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

Andreas P. Briner¹, Sergio Tessari¹, and Ali Mahrouqi¹

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¹Gas Directorate, Petroleum Development Oman, Muscat, OMAN (abriner@yahoo.com)

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

**Logging Strategy**

**Exploration Wells:**
1. Fat Well Design
2. UID
3. Present Presence of Hydrocarbon

**Appraisal Wells:**
1. Updated Well Design
2. Present Extent of Structure
3. Check Hydrocarbons
4. Diversity

**Pilot Wells:**
1. Completion Optimization
2. CUD/Well Optimization
3. Central vs Horizontal
4. Well Cost Reduction

**Development Wells:**
1. Fit for Purpose Well Design
2. Reverse Well Duration
3. Reduce Well Cost

**New Solutions**

Two Game changers in 2015:
- Transient temperature modelling
- New OH HT tractor

**Challenges – Hot and Hard**

**Reservoir Depth**
- 4700-5200m BDF

**Fluid Gradient**
- 2.8 – 3.0 kPa/m

**Reservoir Pressure**
- 70,000 – 90,000 kPa

**Reservoir Temperature**
- 170-180°C

**H2S in Reservoir Fluid**
- 5-25 ppm

**CO2 in Reservoir Fluid**
- 1.5-2.5 mol%

**Fracture Gradient**
- 19-25 kPa/m

**Rock Compressive Strength**
- 20-65 kPa

**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.

**References:**
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)