Have we run out of conventional plays in the WCSB?

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Summary

The Alberta Deep Basin is one of the most productive areas of Western Canadian Sedimentary Basin (WCSB), which contains the maximum number of formations preserved due to its complex and lengthy tectonic history. Some of the Deep Basin conventional plays are plentiful but yet underexplored. The Mississippian Kiskatinaw sandstone is one of those conventional plays. Exploration trends in the WCSB are currently focused on unconventional targets; but the high drilling and completion costs of unconventional plays are not paying off due to sluggish domestic demand and inaccessible global markets. As an attempt to trim down the soaring exploration costs, shifting of exploration focus to potential conventional plays can be a feasible alternative. In this context, the underexplored Kiskatinaw sandstone of the WCSB deep basin has been reviewed, analyzed and examined for production potential.

Introduction

In spite of a long exploration history, the WCSB still contains abundant hydrocarbon. There are a substantial number of conventional plays in the Deep Basin and the Foothills regions that are prolific but underexplored. The main challenge of the current energy market is the increasing drilling-completions costs of unconventional resources plays. On the contrary, exploring conventional plays have a significantly lower price. For example, the Mississippian plays of the Deep Basin area have been relatively under-explored. The Kiskatinaw sandstone of the Mississippian Stoddart Group is one of the prominent conventional plays in the Deep Basin. The Golata shale and the Kiskatinaw sandstone of the Stoddart Group are two clastic deposits sandwiched between carbonates during Carboniferous time. The Mississippian (Upper Viséan) Kiskatinaw is composed primarily of quartzose sandstone with minor shale, siltstone, limestone and dolostone (Halbertsma, 1959; Bamber and Mamet, 1978; Kirkland, I.K., 1993). Lateral and vertical lithology variations in shale, siltstone and carbonate proportions are also noted (Richards et al., 1994). Deposition of the Mississippian was heavily influenced by the foreland type basin setting with extensive faulting in and around the Deep Basin area (Richards et al., 1994). The majority of the carbonates were deposited in platform and ramp settings whereas the Golata and the Kiskatinaw of the Stoddart Group were deposited in marine, estuarine and deltaic settings (Richards et al., 1994). Core studies show the siliciclastic Kiskatinaw Formation incised into the marine Golata shales locally where it is preserved (Barclay et al., 2000). Deposition and thickness variations of the Kiskatinaw are controlled by its syndepositional preservation and postdepositional erosion events. The study area (Figure 1) comprised of about 2905 sq. km, which is equivalent to 32 townships (each township equals to 6 by 6 mile grid). It has only 1041 wells drilled within the boundary of the project area, which is sparse compared to the overall well density of many other parts of Alberta. Among these wells, only four hundred (400) have some production records attached and only sixty-nine (69) of these wells successfully targeted the Mississippian Kiskatinaw Formation. A structure map (Figure 2A) of the Kiskatinaw Formation indicates the depositional extent is entirely controlled by the faults and the Kiskatinaw gross thickness map (Figure 2B) indicates the fault-controlled accommodation space. From the geology cross-sections (Figure 3), we can see the Kiskatinaw Formation is not uniform in thickness and either present or absent due to its deposition in the graben or non deposition on the horst side of the fault blocks. Some parts of the Kiskatinaw deposition were thinned due to erosion on a post-depositional re-activation of the faults. Cross-section A-A’ illustrates the absence (erosion or non-deposition) of the Kiskatinaw to the north part of the study area. Cross-section B-B’ illustrates the thickening and thinning of the Kiskatinaw due to the different faulting throughout.
The re-activation of the faults during Devonian through Permian time influenced the deposition and preservation of the plays in the Deep Basin areas (Figure 1). Far field Antler Orogenic Movement may have triggered the re-activation of the faults (Greggs, 2006) and collapse of the Peace River Arch.

Theory and/or Method

This study is based on reservoir evaluation and play assessments of the Kiskatinaw play in the Deep Basin area. Sedimentological characteristics, depositional settings, play maps, cross-sections and production evaluations of different wells and pools have been conducted to make predictions on the Kiskatinaw hydrocarbon production potential and recoverable reserves estimates. Three core analysis reports have been reviewed to identify reservoir properties, sedimentology and lithology characteristics. About four hundred thirty-seven (437) wells were used to construct Kiskatinaw structure and gross-pay maps. The Permian Belloy Formation has been considered as the datum for the geology cross-sections. All available gas-oil pools (Thirty-seven within the study area) were superimposed on the gross-pay map (Figure 4A) and a net-pay map was also constructed (Figure 4B) applying suitable cut-off values to the raster logs. Production analysis and cost comparisons with other unconventional plays were carried out using geoSCOUT and frac-database. Within the study area, only sixty-nine (69) producing Kiskatinaw wells were identified through geoSCOUT search criteria. Most of these wells were drilled prior to the year of 2000 using older technologies. In spite of older wells, the first ten (10) of the highest gas producers within the study area appeared to be Kiskatinaw wells. The existence of nine (9) Kiskatinaw oil wells were also identified with the search. A multi-well plot (Figure 5) of the producing Kiskatinaw wells displays a range of production, which also includes an average production curve. In the context of this study area, the gross-pay map superimposed with the Kiskatinaw pools (Figure 4A) can be reviewed to identify many empty spaces, which had not yet been drilled successfully targeting Kiskatinaw. Those empty spaces can further be analyzed with respect to the Kiskatinaw net-pay map (Figure 4B), log pays and available DST (Drill Stem Test) data for potential well locations. Placing new wells in compartments formed due to the intense faulting and not having been drained by an adjacent well, will have a greater success rate. Many of the Kiskatinaw gas and oil pools within this study area have not yet been produced to their full capacity, which supports the options for infill drillings and future well locations. Suitable reservoir parameters (i.e. average porosity of +13%, average permeability of +30 mD, high gas saturation of ≈75% and high gas recovery factor ≈70% and high initial pressure +13000 kPa) of the Kiskatinaw play can be attractive for the operators. The drawback of exploring these plays is the associated risk factors of drilling a dry hole or marginal wells with high water production. Due to the complex geology setting and unpredictable nature of the deposits, the Kiskatinaw is a high risk play. Depositional settings, tectonics and diagenetic studies are keys to the exploration success (Yousuf, A., 2013). Unconventional resource play wells on the other hand are technically almost risk free.

As per the multi-well plot (Figure 5), some Kiskatinaw wells exhibit tremendous performance and have cumulative production of more than 100 e6m3 (3.5 Bcf) of gas. However, not all wells are similar. A type production curve has been constructed to represent this group of wells (Figure 6) indicating an estimated ultimate recovery (EUR) of 47 e6m3 (1.6 Bcf) per well. These Kiskatinaw wells are typical vertical or deviated wells with an average measured depth (MD) of about 1400 m. Completion work includes perforations and acidizing. Another multi-well plot of Montney horizontal wells (Figure 5; inset) exhibits range of production, which also includes an average production curve. Many of these wells show very high initial production rates with significant decline in two years. A corresponding type production curve to represent these multistage frac-stimulated wells is estimated to produce an average of about 52.5 e6m3 (1.8 Bcf) of gas. There are many Montney horizontal wells that have or will produce much more than the type curve estimation, but this EUR can be interpreted as median to cover both the highs and the lows. A Montney horizontal well in the Karr area with an average MD of about 4500+ m, completed with a 12 stage slick water frac may cost about $10M. Whereas a similar gas producing Kiskatinaw well may cost about one tenth of a typical Montney horizontal well.
Conclusions
The purpose of this study is to illustrate the production potential of underexplored Mississippian resources in the Deep Basin area. This study focuses on the Deep Basin Kiskatinaw conventional plays, which are still prolific and can contain significant quantities of hydrocarbons. These wells display longer production lives with lower exploration and exploitation costs compared to some of the unconventional wells. Nevertheless, this is a high-risk play due to complex depositional setting and good geological understanding is a major key for success.

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Disclaimer: This paper is based on the research, review and analysis of public domain data. Type production curves produced for this study based on specific assumptions, may vary with other studies. Findings of this paper is author’s view and interpretation, has no association with any organization.

References


Figure 1: Location map with respect to the WCSB (modified after Zonneveld, 2010) and heavily faulted Deep Basin area in the pullout map (Richards and Halbertsma, 1994).
Figure 2: Kiskatinaw structure contour (A) and a gross thickness map (B) of the study area.
Figure 3: Geology Cross-section AA' and BB' of the study area to capture the thickness variations in north-south and east-west directions respectively.
Figure 4: Oil-gas pools superimposed on the gross-pay map (A) and Kiskatinaw net-pay map (B).
Figure 5: Multi-well plot of the Kiskatinaw gas wells and the Montney Horizontal gas wells (inset).

Figure 6: Type production curve comparison of Kiskatinaw well with Montney well.