# Integrated Reservoir Characterization and Landing Zone Selection in the Liquids-rich Duvernay Formation, Kaybob North, Central Alberta

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## Summary

An integrated approach is taken towards reservoir characterization using cores and logs in order to identify and rank landing zones for horizontal well placement. We aim to select landing zones that have the best reservoir quality with high ROP potential and low net stress in which to place the horizontal wellbore.

## Introduction

Landing zone selection is a fundamental prerequisite to horizontal well placement. The goal of any horizontal well is to place it such that a successful completion can be executed and an economic well can be produced. A number of criteria are often applied in order to ensure that the landing zone is optimal. These are; correlative zone with a distinct marker, effective reservoir pay, higher ROP and low net stress.

Using key wells, we characterize the reservoir as mappable reservoir quality units across the area of interest. This is an integrated approach that encompasses a petrophysical analysis, select special core analysis (SCAL), core description, seismic and geomechanical rock properties. From this characterization, landing zones are defined and ranked for well planning and acreage evaluation.

## Method

Reservoir characterization in the Duvernay is best described as an integrated approach to bring together the assessment of the rocks, pores, and fluids in the reservoir with the sesimic and geomechanical rock properties that allow us to move away from the wellbores. The goal is to ultimately map optimal zones to drill fast and complete with few failures

### *Petrophysical Analysis*

A number of similar analytical methods, both deterministic or probablistic, are employed by numerous companies. With core data and a triple-combo log suite, it is possible to obtain a petrophysically accurate result, calibrated for lithology, TOC content, porosity, and fluid saturations. Using this as a regional baseline, it is impertative to acquire compressional and shear acoustic data, as well as nuclear magnetic resonance logs. The former allows definition of the numerous seismic and geomechanical rock properties, the latter is very useful for advanced characterization of the porosity system.

### *Special Core Analysis*

Analytical methods for unconventional reservoir cores have evolved so the ability to assess intact porosity networks and preserved fluids is now routine. To compliment the unconventional analysis from which fluid saturations are derived, NMR T1T2 mapping and in-situ flow through analysis using the preserved cores is adding another dimension to reservoir quality definition. For this study, T1T2 mapping has been used to interpret water and liquid hydrocarbon distributions related to the reservoir characterization.

*Core Description*

Integration of the colour, lithology, sedimentary features, key surfaces, observed fracturing and other macro-mesoscopic features of the core provides fundamental data from which the petrophysical characterization is related to. In addition,a triage of XRF chemostratigraphy, rebound hammer hardness testing, and handheld tinyperm measurments are used to compliment the descriptive value of the core.

XRF analysis for major and trace elements provide additional means to assess mineralogy, simple geomechanical rock properties, and defines a profile of depositional geochemistry to relate to log response. The rebound hammer measures rock hardness that is used to relate to and validate geomechanical properties derived from wireline logs. Tinyperm is a new handheld technology used to qualitatively measure decay permeabilty along the core.

*Seismic and Geomechanical Rock Properties*

The emphasis on reservoir characterization for the purpose of landing zone selection and well placement should be correlative to a seismic attribute that has utility as a geosteering guide within a 3D volume. The integration of Acoustic Impedance, VpVs, or Poissons Ratio with the petrophytsical analysis and core description enables the assessment of which seismic rock property is useful for well placement. Additional value may be gained by upscaling the log response to one more representative of the seismic response.

Geomechanical rock properties are useful to delineate zones favourable for faster drilling and hydraulic stimulation initiation. Intervals with relatively low unconfined compressive strength (UCS) drill faster. Likewise, hydraulic fracturing is typically easier to initate in intervals with low net stress (SHmin). Similar to the seismic rock properties, integrating these logs with the petrophysical analysis and core descriptions presents an interpretation useful for well placement.

## Examples

For key wells, the compilation of these data gets assembled to represent raw logs – petrophysical analysis – core description – chemostratigraphic zonations – geomechanical zonations – and seismic rock properties (Figure 1). This integrated dataset forms the basis for a multidiscipline characterization of the reservoir.

From this work-up the objective is to identify the characteristics of higher quality pay (better porosity, low clay volumes) that relate to favourable UCS Rock Strength for faster ROP and Poissons Ratio / SHmin for low stress in which to target horizontal wells. The synthesis of these criteria is presented as Figure 2.

In Figure 2, the interval identified as LZ 1 has well-developed porosity with low clay volume. On the T2 waveform note the absence of a low T2 response typical of a clay-bound water signal. UCS rock strength is marginally greater in this interval due to lower clay volumes, however with Poissons Ratio low and the computed SHmin also low, this is an interval favourable to complete. The net effect is that LZ 1 represents a pay interval that should drill fast and complete well.

The interval shown as LZ 2 has been tested in the past. It is equally porous but has higher clay volumes. The increase in clay volume shows in the T2 waveform, and has lower (softer) UCS rock strength and more ductile Poissons Ratio, yet lower SHmin stress.

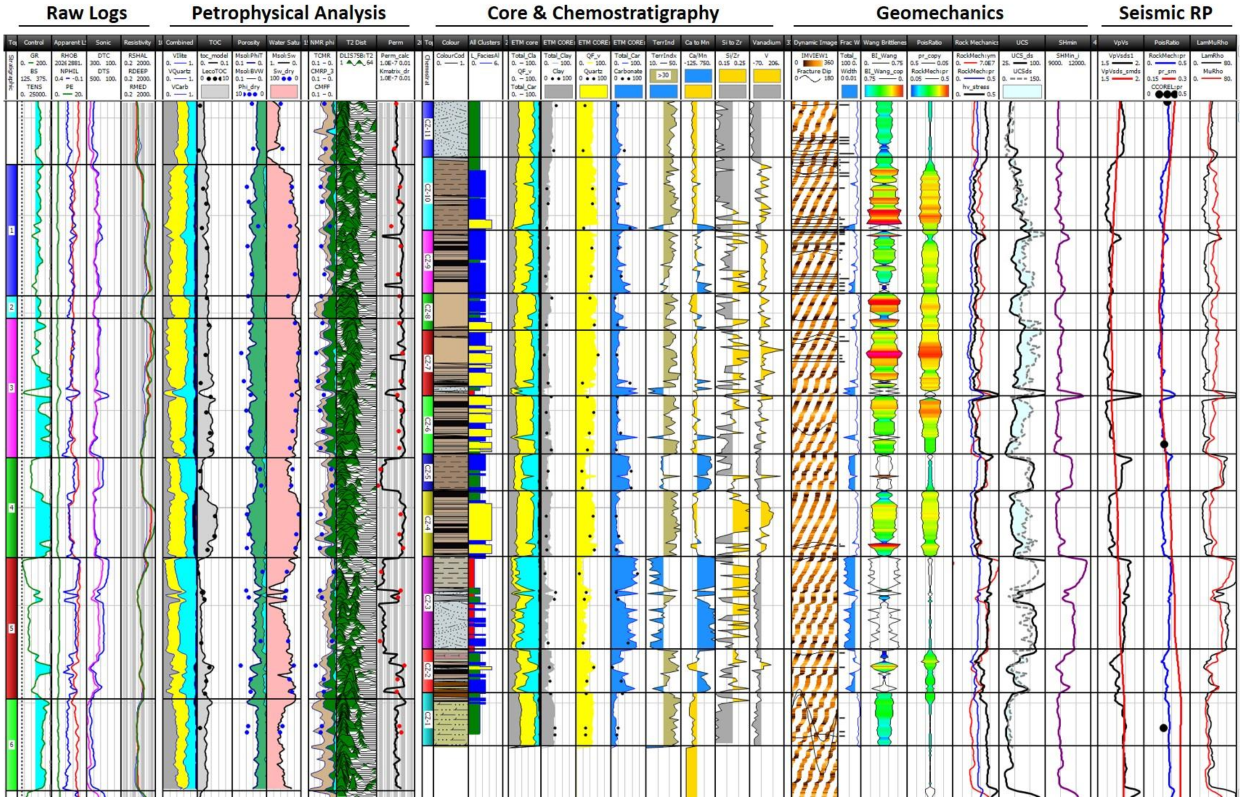


**Figure 1: Integrated display panel of Raw Logs, Petrophysical Analysis, Core Description and XRF-based Chemostratigraphy, Geomechanics, and Seismic Rock Properties for the whole Duvernay interval.**

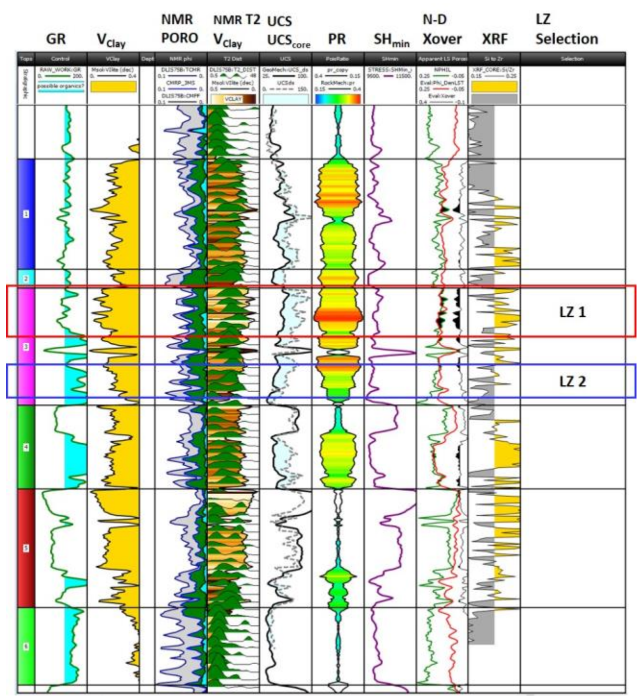


**Figure 2: Synthesis display of key attributes. The interval highlighted as LZ1 differs from LZ2 in that it has less clay, no apparent clay-bound water (T2 waveforms), lower Poisson's Ratio, and a different trace element signature, than observed in LZ1. The integration of pay criteria, rock moduli and chemostratigraphic data differentiate this interval as favourable to drill and complete.**

## Conclusions

The workflow to assemble many data from geological, Petrophysical, mechanical, and seismic datasets as a 'storefront' of information is an approach to address cross-discipline comprehension of what we select as a landing zone for horizontal well placement. In this case, we reduce the characterization from Figure 1 into Figure 2, and have mapped one attribute as a 3D property model (Figure 3). The attribute of reservoir quality, serves to represent high grade landing zones across a region that are mappable and useful for development planning.

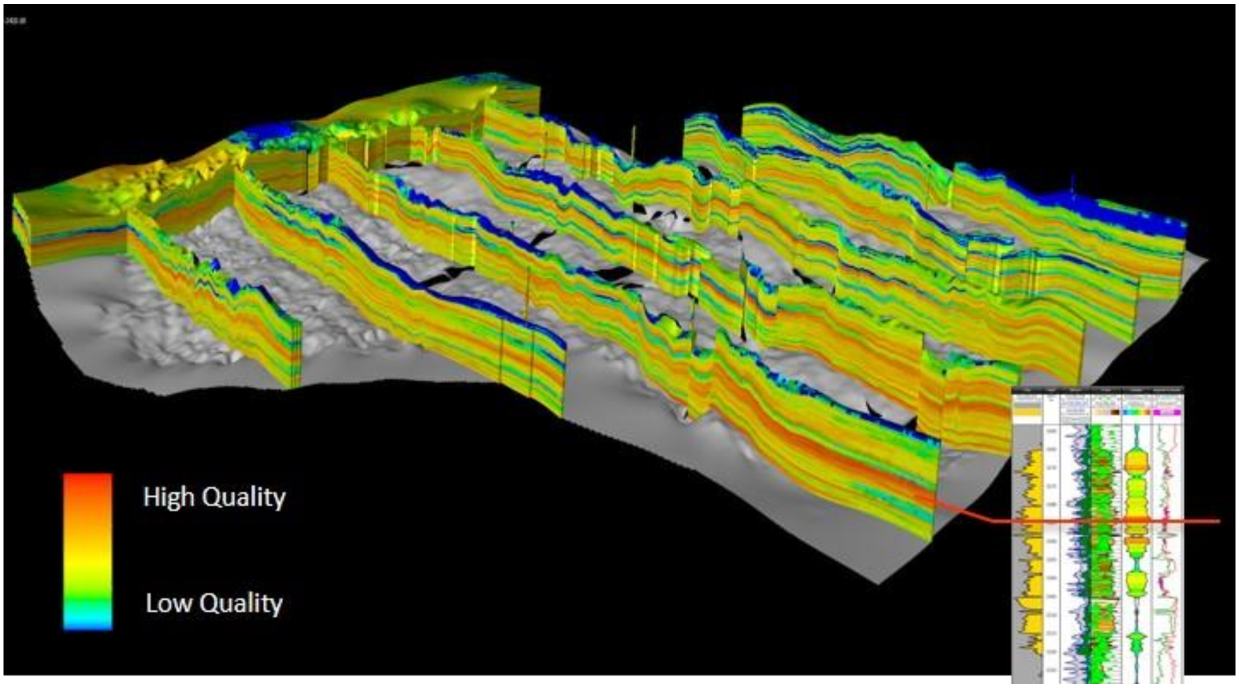


**Figure 3: Three-dimensional property model of reservoir quality derived from the integrated storefront workflow.**

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