

# **PS Turning Challenges into Opportunity – Lessons Learnt from Data Acquisition in HPHT Horizontal Wells\***

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## **Abstract**

Petroleum Development Oman's tight gas flagship project recently advanced from the exploration/appraisal to the pilot phase. One of the key changes in well construction was piloting the first horizontal wells into these deep HPHT tight gas reservoirs to assess increased EUR/well compared to nearby vertical wells. One fundamental challenge encountered when drilling the first horizontal wells was that the established EWL logging strategy no longer could be pursued successfully, and, as a result, various alternatives needed to be established.

In 2012, the first horizontal well demonstrated that like in most unconventional projects, adapting the working strategy is a must. Where the down hole conveyance of logging tools in the project's vertical HPHT wells traditionally could be handled by conventional wireline equipment, it proved that deploying these tools on drill pipe (TLC) did not result in satisfactory results. Several workshops with various vendors finally resulted in a LWD solution that did not only overcome the logging challenge but turned out to be a commercial opportunity as well.

The third horizontal well drilled in 2014 with an open hole completion however required accurate caliper data that could not be acquired with LWD. A recent introduction to the market of an Open Hole HT tractor however was successfully deployed with calipers and presents a solution for other data acquisition in the next horizontal wells too. Similar to the learning curve witnessed in well construction by the well engineering team, the subsurface team has also gone through a steep learning curve with respect to data acquisition in horizontal wells. The journey from painfully slow and unreliable wireline data acquired on drill pipe to

LWD with a limited tool set back to wireline tools but deployed with an open hole tractor was only possible through the increased understanding of downhole temperatures as a function of mud type and also availability of new technology.

This presentation will demonstrate the changes that PDO was required to perform to satisfy the projects data acquisition and drilling requirements whilst minimising risks and limit costs. We think that these are lessons that other participants of this conference can apply in similar assets too.

# Turning Challenges into Opportunity – Lessons learnt from Data Acquisition in HPHT Horizontal Wells

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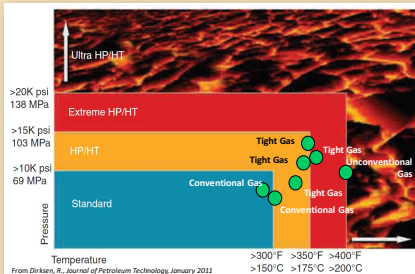
## Project Overview



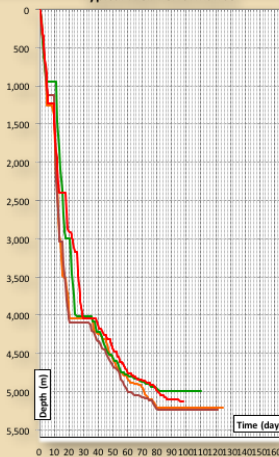
In 2009 Petroleum Development Oman (PDO) has started an ambitious deep and tight gas exploration programme exploring for previously untapped reservoirs. Several discoveries are now heading to the development phase.

## Challenges – Hot and Hard

Reservoir Depth	4700-5200m BDF
Fluid Gradient	2.8 - 3.0 kPa/m
Reservoir Pressure	P170,000 – 90,000 kPa
Reservoir Temperature	170-180 °C
H <sub>2</sub> S in Reservoir fluid	5-25 ppm
CO <sub>2</sub> in Reservoir fluid	1.5-2.5 mol%
Fracture Gradient	19-25 kPa/m
Rock Compressive Strength	20-65 k PSI

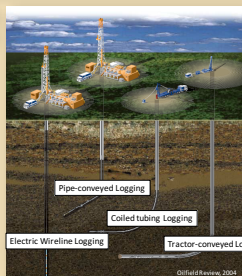


Typical Well Performance

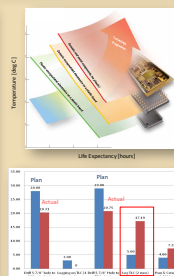


## Logging Strategy

2009	2010	2011	2012	2013	2014	2015
Exploration	Appraisal	Pilot	Development			
<b>Exploration Wells:</b> <ol style="list-style-type: none"> <li>1. Fat Well Design</li> <li>2. UBD</li> <li>3. Prove Presence of Hydrocarbon</li> </ol> <b>Appraisal Wells:</b> <ol style="list-style-type: none"> <li>1. Updated Well Design</li> <li>2. Prove Extent of Structure</li> <li>3. Chase Hydrocarbons Down Dip</li> </ol> <b>Pilot Wells:</b> <ol style="list-style-type: none"> <li>1. Completion Optimisation</li> <li>2. EUR/Well Optimisation (Vertical vs Horizontal)</li> <li>3. Well Cost Reduction</li> </ol> <b>Development Wells:</b> <ol style="list-style-type: none"> <li>1. Fit for Purpose Well Design</li> <li>2. Reduce Well Duration</li> <li>3. Reduce Well Cost</li> </ol>						



Openhole Conveyance Method for logging	Advantages	Disadvantages
Slickline	1. Cost effective 2. Fast	1. < 65 deg 2. No electr. connection
Conventional Wireline	1. Cost effective 2. Fast	1. Gravity dependent (< 65 deg)
Tough Logging Conditions (TLC)	1. Tool availability 2. Good for well control	1. Requires pipe and personnel 2. Slow
Logging While Drilling	1. Successful 2. Realtime	1. Expensive 2. Not all tools available



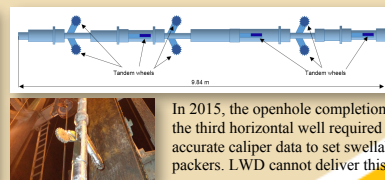
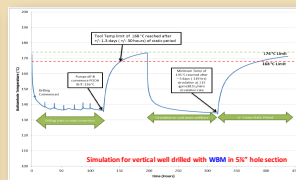
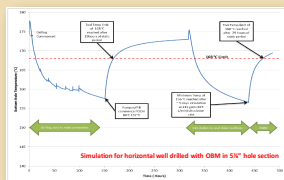
In 2012, the first horizontal well demonstrated that the established logging strategy required adapting. EWL tools on pipe did not work. HPHT LWD was introduced for the first time in the Middle East, which was both technically and financially successful.

## New Solutions



Two Game changers in 2015:

- Transient temperature modelling
- New OH HT tractor



In 2015, the openhole completion in the third horizontal well required accurate caliper data to set swellable packers. LWD cannot deliver this. Luckily, OH HT tractors were introduced to the market in time.

## Summary

Similar to the well construction learning curve witnessed by the well engineering team, the subsurface team has also gone through a steep **learning curve** with respect to data acquisition in horizontal wells. The journey from painfully slow and unreliable wireline data acquired on drillpipe to LWD with a limited tool set back to wireline tools but deployed with an openhole tractor was only possible through the increased understanding of downhole temperatures as a function of mud type and also availability of new technology.

**Integration** between all subsurface functions, well engineering and drilling fluid specialists was a key corner stone to achieve a solution to obtain the required data sets to complete and evaluate some of the world's deepest and hottest reservoirs.

In-depth **collaboration** with leading service providers first led to a successful deployment of HPHT LWD and more recently to a first successful OH HT tractor run. Both these successful deployments open up new deep prospects where reliable and affordable data acquisition strategies are of paramount importance.



Swell Packer pic



## References:

1. SPE 175729 • Overcoming High-Temperature Logging Challenges While Staying Cost- Effective for a Tight Gas Project in the Sultanate of Oman (2015)
2. SPE 177761 • From Exploration to Production in 4 Years: Industry Collaboration Leading to Accelerated Learning Curve for Large Tight Gas Project in the Sultanate of Oman (2015)
3. SPE 178203 • Successful Logging on Tractor in a High-Temperature Openhole Horizontal Well in a Tight Gas Field in the Sultanate of Oman (2016)



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Petroleum Development Oman