GEOSTEERING

What Works,
What Doesn’t
Summary

- What is geosteering
- Where is geosteering used
- Examples of geosteering interpretations in various reservoirs
- Challenges for geosteering interpretations
- Conclusions: what works, what doesn’t
- Potential applications of geosteering process in WCSB plays
Geosteering process

- **Setup**
  - Real-time data stream, 24/7 supervision, specialized software

- **Correlation of MWD curves with TVD curves of offset wells**
  - Pinpoint distance from stratigraphic markers
  - Determine apparent dips and their lateral extent
  - Establish trends and projections, MD/TVD/Inc targets
A. Acquire data
B. Determine **blocks** of constant apparent dip
C. **Correlate** curve signature
D. Calculate apparent **dip** and **distance** from markers

**Signature correlation**

Wellbore position in structure and apparent formation dip
Geosteerer assesses stratigraphic position and project targets based on calculated apparent dips:
Geosteering Efficiencies

- Drilling efficiencies
  - Increased ROP, less sliding, staying in optimal drill window, longer reach
- Better reservoir penetration
  - Better in-zone vs out-of-zone, staying in optimal reservoir target
- Faster completions
  - Decreased tortuosity, uniform reservoir conditions
- Increased ROI, predictability

**Drilling Days vs Depth**

- Not Geosteered
- Geosteered

**Drilling Efficiency over Time**

- Not Geosteered
- Geosteered
Examples of geosteering

- Montney
- Duvernay
- Horn River
- Bakken
- Spirit River
- Cardium
- McMurray
- Viking
The Montney can be very different from the shales in the West of the basin to the shaley siltstone (“shilts”) at the Alberta/BC border and the oil charged sandstone in the north-eastern reaches of the trend. Gamma signatures vary wildly from very busy to almost character-less.
Montney

Gamma curve character is very consistent across large distances, making it easy to correlate even when curve character is not very well defined in depth.
Geosteering in the Duvernay Formation is relatively straightforward, as the formation exhibits good gamma curve definitions, correlated over long distances. The organic rich shale has high gamma readings, while readings drop sharply in the more calcareous layers. Lateral continuity is generally very good, especially in the northern Duvernay trend. Geosteering issues can arise in the Southern Duvernay trend where lateral changes can occur in gamma signatures. Bulk resistivity is a viable option in that scenario.
The Horn River Formation (including the Evi, Otter Park and Muskwa Members) have very good vertical definition on the gamma curves, similar in character to the Wolfcamp and Spraberry in Texas. Signatures are easy to identify and to follow along lateral sections of horizontal wells.
Bakken
Channel plays are complex, with shale lenses and channel margins and incisions, making it more difficult to geosteer. Channel sizes vary from hundreds of meters to kilometers, with smaller scale lithological and sedimentary features that can throw off correlations.
A combination between geomodelling and geosteering is better suited in steering these type of plays than pure geosteering based only on type logs. Other channel plays and shallow water reservoirs exhibit the same issues.
The Cardium Sandstone has a relatively monotonous Gamma signature, with significant lateral variation. Geosteering wells drilled in the Cardium Sand require a lot of attention, and several offset wells along the section are needed for accurate interpretation. Wells drilled below the Sandstone horizon (as are most horizontal wells targeting the Cardium oil in Central Alberta) show more vertical definition in gamma signature, as well as better lateral continuity. Wells drilled in the Cardium Siltstone are easier to steer than wells targeting the Cardium Sandstone proper.
McMurray

Besides clean sand saturated with bitumen, the McMurray contains inclined heterolithic beds (IHS) and breccia, both with beds/clast scale of millimeters to centimeters. It is impossible to identify features of this small scale on logs (that have resolutions of 0.2 meters). Azimuthal Resistivity on its own may not be enough for effective steering, but in connection to resistivity modelling, it remains key to steering McMurray wells.
The Viking Sandstone is generally thin and gamma signature above and below the sandstone are relatively well preserved laterally. Drape features and other structural events along Viking wells are generally easy to identify. The difficulty in geosteering Viking wells is more related to the extreme rate of penetration recorded in this play. Data quality is also negatively impacted by extreme speeds of drilling.
Other plays with geosteering Potential

- Exshaw
- Shaunavon
- Glauconitic
- Ellerslie
- Pekisko
## Applicability of geosteering approach

<table>
<thead>
<tr>
<th>Play</th>
<th>Geosteering</th>
<th>Depositional environments</th>
<th>Energy</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montney</td>
<td>Very good</td>
<td>Turbidite fans to lower shoreface</td>
<td>Deep, low energy</td>
<td>10-100km trends</td>
</tr>
<tr>
<td>Duvernay</td>
<td>Very good</td>
<td>Deep basinal mudstones</td>
<td>Very deep, low energy</td>
<td>10-100km trends</td>
</tr>
<tr>
<td>Bakken</td>
<td>Good</td>
<td>Shallow marine</td>
<td>Shallow, high energy</td>
<td>10-50 km trends</td>
</tr>
<tr>
<td>Spirit River</td>
<td>Poor</td>
<td>Coastal plains, lagoons, channels, deltas</td>
<td>Shallow, high energy</td>
<td>150-500m wide, 1-10 km long</td>
</tr>
<tr>
<td>Cardium</td>
<td>Moderate</td>
<td>Marine sandstones, inner shelf, shoreface</td>
<td>Moderate, high to moderate energy</td>
<td>5-20km trends with 200m wide channels</td>
</tr>
<tr>
<td>McMurray</td>
<td>Poor</td>
<td>Fluvial channels, tidal estuaries, channels</td>
<td>Shallow, high energy</td>
<td>1-5km, features 1-20mm</td>
</tr>
</tbody>
</table>
Optimal Geosteering targets

- Deep, low energy depositional systems
- Large scale deposit
- Lateral continuity
- Well defined curve signatures
- Where cuttings are not critical for steering