

The Seamless Connection – Geoscience Enabled Engineering in Montney and Beyond

Chase Gilbert

McDaniel and Associates Consultants

Summary

Collaboration between geologists and engineers is essential for successful oil and gas development, spanning the entire lifecycle from exploration and field appraisal to production, evaluation, and optimization. Geological models serve as a critical tool for quantifying resources and mitigating risks, offering a framework that engineers can leverage. This presentation highlights how improved accessibility and integration of geological characterizations enables engineers to have a more comprehensive understanding of production dynamics and outcomes.

Method

Geological mapping and characterizations span from hand-drawn two-dimensional (2D) maps controlled by raster logs to modern billion-cell three-dimensional (3D) geomodels built from digital data. Over the past five years, software advancements have enhanced accessibility to geological characterizations that facilitate the examination of horizontal wells in relation to structural zones, geological parameters, and production, enabling more efficient integration of 2D and 3D mapping into reserve evaluations, machine learning workflows, supply studies, and asset optimization processes. The accessibility of geological characterizations in this presentation is based on two main approaches: 2.5D mapping and 3D geomodels.

Two-dimensional (2D) maps are flat planes that visualize spatial relationships of a structure or reservoir parameter but do not capture vertical variability within the zone of interest (Figure 1a). Furthermore, their integration with well data, such as well surveys, is also limited. However, this can be addressed enabling the stacking of 2D maps while honoring their respective elevations or structural positions (Figure 1b). Through this structural framework, zones can be defined between 2D horizons, and subsequently ‘interact’ with well data. This approach enables the extraction of relevant spatial information in the vertical direction, hence 2.5D, which is otherwise difficult to access. Once wells are binned by their corresponding zones, they can sample the 2D data from that horizon.

In contrast, 3D geomodels incorporate both lateral and vertical variability using volumetric grid cells (Figure 1c). This significantly enhances the granularity of geological characterization and data sampling capabilities. For example, a specific volume around a lateral wellbore can be sampled to evaluate gross rock volume, sweet spots, or landing zones (Figure 2a), providing more detailed information compared to sampling from 2D maps (Figure 2b)

The seamless integration of geological models with well and production data has been significantly enhanced through software, and the workflow follows the steps in Table 1. This integration enables engineers to incorporate geological parameters into performance analysis and decision-making.

Figure 1 a,b,c: 2.5D mapping are like stacked pancakes with vertically blended parameters per zone, while 3D geomodels capture vertical and lateral heterogeneity.

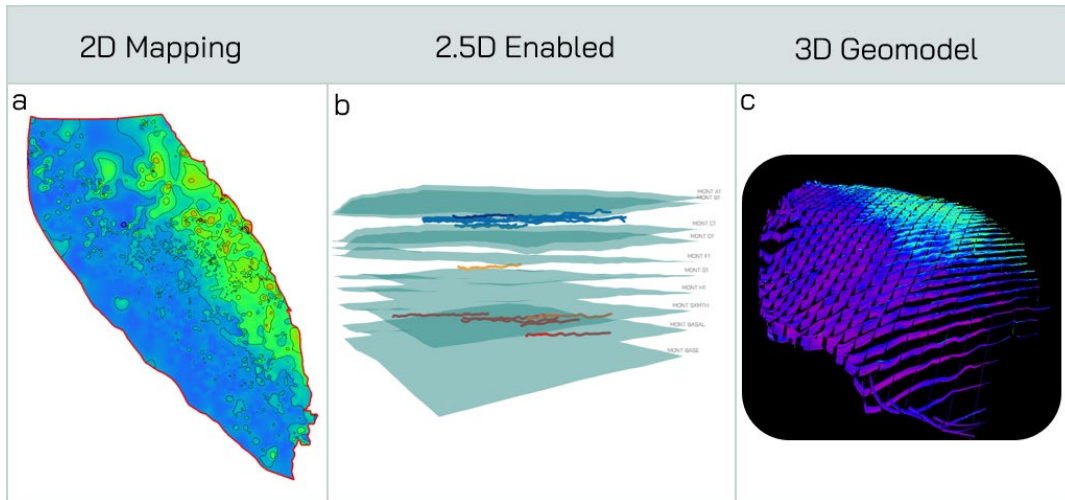


Figure 2: Data sampling around a lateral well in 3D model (a) vs 2.5D mapping (b). Notice granularity of data sampling is much higher in the 3D geomodel compared to the 2.5D mapping.

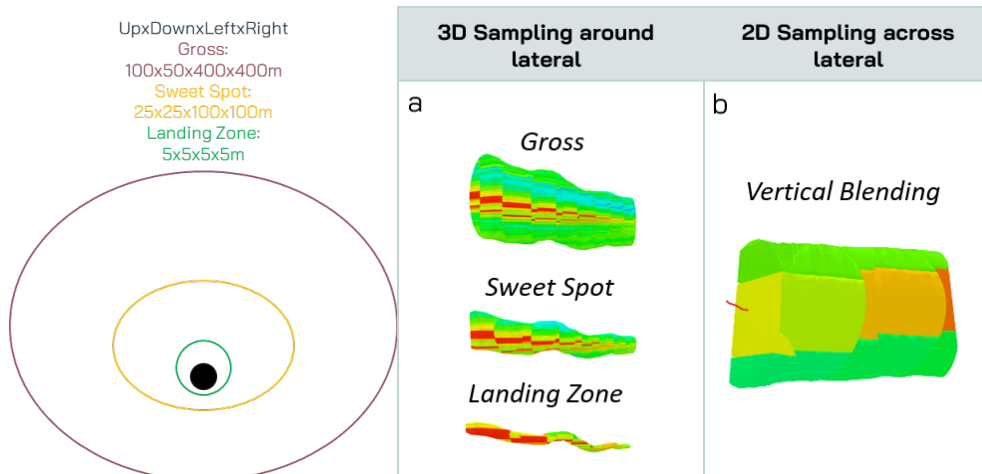


Table 1: General process for 2.5D mapping and 3D models.

Process	Process Description
Data Collection and Quality Control	Public data, including well logs, core, surveys, fluid analysis, pressures, and PVTs, are collected and quality controlled. Recent improvements include using a script to standardize LAS log naming conventions, normalize units (e.g., Bulk Density: g/cm ³ vs. kg/m ³), and ensure logs cover the depths of interest. High-quality data is essential for reliable models.
Stratigraphic Framework	Fundamental to geological mapping as it provides a framework for understanding the arrangement and distribution of strata. Recent advancements in workflow include a machine learning “auto-picker”, particularly useful for interpreting well-defined and consistent horizons, and the ability to dynamically visualize this stratigraphy in a projected cross-sectional view and bin same-zone wells easily.
Petrophysics and Reservoir Characteristics	Petrophysical models tailored to the unique rock characteristics of different plays and incorporating lateral and vertical variability of anchor data (e.g., grain density, pressure, viscosity) are key building blocks of geological mapping.
“2.5D” Mapping	Stacked 2D maps capturing blended rock properties for each zone vertically and correlating them laterally provide a powerful tool. Combined with a stratigraphic framework, they highlight reservoir trends, estimate resources in place, and enable efficient binning and organization of producing wells within a zone of interest.
3D Mapping	Captures vertical and lateral variability and enables discrete ‘sampling’ of the reservoir to better understand the impact of geological parameters on production.

Observations and Examples

The examples below aim to illustrate how integrated geological characterizations are transforming workflows and enabling more comprehensive evaluations of oil and gas assets and well performance.

Example 1: Montney 3D Geomodel and Improved Machine Learning Accuracy in Vertically Heterogeneous Reservoirs

Montney Geomodel Details

The Montney geomodel used is built with ten stratigraphic horizons providing lateral (300 m x 300 m) and vertical (2 m) variability for relevant reservoir parameters across 1.6 billion cells (see Figure 1c). General Montney geomodel parameters can be found in table 2.

Table 2 General Montney Geomodel Parameters

General Montney Geo Model Parameters

Data and Quality Control	Well control with tops n ~ 28,000
Stratigraphic Framework	Horizons: 10
Model Size	1.6 Billion Grid Cells
Properties in 3D	Porosity & PhiH
	Water Saturation
	Pressure & Pressure Gradient
	Temperature
	Solution-Gas (Rsb) and Oil Formation Volume Factor (Bo)
Model Resolution	BVH, OOIP and OGIP
Algorithm	Vertical (2 m) and horizontal (300 m x 300 m)
	Kriging (deterministic)

Montney Machine Learning Case Study

A case study was run to compare the predictive outcome (24-month cumulative gas production) of two machine learning models, one sampling data from a 3D geomodel, and the other sampling data from a 2.5D model. The Montney 3D model captures vertical heterogeneity that can have important implications to well-performance outcomes, and capturing this heterogeneity improves machine learning predictions. The charts below (Figure 3 a and b) can be read as follows:

1. Baseline Value:

- Average 24-month cumulative gas (24M Gas) = 1530 MMcf which represents the base input

2. Feature Contributions

- Each feature is shown on the y-axis. Controlled variables (i.e., horizontal length, proppant intensity, completion design, etc.) are whited out, with uncontrolled variables (geological) shown.
- Each feature has a positive or negative impact on the prediction:
 - Positive contribution pushed prediction higher
 - Negative contribution pushed prediction lower
 - Size of the bar represents magnitude of contribution

3. Prediction Output

- The cumulative effect of all feature contributions (starting from 24M Gas = 1530 MMcf) results in the endpoint of the prediction.

The actual 24M gas of this well is 1390 MMcf, and the 2.5D machine learning model with vertically blended porosity predicted 619 MMcf (54% error) seen in Figure 3a, and the 3D model that captures vertical heterogeneity predicted 1270 MMcf (9% error) seen in Figure 3b. A notable improvement has been observed in model predictions using 3D geomodels, particularly in vertically heterogeneous reservoirs (Schlosser, 2022), by effectively incorporating controlled and uncontrolled variables to predict well performance.

Figure 3A: Porosity model sampled (2.5D) and used as input into machine learning model. The 2.5D model exhibits ‘vertical blending’ of porosity and does not capture the vertical heterogeneity of the Montney reservoir. Using this porosity data resulted in a model error of 54% (Schlosser, 2022).

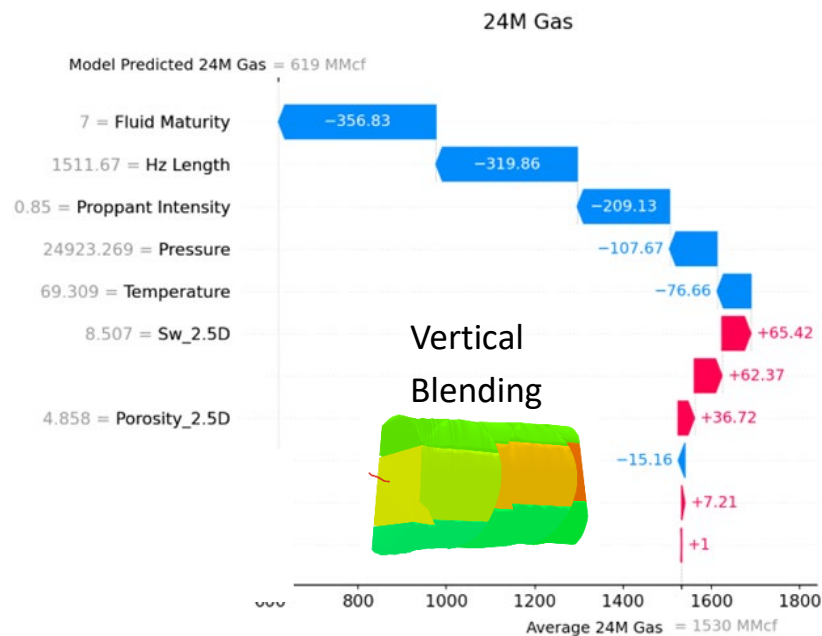
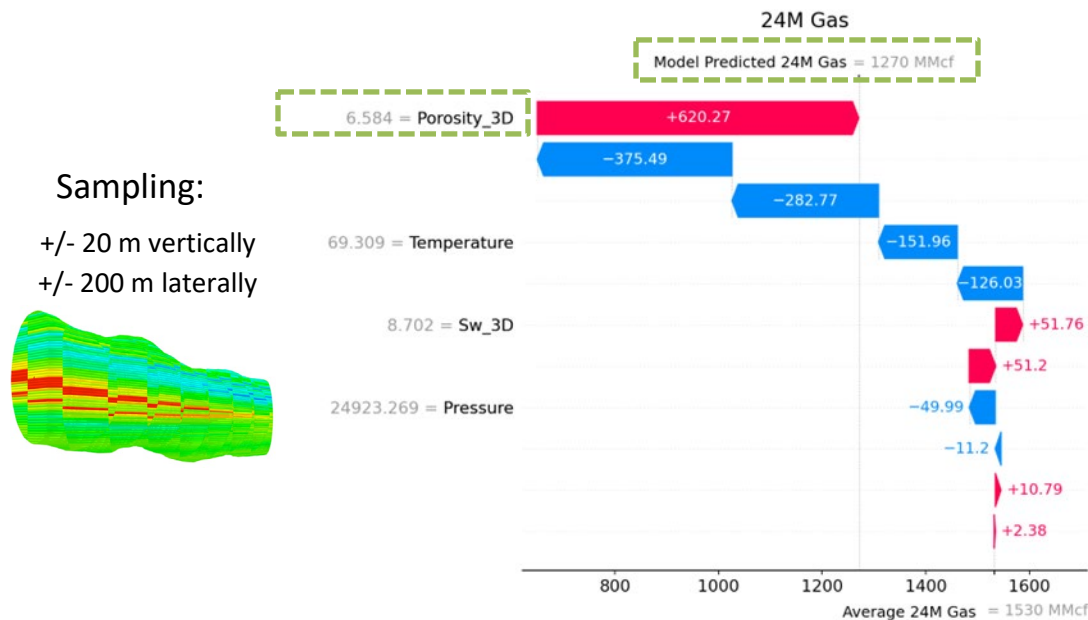


Figure 3B: Porosity sampled from 3D Montney geomodel and used as input into machine learning model. The 3D geomodel captures vertical heterogeneity at a 2 m resolution and resulted in a model error of 9%. It is significantly better than using vertically blended porosity (Schlosser, 2022).



Example 2: Using 2.5D Mapping to Untangle Stacked Production in the Spirit River

While 3D geomodels have shown improved machine learning predictive capabilities, not all plays have 3D geomodels to leverage. Considering this, however, improving accessibility of ‘2.5D’ mapping can be used to help organize and bin production data in complex stacked reservoirs. Furthermore, sampling of 2D mapped geological parameters along lateral well length, allowing engineers to incorporate vertically blended geological factors to well performance and type curves. Combined, this allows consistent in-house naming conventions of production formations, differentiation of stacked producing zones, and improved understanding of well spacing and performance across the fairway.

Spirit River Mapping Details

The Spirit River regional 2.5D mapping used in this example spans from southeast of Willesden Green to north of Elmworth. The mapping separates the formation into the Wilrich (Lower Falher), Falher (four members), and Notikewin. Although differentiating the typically “undifferentiated Manville” section between the Notikewin and Wilrich is a simplification, the approach effectively captures the complexity of stacked development. General characterization parameters are summarized in Table 3.

Table 3: General mapping parameters across Spirit River Fairway

General 2.5D Model Parameters

Data and Quality Control	Well control with tops n ~ 14,000
Stratigraphic Framework	Horizons 6
Map Extent	43,500 km ²
Properties in 2.5D	Porosity
	Water Saturation
	Pressure
	Temperature
Mapping Resolution	OGIP
	250 m x 250 m
Algorithm	Minimum curvature

Stacked Development in the Spirit River

Industry nomenclature for producing formations is inconsistent, complicating the organization of wells by producing zones and their proximity to offsets. Figure 4 compares producing formation data from public sources with 2.5D mapping-derived zone names. The structure mapping and well binning significantly improves producing zone organization, enabling engineers to identify same zone offset production, assess the implications of stacked zones, and analyze regional stacking trends within the fairway to support development planning (Figure 5).

Figure 4: Producing formation from public data (left) compared to 2.5D-defined producing zone (right).

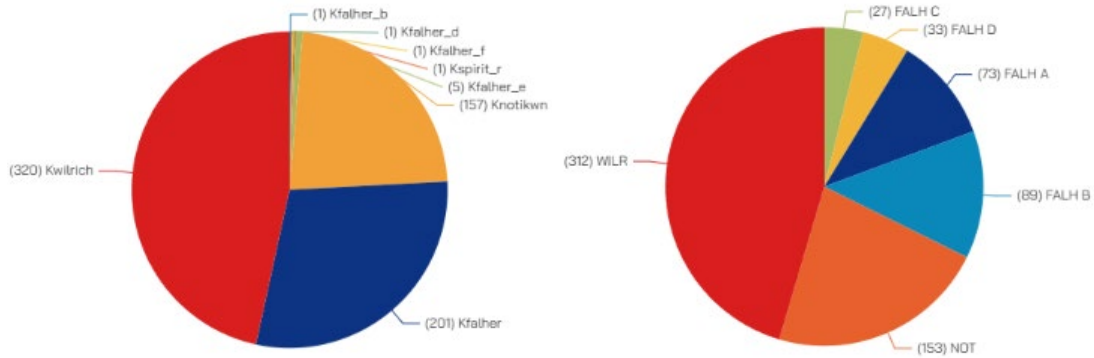
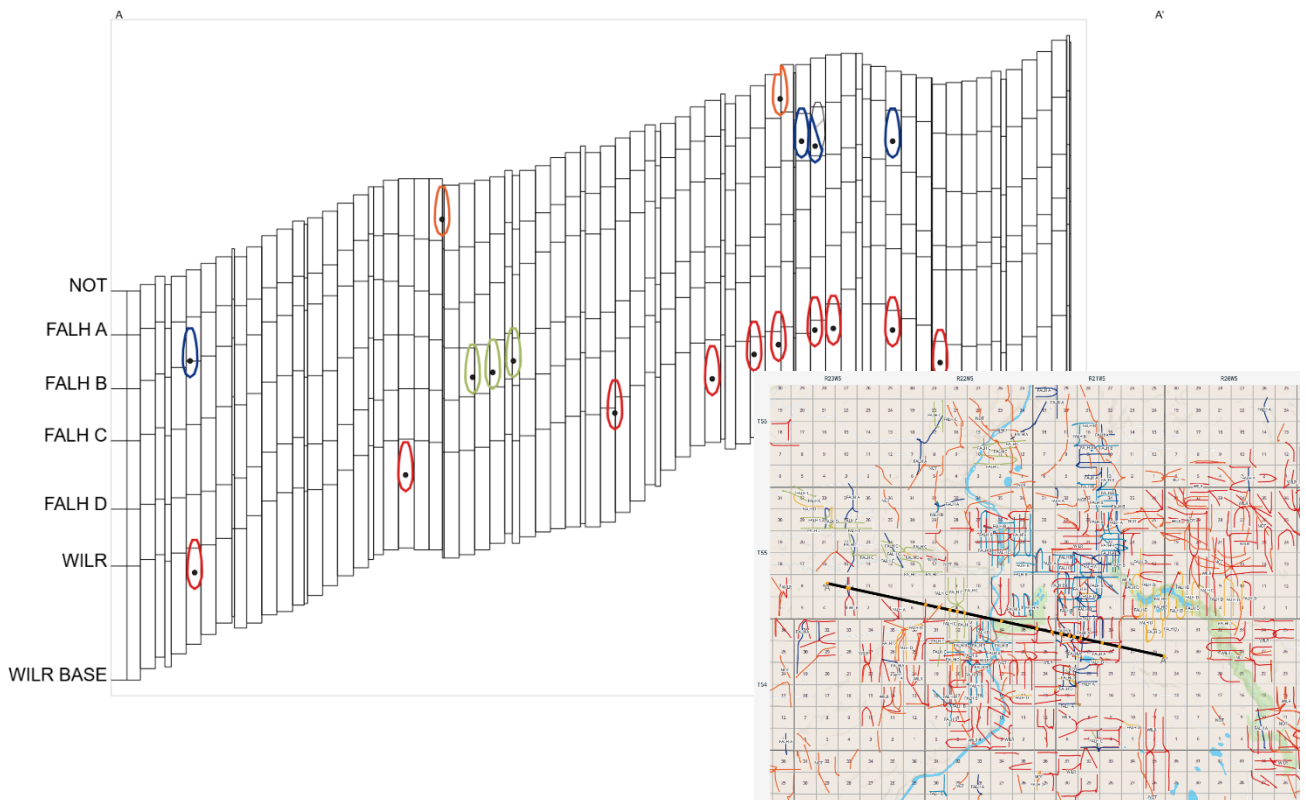


Figure 5: Example of ability to visualize and organize stacked zones using 2.5D horizons. Projected cross section shows 2.5D defined Spirit River horizons and producing lateral wells coloured by zone (gun barrel view).



Conclusion

Improving the accessibility of geological characterizations empowers engineers to address complexities across the oil and gas lifecycle, from exploration and appraisal to production, evaluation, and optimization. Case studies from the Montney and Spirit River formations illustrate these benefits, showcasing enhanced machine learning accuracy in vertically heterogeneous reservoirs and better organization of stacked production zones. Improved accessibility to geological characterizations enhances collaboration between geologists and engineers in achieving successful reserve evaluations, asset optimizations, valuations, and supply studies.

Acknowledgements

References

Schlosser, T. (2022). Revenge of the Grid Cells. *SPE Workshop: Montney and Duvernay - Poised to Capitalize Upon Opportunity*. Nov 1 – 3, 2022. Lake Louise, AB.