Identifying Opportunities through Value Mapping of the Alberta Montney Wet Gas Fairway
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Abstract

Statement of the background
The liquids rich Alberta Montney in the Western Canadian Sedimentary basin ranks among the top unconventional plays in North America. Value mapping has enabled the Shell Regional Studies team to proactively rank and evaluate commercial opportunities over the entire play fairway which extends over 100 townships. This was achieved by combining advanced multi-disciplinary subsurface play-based exploration (PBE) and common risk segments (CRS) mapping with single well economics to derive quantitative value maps. Within the hybrid (not fully self-sourced) Montney unconventional play fairway, a strong correlation was derived between condensate-gas-ratio (CGR), in-place volumes and well performance, which ultimately drives project economics. In a market ripe for consolidation, this allows for proactive evaluation of opportunities in the region with a focus on optimizing growth.

Aims and Objectives
The objective of value mapping is to combine the subsurface technical work that underpins an evaluation of the oil and gas production potential of an area with the cost associated with extraction of these resources to produce an economic evaluation over a geographic area.

Materials and methods
The Montney Formation in has been recognized as one of the most prolific and material unconventional gas plays in Western Canada (NEB, 2013). This paper focuses on the liquids-rich portion of the Middle and Lower Montney play in Western Alberta (Figure 1a). Within the study area, the Montney is approximately 200m thick and consists of fine clastic sediments of early Triassic age (Figure 1b). Regional lithostratigraphic correlations of the Middle and Lower Montney (Figure 1c) were combined with a core-calibrated regional petrophysical model to develop a detailed 3D static model to derive in-place volumes. The top of the upper Lower Montney likely corresponds to the maximum extent of flooding after the end of the Griesbachian-Dienerian T-R sequence (Embry, 1997).
Figure 1: (a) Alberta Montney Value Mapping Project AOI is outlined in red. Map modified from NEB, 2013. (b) Stratigraphic nomenclature used in this project – this paper is focused on two members of the Middle Montney, and the upper member of the Lower Montney. (c) A North to South cross section of three wells located on the in the Project AOI.
A key value driver in the Alberta Montney play is the condensate yield. Due to production reporting limitations, the CGR of individual wells is often unknown. Basin modelling and fluid composition analysis was used to characterize liquids potential and gas migration trends in the Montney.

Common Risk Segment (CRS) maps were generated based on key cutoffs in reservoir thickness, water saturation, condensate yields and overpressure. Production and completion trend analysis was done on over 700 Montney horizontal wells to derive length and completion intensity normalized typecurves for 10 regional CRSs.

**Results and discussion**

Gas Composition and Migration

Concentration of butane isomers are a product of source rock type, migration and maturity (Igari et al. 2007, Wood et al. 2016). Within unconventional reservoirs like the Montney, the source rock and migration variables are eliminated and there is a predictable relationship between n-butane (nC4) and isobutane (iC4) with maturity. Butane isomer methods identifies migration from standard gas analyses without vitrinite reflectance data, a basin model or ethane isotopes. The degree of migration can be quantified as deviation from a linear relationship by plotting the gas dryness index vs. butane ratios as shown in Figure 2. Deviation from the in-situ baseline indicates that additional methane has migrated into the reservoir, as observed in the areas of Gold Creek and Simonette. The migrated/unmigrated boundary derived from the gas analysis work also correlates loosely with a charge ratio of 1 from the regional basin model.

![Gas Dryness Index vs Butane Ratios](image)

**Figure 2:** Butane isomer methods identifies excess methane and gas migration from standard gas analyses.
Petrophysical Model

The petrophysical evaluation was key to determining accurate in-place volume maps for the Montney. A unified regional Montney petrophysical model was developed to capture the subsurface properties (porosity, water saturation and mineral model that includes total organic carbon, clay, sandstone and limestone) over the unconventional liquids-rich trend in the Alberta Montney. This iterative model covers the entire Montney zone and is not dependent on intra-Montney zone picks or trend regressions that are only valid over limited geographic areas. Over 1000 wells were evaluated in the study area and calibrated to cored wells. One example is shown in Figure 3.

The parameters below were evaluated using wireline log data and associated petrophysical relationships calibrated to core:

- Total organic carbon is calculated using a multi-linear model empirically derived from density and neutron logs and LECO total organic carbon (TOC).
- The clay volume is derived from the hydrogen balance between kerogen, clay and fluid volumes measured by the neutron porosity log and calibrated with X-ray diffraction mineralogy (XRD).
- Density porosity is calculated by combining matrix density, calculated from the density/neutron relationship, an assumed fluid density and the measured bulk density from wireline logs calibrated with routine core analysis and shale rock properties.
- Water saturation is obtained by applying an Archie saturation model, with a constant m and n calibrated with routine core analysis and shale rock properties.

Figure 3: A regional petrophysical model was developed for the Montney to evaluate porosity, water saturation and mineralogy. The model is not dependent on intra-Montney zone picks or trend regressions. Red dots indicate core calibration.
Mapping EUR

A key input for value mapping is a prediction of the production potential, or estimated ultimate recovery (EUR), of a well and the its fluid composition over a geographic area. This was done deriving relationships between CGR vs. GWI, and recovery factor vs. CGR over the producing wells grouped by CRS.

As shown in Figure 4, the first step is calculating a CGR map using the relationship derived from plotting the CGR vs. GWI (modified by the degree of excess gas migration). A recovery factor to CGR relationship was then derived by correlating the P50 typecurves to the in-place volumes (assuming 300 m well spacing, 70 m reservoir thickness, 2 layer model). These regional correlations were applied to the detailed 3D static model to generate a EUR/well map which was extracted on a 1x1 mile grid for value mapping.

Even though there is quite some variability in the CGR for a given GWI, the derived relationship is useful for understanding regional liquids trends and areas where the CGR may be uncertain due lack of actual CGR data and producing well conditions. The recovery factor vs. CGR trend was surprisingly well behaved – intuitively, the recovery factor is negatively correlated with CGR, and increases as you move west from the condensate into the dry gas window.

![CGR vs. Gas Wetness Index](image1)

![Recovery Factor vs. CGR](image2)

Figure 4: In order to create a CGR map, a relationship was derived between CGR and the gas wetness index modified by a degree of excess methane factor. EUR/well maps could then be generated by deriving a recovery factor vs. CGR relationship wells were grouped by CRS and plotted against their wells were plotted to derive a relationship between CGR and the GWI in order to map CGR.

Half-Cycle Single Well Economics

The economic attractiveness of the Montney within the project AOI was derived based on half-cycle economics as defined by Kleinberg et al. 2018. This excludes exploration, leasing and gathering infrastructure costs, but includes all the well capex (pad construction, drilling, completions, tie-in) and operating expenses (lifting cost). Regional well capital costs were projected based on depth and lateral length for a fixed completions architecture and mapped on the same 1x1 mile grid. Operating expenses were modelled based on sweet vs. sour (H2S) areas. Long term commodity prices and differentials to HH, royalties and corporate tax were included in the economic model. An annuity model is used to simulate a development scenario over a period of 15 years. Cost assumptions were ground-truthed with competitor and consultant databases (Canadian Discovery Sproule play metrics and RSEG Core), and sensitivities were run to generate tornado plots to understand the impact of uncertainties in the assumptions.

The economic results are presented as VIR and NPV/acre maps over the entire Alberta Montney fairway. There is considerable variability within a single CRS, with inputs and outputs varying on a township scale. Within the Alberta Montney, the value maps are used to proactively identify opportunities going forward.
Conclusions

Value mapping has allowed us to economically benchmark the liquids-rich Montney play in Alberta by understanding the main revenue parameters (CGR, EUR/well) and the development costs. Within the project area, a strong correlation between CGR, in place volumes and well performance was observed.

Since condensate is the primary value driver in the Alberta Montney, additional work to refine the CGR prediction would be worthwhile – possibly by splitting into multiple Montney benches as additional data data from the Lower Montney becomes available.

Value mapping is a useful way to compare projects across different plays, in multiple basins. Value maps from various zones can be stacked and risked to understand the ultimate potential of a geographic area. Macro-level analysis can also be conducted to understand the cost of supply and competitor landscape. Most of all, value maps translate technical subsurface concepts into the language of decision makers - dollars and cents!

References


