Remote Geosteering
Applications in Conventional and Unconventional Plays in Canada

CSPG, Operations Division Talk
Calgary, January 15, 2020

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McLeay Geological Consultants
Introduction:
In Canada, there is a big hesitation in using Remote Geosteering, either due to initial price or if they tried to use it, didn’t get desired result because of wrong selection of very expensive tools. The advancements in the field of Remote Geosteering, has proved that it is not only safe, but also provides improved/maximized reservoir contact, resulting in higher production, better sustainable rates and better sweep. It has greatly helped drilling successfully in the geological and structurally challenging reservoirs, conventional and unconventional, simple to complex and thick to thin reservoirs and ultimately resulting in the form of lower development costs.
Remote Geosteering has almost eliminated the concept of lithological and structural question marks, sidetracks and completion issues due to poor well trajectory.

Now the important thing is the selection of tools. Not all the tools respond the same or are utilized in every type of reservoir. The normal understanding about the service companies is that they want to sell their tools and will try to encourage the most expensive tools irrespective of whether it will be fully beneficial or not for those specific reservoirs. Being Geosteering geologists, we have experienced this issue first hand. So, I believe an experienced good geosteering geologist can advise the specific tool required for each different type of reservoir.

The good thing about utilizing these advanced tools is that prices are comparatively lowered down too much and some of the service companies, instead of total package, like tool plus RNS are offering tools only. The clients can save a lot by using other Geosteering consulting companies like McLeay Geological Consultants, we have monitored these tools and navigated successfully for our clients a lot.
Build Section
1. Proper landing in the target zone is the key factor
2. Normally Start MWD tools from KOP and land in target zone.
3. In some cases like conventional carbonates, targeting specific layer, we normally use LWD tools to make sure we are landed in that specific layer.
4. In more critical situation, when we just prick into the target zone and drill ½ to 1 meter into it and stop for the casing, we use bit resistivity tools, GVR, AFR etc
5. When we want to land the well below low perm zone in carbonate, we run gamma and do the periodic pressure tests to confirm the zone.

Lateral Section:
1. Gamma
2. LWD tools (Gamma, Density / Porosity & Resistivity)

In the International market the standard LWD tools used are triple combo. But in Canada, due to regulatory limitation of density tool, gamma only. Comparative to traditional well site, Geosteering software's have enabled us to use the gamma tool in more versatile and effective manner and most of the time we can exactly pin point our position in the reservoir. Gamma tool has certain limitations in different reservoirs and we need to supplement with other tools. Image tool gives the cutting up and down feature, identify exact position in the reservoir, best zone to place the well and calculates formation dip.

Types of Images:
Gamma, Density and Resistivity
Different types of images behave differently in different type of reservoirs. Proper image tool be selected for that specific zone.

**Bed Boundary Mappers**
In discontinuous, lenticular bodies or laterally heterogeneous reservoirs we need to add some advanced bed boundary mapping tools like, ADR, Periscope, Azitrek, Guidewave or further advanced tools like, Periscope Plus, Geosphere, Visitrek, Earthstar etc. Good thing about utilizing these advanced tools now is that the prices are comparatively lowered down too much and some of the service companies, instead of total package, like tool plus RNS are offering tools only. The clients can save a lot by using other geosteering consulting companies like, we have monitored these tools and navigated for our clients a lot.

Normally 2 terms are used in Geosteering, Active (Reactive) and Pro-active. In Canada most of the geosteering is the reactive geosteering where we orientate our well trajectory based on the tools response when they are in contact with the lithological variations. While in pro-active geosteering we use the advance LWD tools, like Bed boundary mapper. These tools give the information about dip changes or culmination of clastic beds based on distance to boundary changes so we can orientate the well trajectory in advance before digging into the top or bottom of the reservoir.
Standard Geosteering Applications
In thin carbonate layers, it is very difficult to land in a specific layer with gamma curve only. We use LWD tools for landing.
In more critical situation, when we just prick into the target zone and drill ½ to 1 meter into it and stop for the casing, we use at bit resistivity tools.
Pressure Test while drilling is used to land and geosteer the well in better permeability zones.
Lateral Section
### Triple Combo Lithological & Petrophysical Indicators

<table>
<thead>
<tr>
<th>ROP Avg</th>
<th>At Bit Inclination</th>
<th>Gamma Ray</th>
<th>MD</th>
<th>Surveys</th>
<th>Deep Phase Res</th>
<th>Bulk Density</th>
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<td>fph</td>
<td>deg</td>
<td>api</td>
<td>ft</td>
<td>Inc</td>
<td>ohmm</td>
<td>g/cc</td>
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#### Delta Rho LCR
- g/cc: -0.75000 to 0.25000

- Shallow Phase Res: ohmm
  - 0.20 to 2000.00

- Medium Phase Res: ohmm
  - 0.20 to 2000.00

- Rapid Sample PE: b/e
  - 0.00 to 10.00

#### Key Observations:
- **3 b/e:** Density > Neutron in Dolomitic Limestone
- **4 b/e:** Density = Neutron in Dolomitic Limestone
Image tool gives the cutting up and down feature, identify exact position in the reservoir, best zone to place the well and formation dip.
## Types of Images: Gamma, Density and Resistivity

<table>
<thead>
<tr>
<th>Index</th>
<th>ROP</th>
<th>Resisivity AT Corr 2KHz</th>
<th>Resistivity MD Corr 4KHz</th>
<th>StarTrek Image</th>
<th>FD-Helium 16</th>
<th>Near Bit Gamma Image 4 Quad</th>
<th>Gamma</th>
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**Images**

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<tr>
<td>Vertical depth</td>
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**In Slips**

- 7.22 hours, Running Rotating Circulating
- 5.58 hours, Drilling Rotating Circulating
- 5.44 hours, In Slips
- 2.30 hours, In Slips Rotating
- 1.07 hours, Off Slips Rotating
- 1.03 hours, Off Bottom

**Brig Hole**

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<tr>
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<th>Inc dega</th>
<th>Az dega</th>
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<th>LW offs. ft</th>
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Thin layer Identification with ADN, GVR and AFR Images
Homogeneity in Carbonates, ADN does not show any feature
Thin Zone (Carbonates)

<1m thick zone in carbonate geosteered with Triple Combo and AFR image
Thin Target Zone (Carbonate)

<1m thick zone in carbonate geosteered 100% reservoir contact with Triple Combo and AFR image
Bed Boundary Mappers

- Periscope & DDR (SLB)
- ADR (Sperry)
- Azitrak (BHI)
- Guidewave (Weatherford)

Tool picks the resistivity contrast boundaries Azimuthally, DOI 4-7m
AZM (Limited to pick single bed boundary, can’t pick many layers)
Bed Boundary Mappers

Conductive beds from bottom

Well Path
Deep Directional Resistivity (DDR)

AZM DOI +30m, can’t mark boundaries in different layers
Ultra Deep Resistivity
AZM DOI +30m, can mark boundaries in different layers

Geosphere & Periscope Plus
Visitrek
Earth Star
Conventional and Unconventional Plays in Canada
If thick heterogeneous sand zone then use Ultra Deep Resistivity tool
Cardium Sand
Gamma Model

Lateral Heterogeneity
Re-Steered Viking Sand

In structural Uncertainty Zones, adding image will help for successful geosteering
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In thick, vertical and lateral heterogenetic zone, for best results add any Ultra Deep Bed Boundary Mapper
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Ellerslie Sand

In thick, vertical and lateral heterogenetic zone, client used Deep Bed Boundary Mapper, no success. Whereas recommended tool for such zone is Ultra Deep Bed Boundary Mapper.
Ellerslie Sand

Geosteering Based on Gamma Model
Duvernay Shale

Geosteered a lot of wells successfully in mid of target with gamma only
In structurally un-certain zones, adding image only will ensure 100% reservoir contact.
In structurally un-certain zones, adding image only will ensure 100% reservoir contact.
Due to poor structural control, client interpreted bottom part. Results after the facts confirmed it was drilled in top. Simply adding image, eliminates such issues.
Due to poor structural control, client assumed bottom part. Results after the facts confirmed it was drilled in top. Simply adding image only, eliminates such issues.
If using 3-4m offset from the bottom, then image tool along with gamma is enough. If using Bed Boundary Mapper then offset to bottom can be reduced to 1m. This will give 2-3m extra pay zone and production.
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Different zones respond frack differently. Instead of gamma only, we can use LWD tools to identify best zone for fracking and stay max in that zone.
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Data provided by the client, originally well placed in wrong sand by the well site. Best results can be achieved by using gamma with the image.
Data provided by the client. Best results can be achieved by using gamma with the image.
Shaunavon Sand
Conclusion

• Good Understanding Of Geology of The Project Area
• Work Out Potential Geological And Structural Challenges
• Select Proper Tools According To The Reservoirs And Challenges. An expert Geosteering Geologist can always suggest better tool options
• Adding Image Tool Can Further Reduce The Structural Issues
Thank You