main purpose of shaly sand analysis is to correct the water saturation down to a more "respectable" value by attempting to take into account the bound (lattice-held) water in clay. This would work fine if one can get an accurate measurement of the bound waters contained in the reservoir rock. Unfortunately, these numbers can only be obtained indirectly(with questionable accuracy) using wireline methods. Rocks that contain much larger amounts of clay than above are not classified as reservoir because of the low permeabilities.

Water saturations in the Brushy Canyon reservoirs typically can exceed 60% and still be productive. High water cuts associated with these reservoirs are the rule with very few (more likely none) exceptions. Thus, a cutoff based on the water cut may be more useful than one based on strictly on water saturation alone. The distinction between non-pay and pay should be determined more by the allowable or tolerable water cut than by a "number" (i.e., water saturation). The reader is referred to an article in the OIL & GAS JOURNAL series titled "Practical Log Analysis," which ran from May 15, 1978 to September 19, 1979, where Fertl and Vercellino show a relatively simple method for predicting water cut in transitional reservoirs using water saturation and irreducible water saturation. Several calculations were made and the results compared favorably with the oil cuts reported by swab tests on many wells in the East Livingston Ridge field. The reader should be aware that there is a certain amount of "slop" in the oil cuts reported just by the nature in which the data was obtained.

Another important "number" to be obtained from log analysis in the Brushy Canyon is the amount of moved hydrocarbons. Almost all of the sandstones in the Brushy Canyon contain varying amounts of hydrocarbons. Low permeabilities will result in these hydrocarbons remaining as residual components in many reservoirs. A simple ratio calculation of Sw/Sxo may be the best indicator. The value of Sxo can be determined from the microspherically focused log or the microlog value. If the value is near 1, then there has not been any hydrocarbons moved, whereas any values below 1 may indicate moved hydrocarbons. A value of 0.7 has been adopted by the service industry. Bulk volume water plots can also be employed to determine what zones will produce with a high water cut. This method is somewhat subjective and zones must be compared with one another to establish a "baseline."

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations that have been suggested during the course of this paper have been summarized below in chronological order:

1. A modified sand-rich submarine fan complex is used to model the Brushy Canyon reservoirs in the East Livingston Ridge field

2. The Brushy Canyon can be split into two depositional "units." The Upper Brushy Canyon represents the intermediate to proximal fan facies. The Basal Brushy Canyon is typical of the more distal fan facies.

3. The Brushy Canyon is classified as a feldspathic sand consisting of approximately 60-80% quartz, 20-30% feldspar and 5-10% rock fragments.

4. The prevalent clay mineralogy in the Brushy Canyon is illite, mixed layer illite/smectite and possibly mixed layer chlorite/smectite.

5. Facies in the Upper Brushy Canyon cannot be easily distinguished by simple porosity-permeability crossplots.

6. Qualitative rather than quantitative log analysis provides the "best" answers. Mud log shows, shows in rotary sidewall cores and wireline log analysis should be combined and compared for anomalies.

7. The lithodensity log yields the best fit when compared to core porosity.

8. The neutron log does not work well in the Brushy Canyon and should be replaced by a sonic log.

9. The high resolution induction log appears to be the best electrical survey to run in the Brushy Canyon.

10. The microlog could be used to differentiate permeable from impermeable zones and should be tested in the Brushy Canyon.

11. The distinction between non-pay and pay should be determined more by the allowable or tolerable water cut than by a "number" (i.e., water saturation).

12. Moved hydrocarbons may be detected using a simple ration of Sw/Sxo provided the logs were not run in non-specified environments.

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