The Upper Mannville Incised Valleys of Central Alberta: An Example of Subtle Gas Traps

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Summary

A methodology to generate a gas prospect in the Upper Manville incised valleys of Central Alberta is proposed in this paper. This methodology is based on a new detailed sequence stratigraphic framework which is used to subdivide this previously undivided continental series. An integrated approach involving geological and geophysical interpretation, as well as log and production data analysis is used to assist with exploration of the subtle gas charged traps.

Introduction

The Lower Cretaceous Manville group (MNVL) is one of the main oil and gas bearing reservoirs of the Western Canadian Sedimentary Basin (WCSB). Although the Lower Manville has been extensively drilled over the past decades, the Upper Manville interval remains relatively immature in regard to exploration for gas charged reservoirs. This is particularly true in Central Alberta, where the Upper Manville reservoirs are formed as incised valley fill, and are therefore mostly discontinuous sand bodies. Furthermore, the litharenitic nature of these sandstones impacts their log responses, making it more difficult to recognize potential plays. Finally, the trapping mechanism of gas probably involves a combination of structural and stratigraphic components, leading to subtle traps and multiple gas water contacts.

The above factors have limited past exploration and development activity in the Upper Manville strata. We hypothesize that large reserves still remain to be found representing a substantial prize for future exploration. Moreover, the considerable volume of publicly available data makes it possible to take up this challenge.

The key to successful exploration in such a difficult play lies in the effective integration of the geological, reservoir engineering and geophysics data. In this paper, we present an integrated methodology leading to the definition of gas prospects in incised valley fill of the Upper Manville in Central Alberta. Regional correlation was performed in order to establish a reference stratigraphic framework of the Upper Manville, which is currently designated as undivided in Central Alberta (Cant, 1996). This sequential organization was then used to correlate and map incised valley sand fills over smaller areas at the scale of a township. The combination of this incised valley model with structural mapping, together with reservoir quality and fluid assessment derived from well log and production data analysis, lead to the delineation of multiple gas prospects. Furthermore, the identification of valley fairway margins on seismic data contributes to lower exploration risk, providing additional constraints with which to select well locations.

Stratigraphic Framework

The Manville group is a clastic wedge deposited during Barremian to early Albian age in the Western Canadian foreland basin, and lies on a major unconformity. It corresponds to a third-order sequence (sensus Vail et al., 1977), who's lowstand and transgressive system tracts refer to the Lower Manville, whereas highstand system tract refers to the Upper Manville.

The marine series of the Upper Manville interval have been intensively studied in Alberta, where the most prolific gas fields are producing in lowstand shoreface sandstones of fourth-order sequences (Cant, 1995, Mc Donald & al, 1988). The upstream continental part of the Upper Manville in Central Alberta remains stratigraphically undivided. It is however punctuated by several sequences whose boundaries are associated with relative sea level drop, inducing the formation of incised valleys. The main reservoirs of the Upper Manville are located in the incised valley fills and the recognition of these sequences is then essential for exploration.

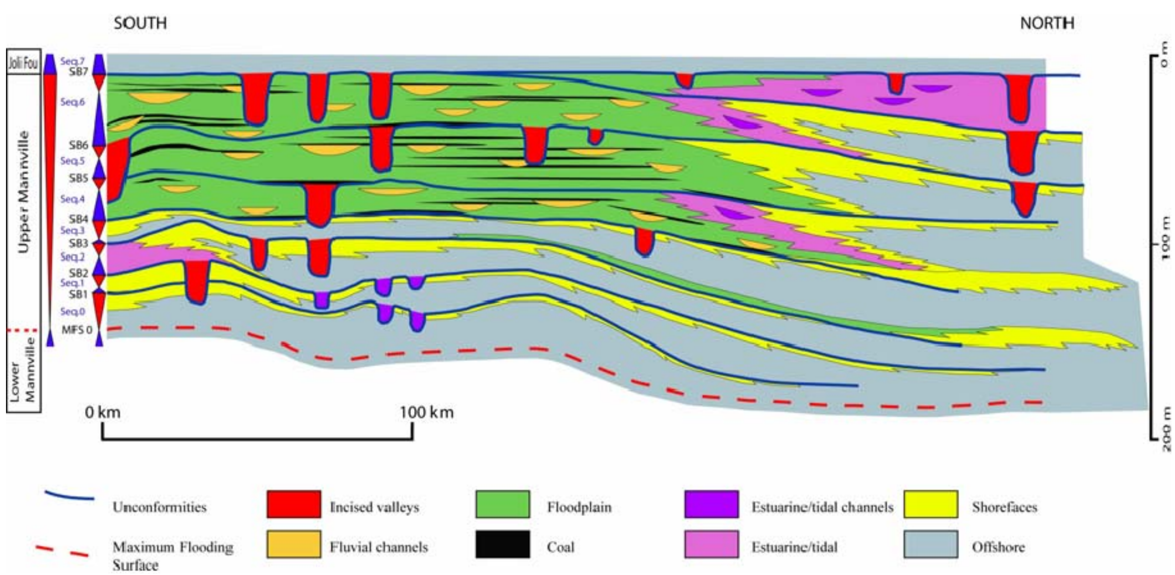

Figure 1: North-South Stratigraphic scheme and facies evolution of the Upper Manville

High resolution stratigraphic correlation was first performed at a regional scale in order to define the stratigraphic architecture of the Upper Manville in the studied area. This correlation was based on the analysis of log stacking patterns, calibrated on core descriptions, and on regional facies transition from continental to marine environment (Fig. 1).

Correlation was then performed at a more local scale (a few townships) within the defined stratigraphic framework in order to identify the incised valleys and to determine the surface (sequence boundary) to which they are linked along the profile. The sequence boundary is quite easy to identify in the presence of an incised valley, because of its sharp base and blocky to fining/shaling upward log response (on Gamma Ray and Spontaneous Potential curves). Outside of the valley however, the sequence boundary is more difficult to recognize because floodplain deposits are present on both sides of the surface. The main criteria used to overcome this difficulty was the continuity of strata above the sequence boundary (extensive coal intervals sometime lie above the valleys), cementation (compact) layers associated with long time emersion periods and the thickness of individual sequences which is quite constant at a local scale.

Nine sequences have been recognized in the Upper Manville at regional scale. However some of them are merging eastward, probably because of decreasing subsidence rate moving away from the Lamarian thrust belt.

In the studied area (Township 57 to 63, Range 1W5 to 4W5), 7 correlatable sequences have been identified. The sequences 1 and 2 correspond to marine deposits, the sequence 3 is transitional between marine and continental environment, whereas the sequence 4 to 7 were deposited in a continental setting. The incised valleys of these 4 uppermost sequences are filled with fluvial sediments, which correspond to the main exploration target of the Upper Manville interval in this area.

At a very local scale (one township), the stratigraphic correlation enables the identification of each incised valley associated with a sequence boundary and the mapping of them.

Prospect Definition Methodology

The methodology used for the definition of a gas prospect in the incised valleys involves the following steps:

- Definition of a target area based on the mapping of the wells producing gas from Upper Manville incised valley fills.
- Stratigraphic correlation of the wells, identification of the incised valleys in the frame of the sequential organization.
- Regional mapping of the incised valleys.
- Structural mapping of the top Manville surface to identify possible structural highs.
- Assessment of fluid content and eventual contact from well log analysis.
- Definition of potential traps using any evidence of structural closure and/or stratigraphic pinch out (valley margin or internal facies heterogeneity if detectable).
- Confirmation of the prospect with seismic data (if available) and mapping adjustment if necessary.
- Selection of a potentially best well locations.

The stratigraphic framework defined at regional scale provides a strong guide with which to identify the different valleys from well to well. This avoids correlating incised valleys of different ages that would lead to misleading mapping of the potential reservoir facies. The stacking of incised valleys from sequence 4 to 7 may constitute gross reservoir intervals up to 40 m thick (131 ft). However, internal heterogeneity such as compact or shaly layers can sometimes lead to the superimposition of two independent gas pools. Careful analysis of production data shows that internal compact layers can also efficiently isolate the reservoir from underlying formation water, thereby preventing any water break through during production.

The identification of the moveable fluid phase in these reservoirs is difficult due to the low resistivity contrast between water and gas bearing sandstones. The SS depth of gas water contact varies regionally, probably related to gas filling of many isolated traps. However, at a more local scale, a fairly constant GWC depth can be mapped over a few square kilometers areas. The combination of this GWC depth with detailed structural and valley mapping enables one to define prospective areas with a fairly good level of confidence.

Conclusion

The Upper Manville incised valley reservoirs constitute subtle gas traps in Central Alberta. We proposed in this paper a methodology to define Gas prospects in this so far moderately developed, challenging exploration fairway. This methodology is based on a reliable stratigraphic framework in which incised valleys can be mapped with an acceptable level of confidence. The combination of this mapping technique with structural contouring and fluid assessment from well log and production data analysis has enabled the definition of gas prospects. Thanks to this better defined stratigraphic framework and to the huge amount of data available, this approach could be applied to many other places over Central Alberta in order to generate new prospects.

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