DEVEX 2017

9 & 10 MAY, AECC, ABERDEEN

Real time data interpretation and integration leads to significant resource volume increase in Lancaster fractured basement field West of Shetland

Dan Bonter – Hurricane Energy

Kamaljeet Singh – Schlumberger

Hurricane

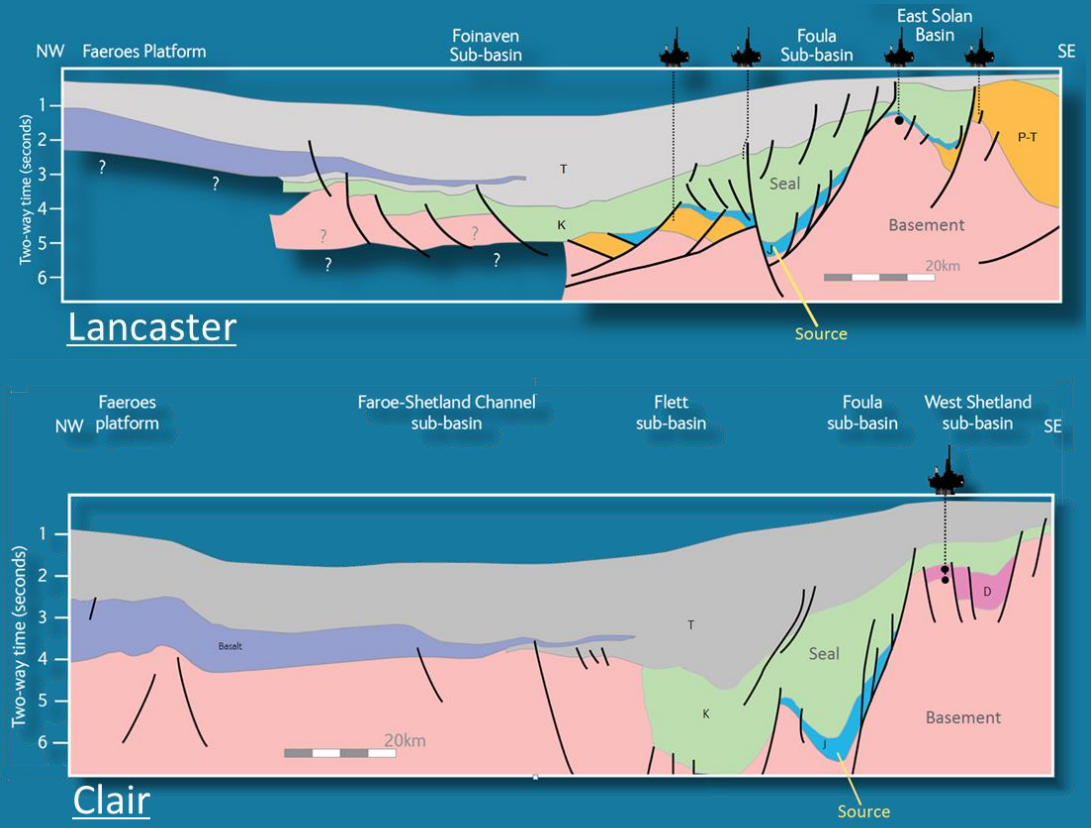
Basement Reservoir Specialists

Schlumberger

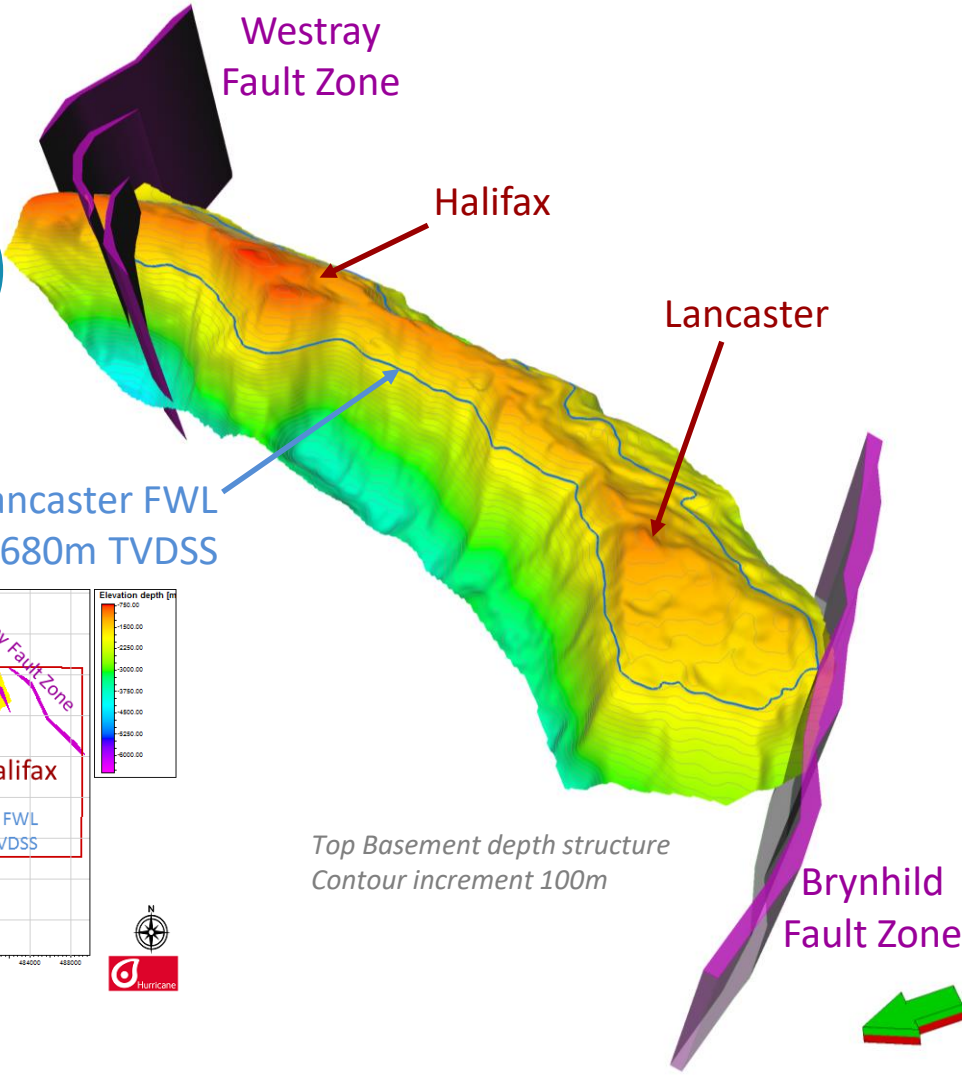

Hurricane Background

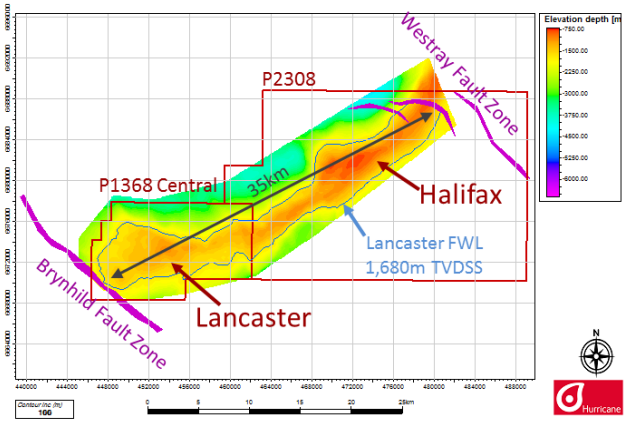
Hurricane Asset Locations

Geological Cross-section



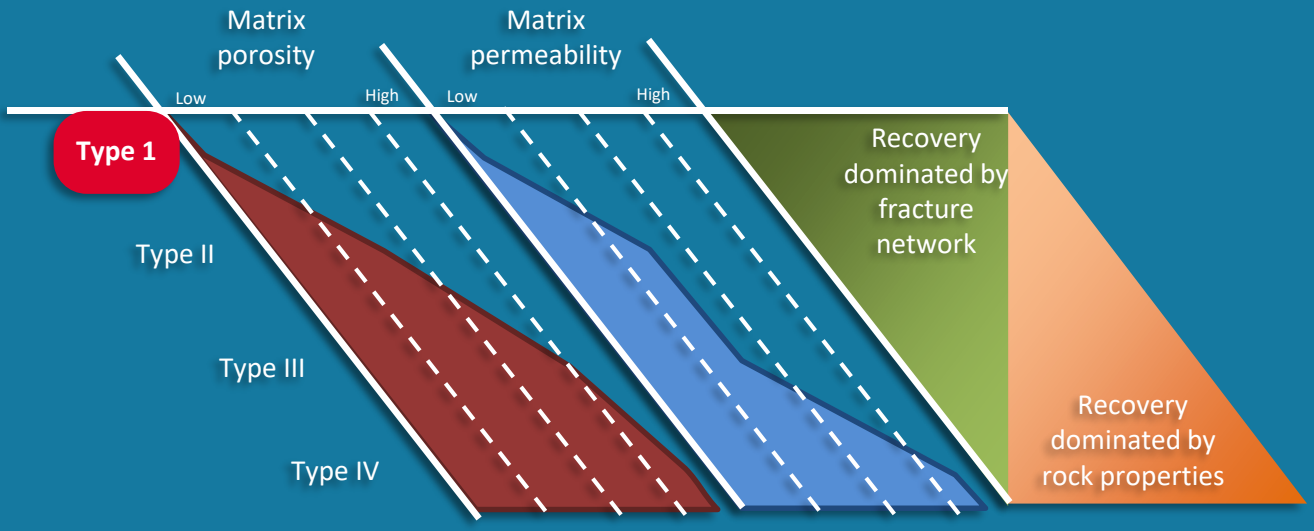
Greater Lancaster Area (GLA)





Top Basement depth structure
Contour increment 100m

Fractured Basement characteristics



Definitions of Naturally Fractured Reservoirs, after Nelson 2001

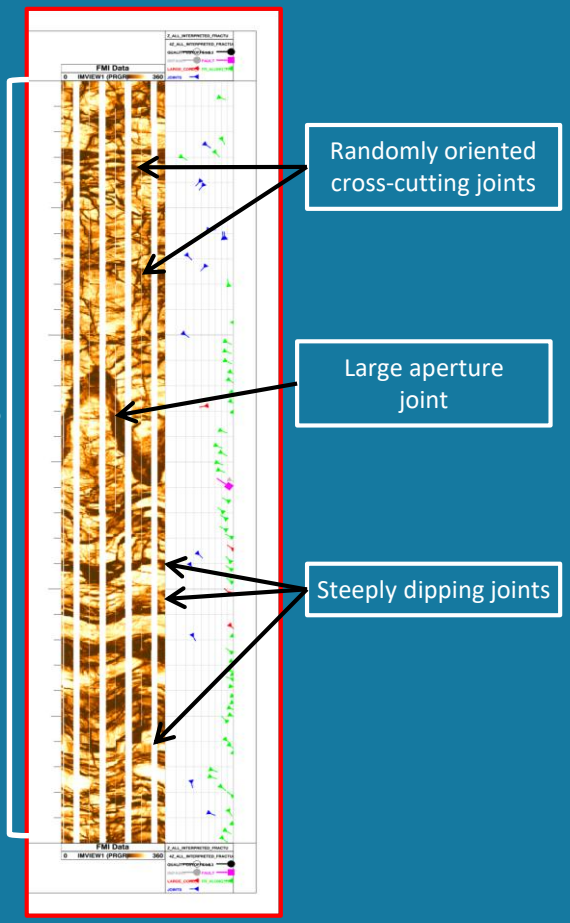
Type 1 Naturally Fractured Reservoirs

- Oil storage and mobility entirely depends on a hydrodynamic fracture network
- Fracture characteristics define reserves
- Static description is critical

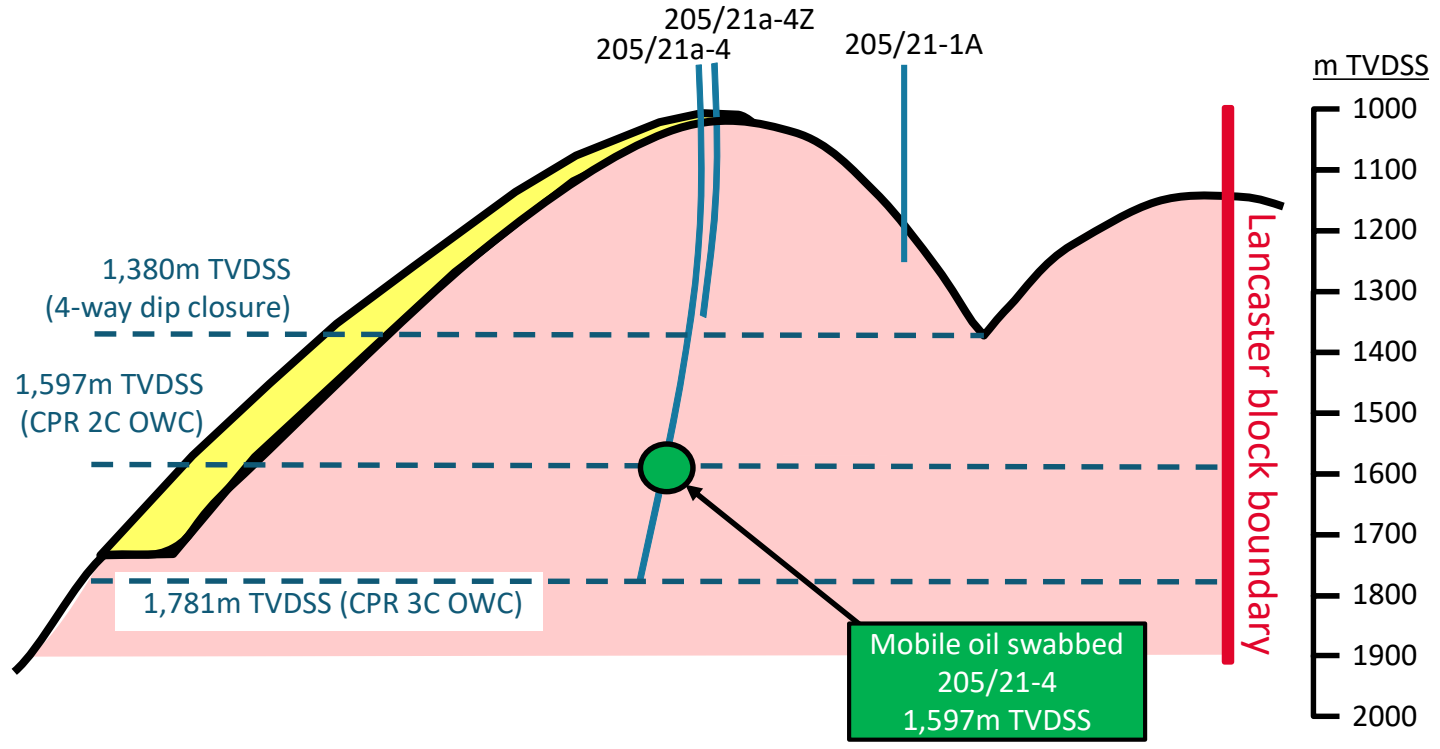
Fractured Basement Reservoir

- Primarily tonalite with minor dolerite intrusions
- 2.3-2.4 billion years old
- Exceptionally long and complex geological history
- Extremely fractured

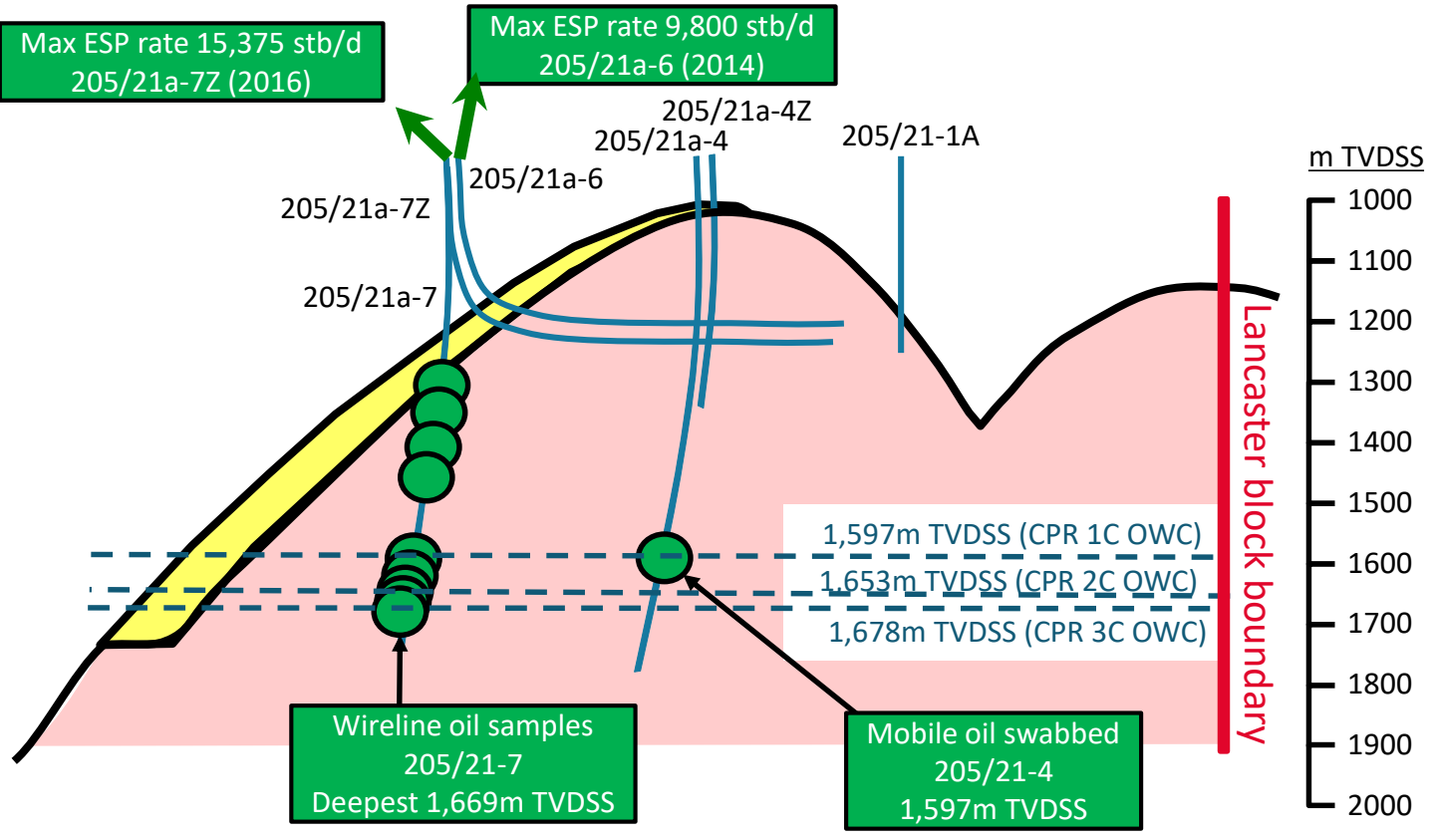
Exposed tonalite on Isle of Lewis, outcrop analogue



Lancaster Schematic (CPR 2013)



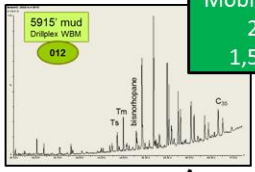
Lancaster Schematic (CPR 2017)



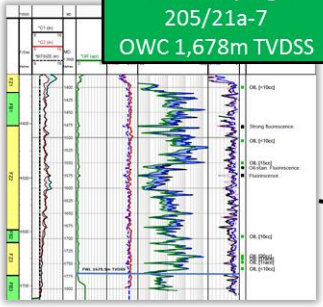
FWL Evidence

Wireline oil samples
205/21a-7
Deepest 1,669m TVDSS

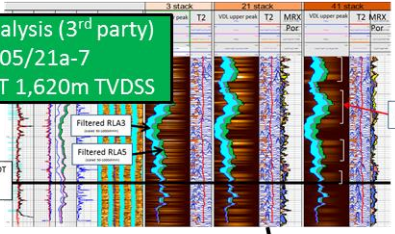
Mobile oil swabbed
205/21a-4
1,597m TVDSS

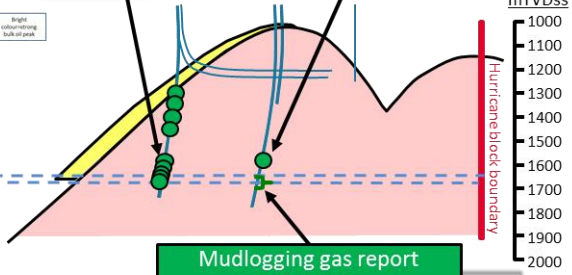


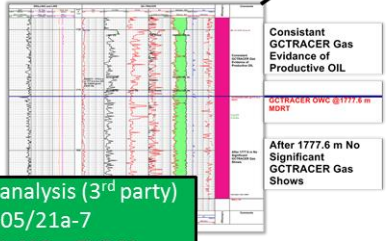
Resistivity logs
205/21a-7
OWC 1,678m TVDSS



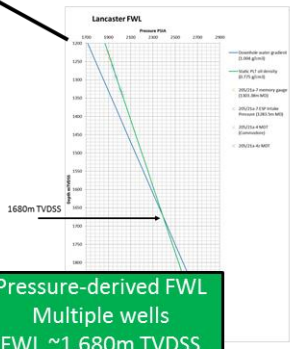
NMR analysis (3rd party)
205/21a-7
Min ODT 1,620m TVDSS







GC Tracer analysis (3rd party)
205/21a-7
OWC 1,685m TVDSS



Pressure-derived FWL
Multiple wells
FWL ~1,680m TVDSS

Mudlogging gas report
205/21a-4
OWC 1,643m-1693m TVDSS

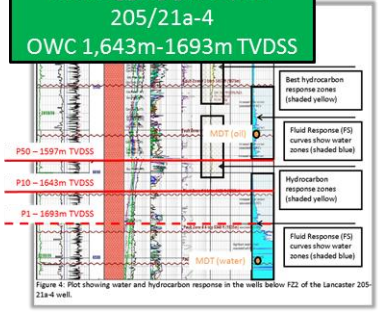
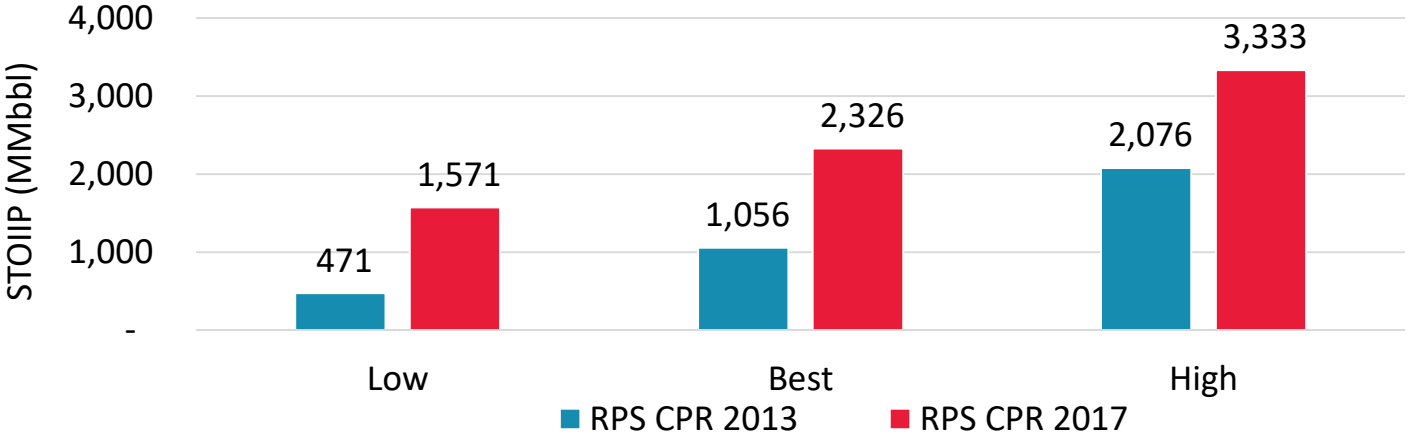


Figure 4: Plot showing water and hydrocarbon response in the wells below FZ2 of the Lancaster 205-21a-4 well.

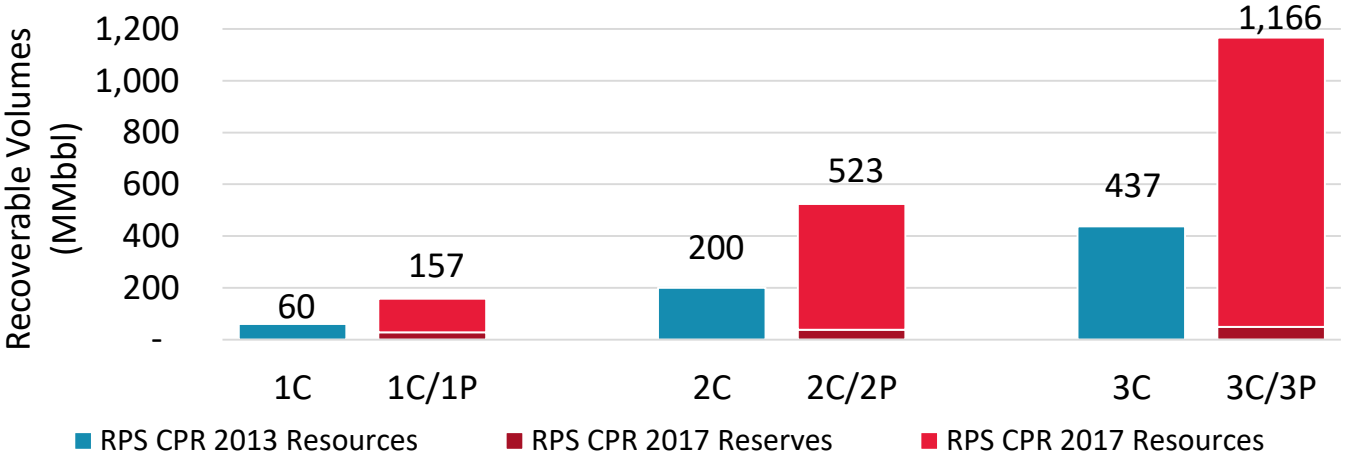
2013 vs. 2017 CPR STOIIP

	RPS 2013 CPR	RPS 2017 CPR
Low	471 MMbbl	1,571 MMbbl
Best	1,056 MMbbl	2,326 MMbbl
High	2,076 MMbbl	3,333 MMbbl



2013 vs. 2017 CPR Recoverable

	RPS 2013 CPR	RPS 2017 CPR		
	Contingent Resources	Reserves	Contingent Resources	**EUR (Reserves + Resources)**
Low / 1P + 1C	**60 MMbbl**	28 MMbbl	129 MMbbl	**157 MMbbl**
Best / 2P + 2C	**200 MMbbl**	37 MMbbl	486 MMbbl	**523 MMbbl**
High / 3P + 3C	**437 MMbbl**	49 MMbbl	1,117 MMbbl	**1,166 MMbbl**

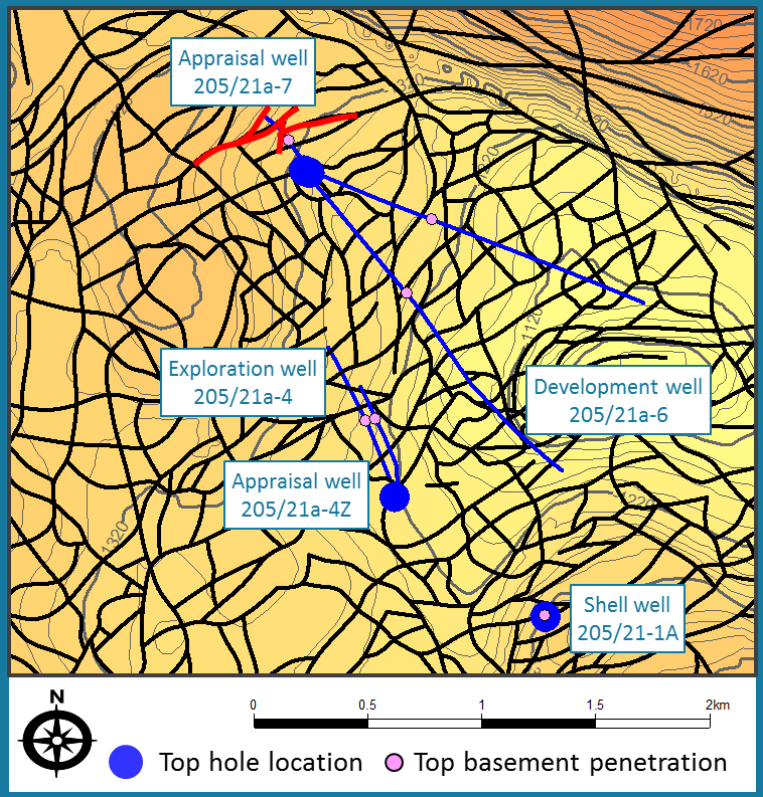


Well 205/21a-7

(Lancaster inclined appraisal well)

205/21a-7 (2016) Appraisal Well

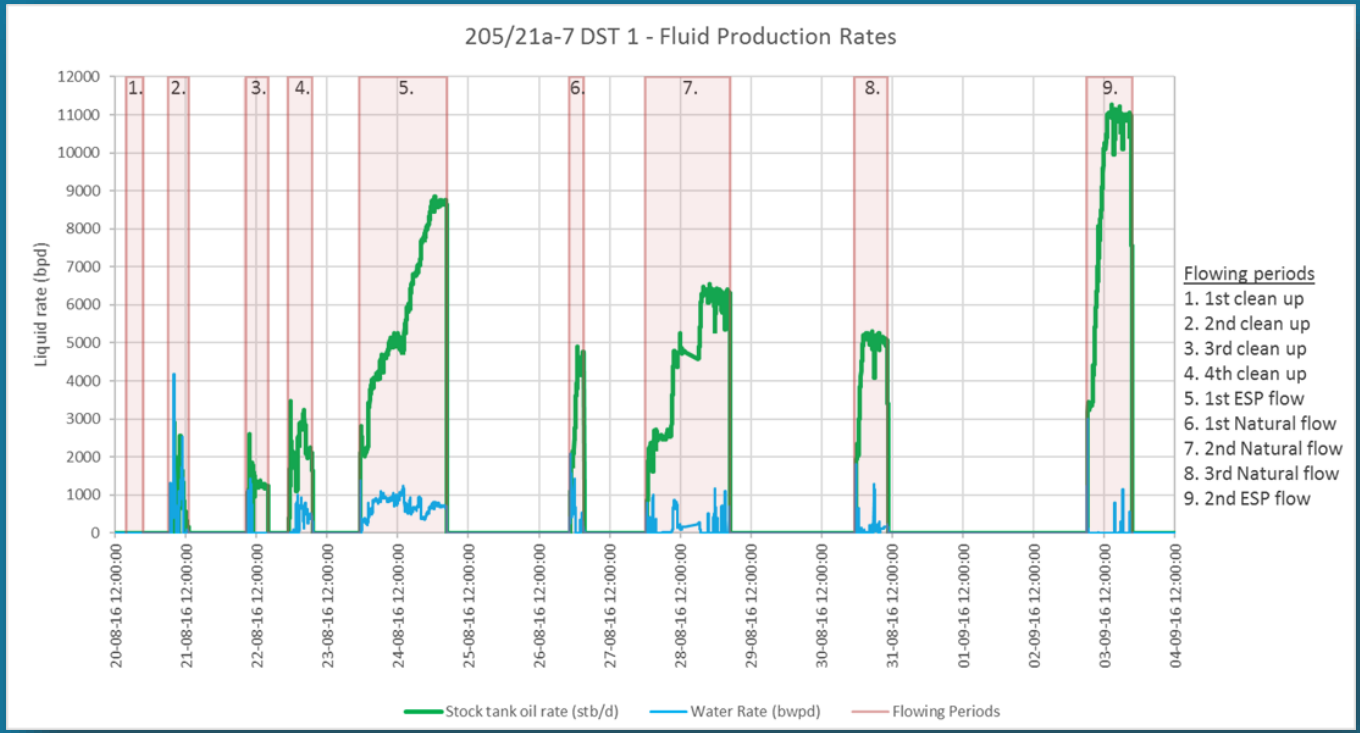
- Inclined appraisal well designed to investigate depth of the oil column and aquifer properties
- Tophole location to be used as second producer via a horizontal sidetrack (25m from 205/21a-6)



Hurricane on the rig

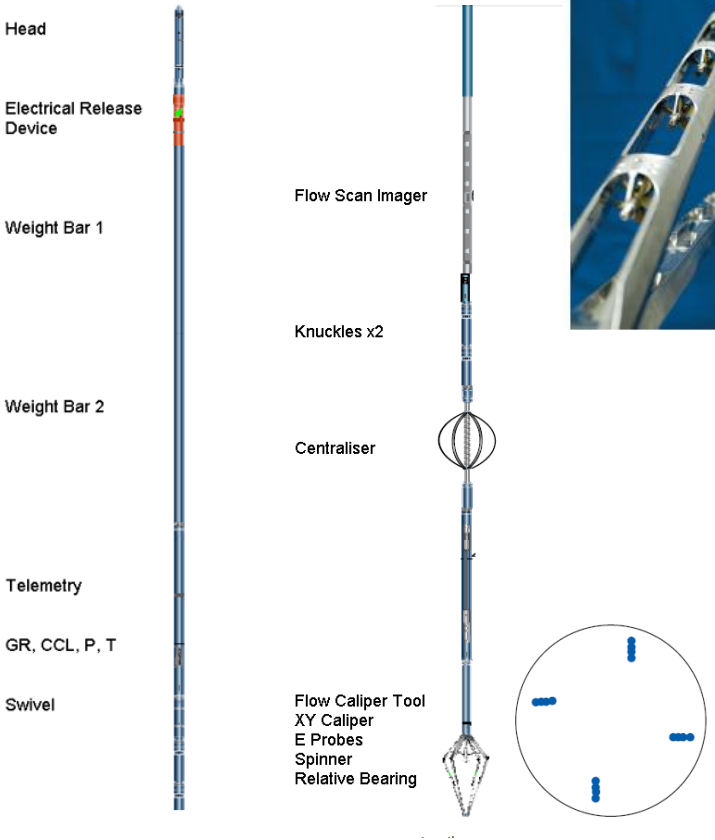
- Hurricane staff (including CEO) onboard during operations to gather and interpret data, making decisions in real time

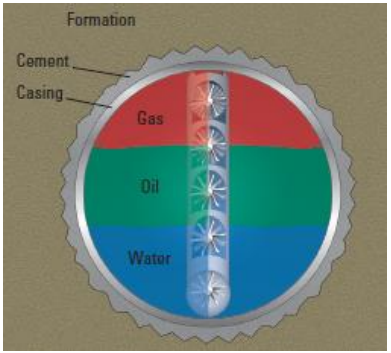
205/21a-7 DST periods

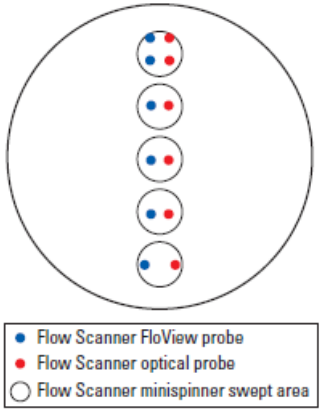


- A number of flowing and shut-in periods were executed to enable a multitude of PLT runs to be performed
- 15 day testing programme

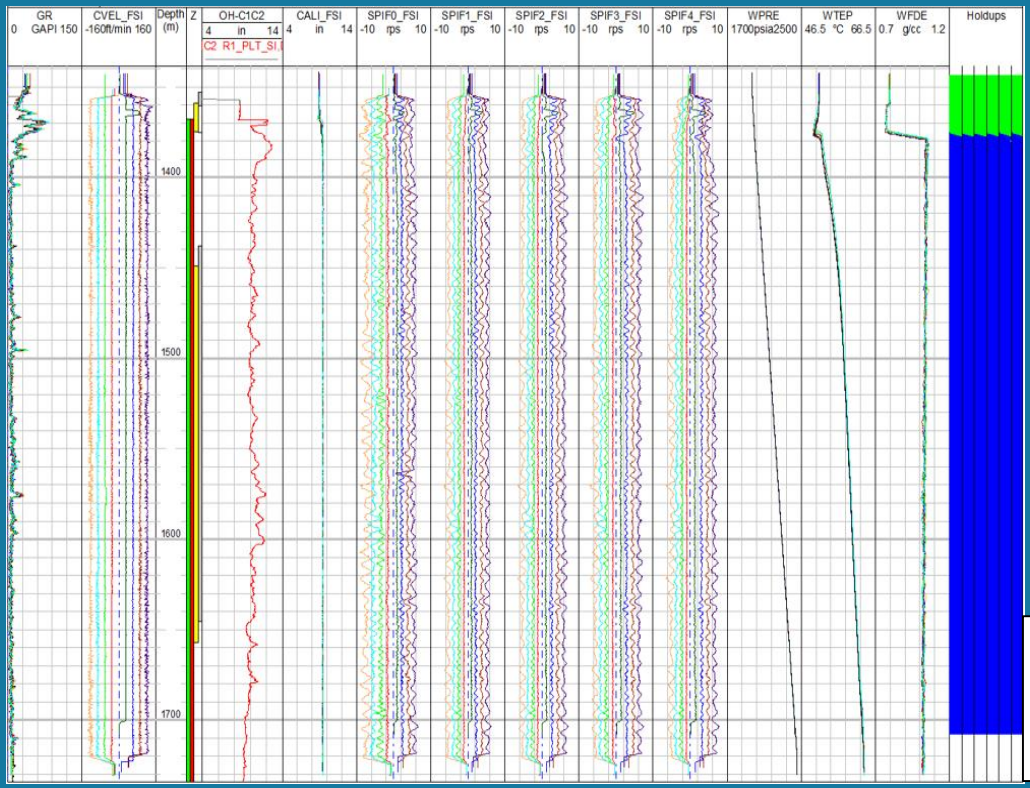
Advanced PLT Tool







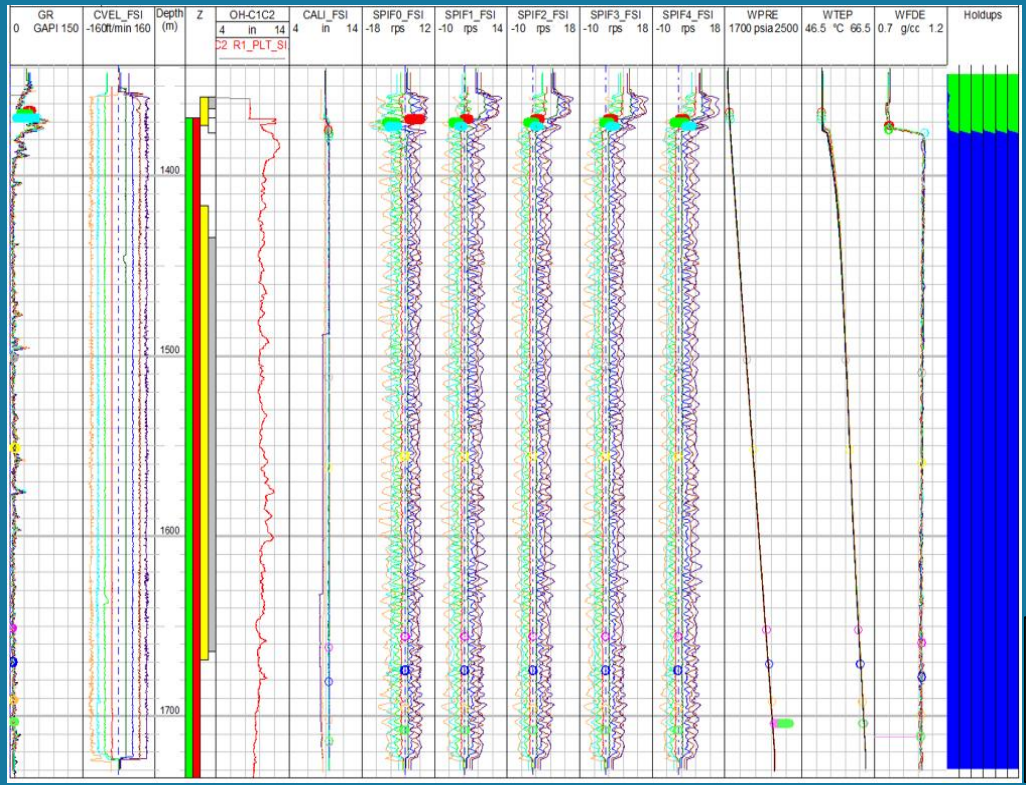
Brine Interface (shut-in)



- Clear Oil Water interface at 1378.8m MD
- No cross-flow detected
- Confusing results due to evidence of deeper oil from earlier wells

Pass coloring:
Up pass1, Up pass2, Up pass3, Up pass4
Down pass1, Down pass2, Down pass3, Down pass4

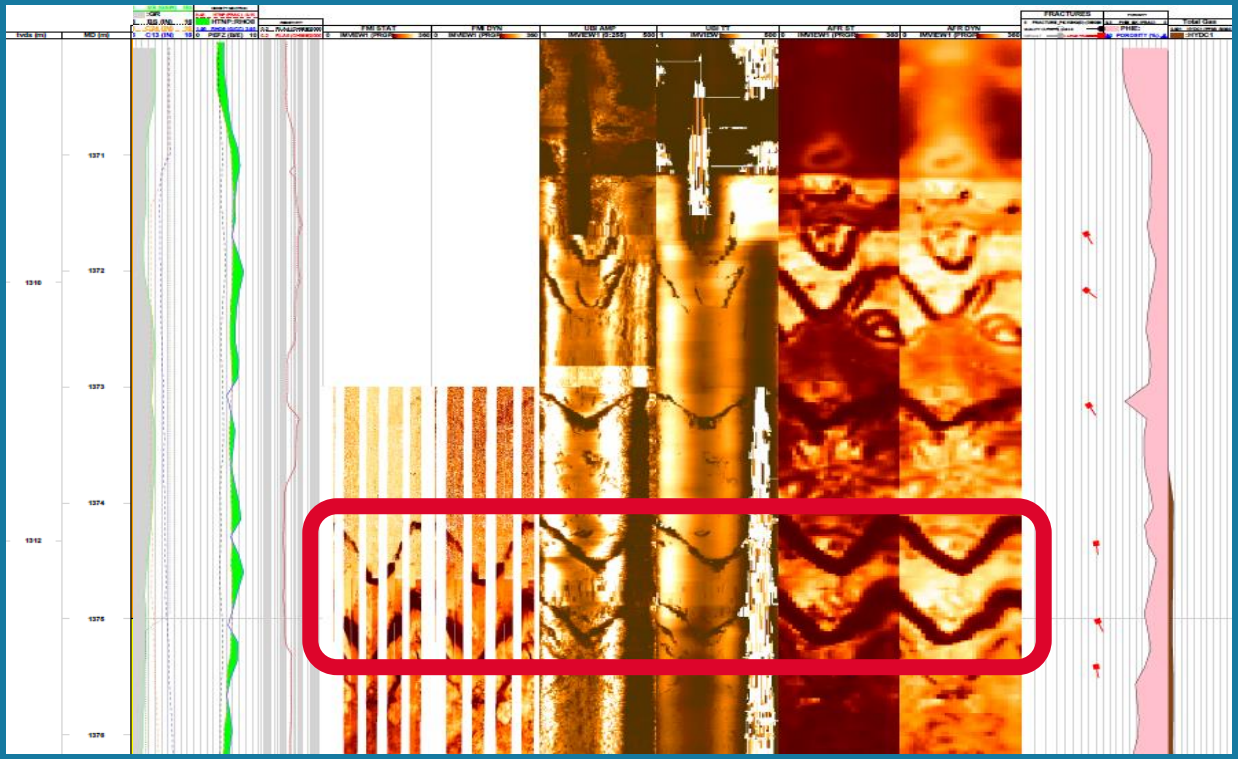
Brine Interface (Flowing)



- Interface has not moved
- Still no cross-flow
- Well flowing at >9,000 bopd
- Brine not moving (demonstrated by spinners)

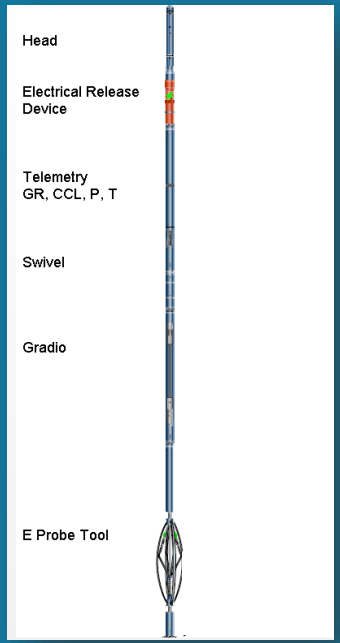
Pass coloring:
Up pass1, Up pass2, Up pass3, Up pass4
Down pass1, Down pass2, Down pass3, Down pass4

Flow contribution



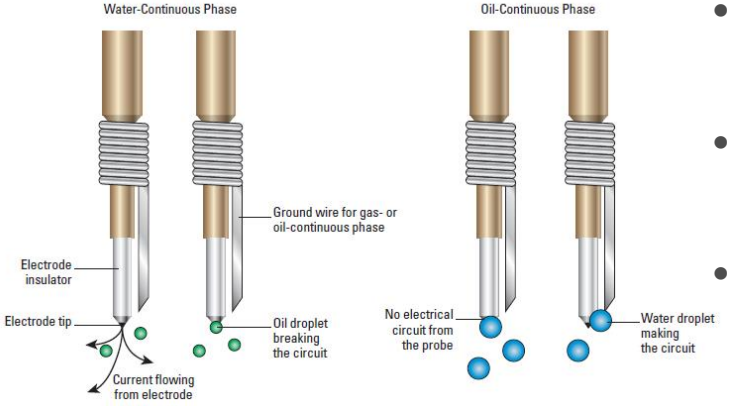
- Flow entirely dominated by two large aperture fractures at the top of the basement reservoir
- Combined aperture of fractures ~9”

Wireline samples



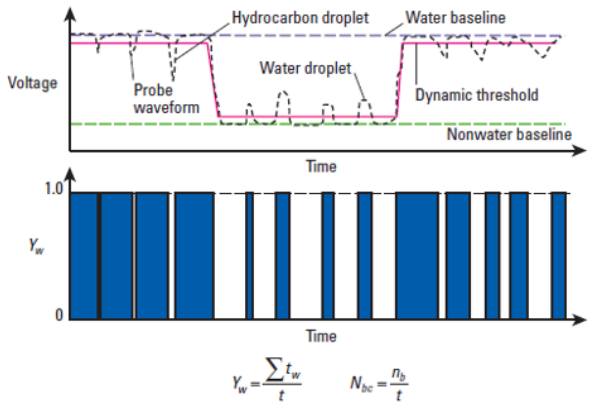
- Wireline samples collected using single phase cylinders from Expro, run on the Schlumberger FSI string
  - ~550-600 cm^3 per sample
  - 5 samplers on a string
  - Controlled by simple timers
- Wireline samplers well depth controlled
- Presence of oil within these samplers indicates oil presence in the reservoir at this depth or deeper
- Decanting of samples onsite during first run was key real-time information for Hurricane to aid in interpretation of PLT data

Electrical Probe Holdup

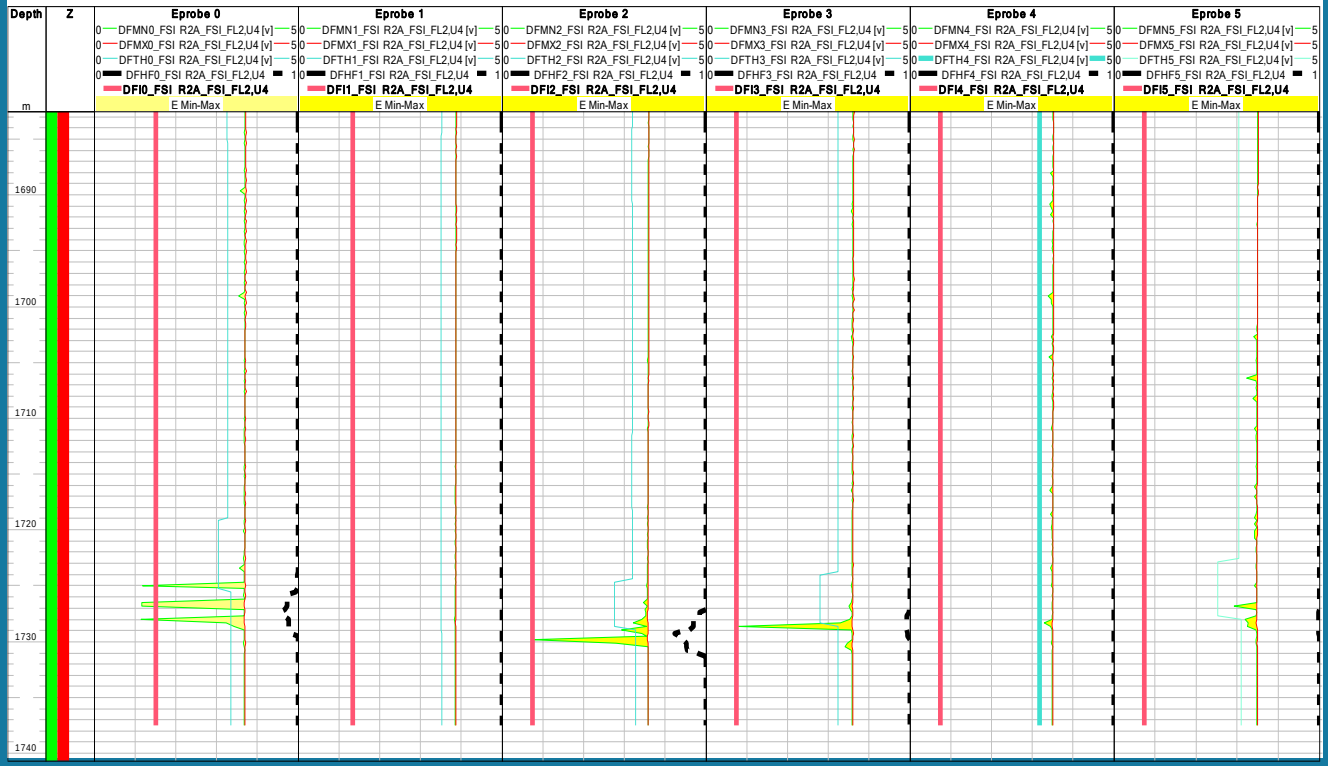


- E-probes uses electrical conductivity of water to distinguish between the presence of water and hydrocarbon
- In addition to holdup, the sensor also records number of bubbles/sec or bubble count, an information very useful to derive rates
- Measurement independent of deviation

- The signal from the probes is used to derive holdup
- Thresholds are used based on the continuous phase changes and size of bubble
- White time is the Hydrocarbon phase
- Blue time is the Water phase

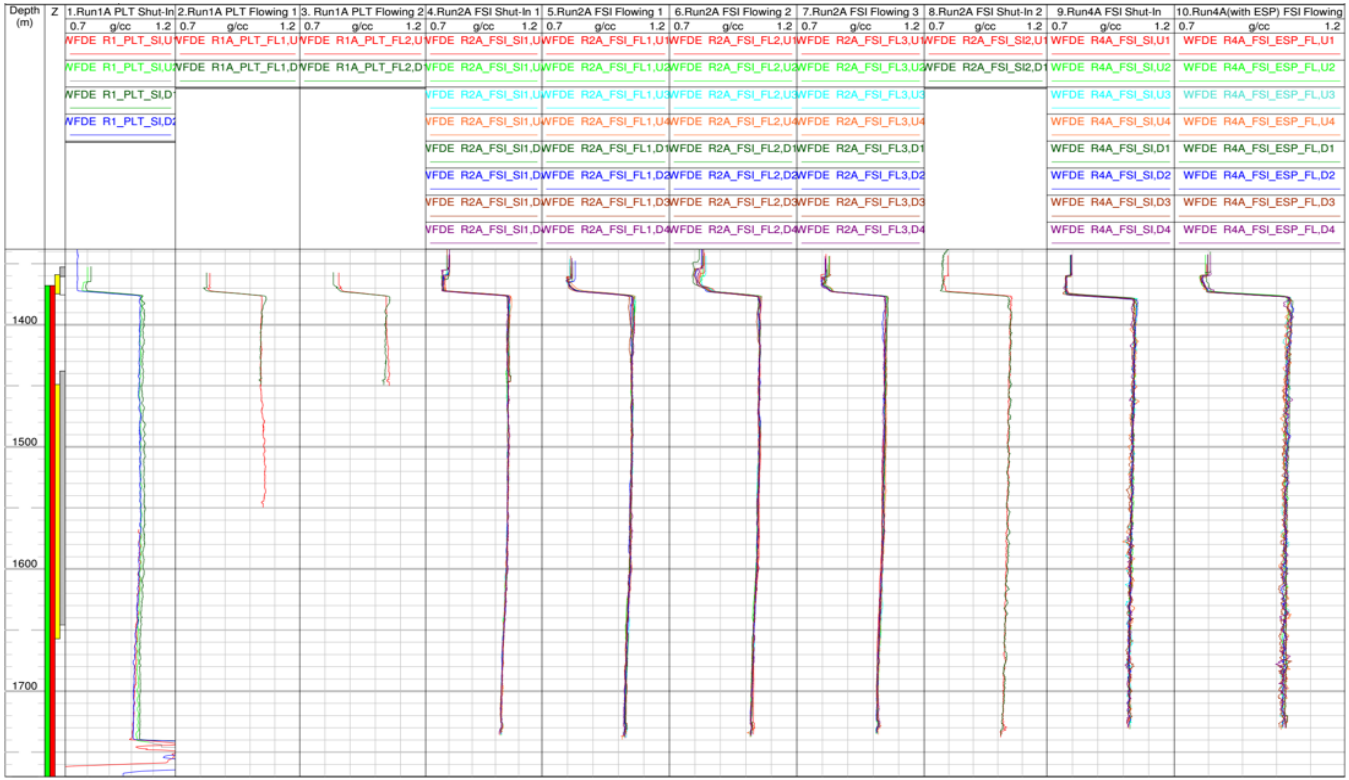


PLT Oil Bubbles



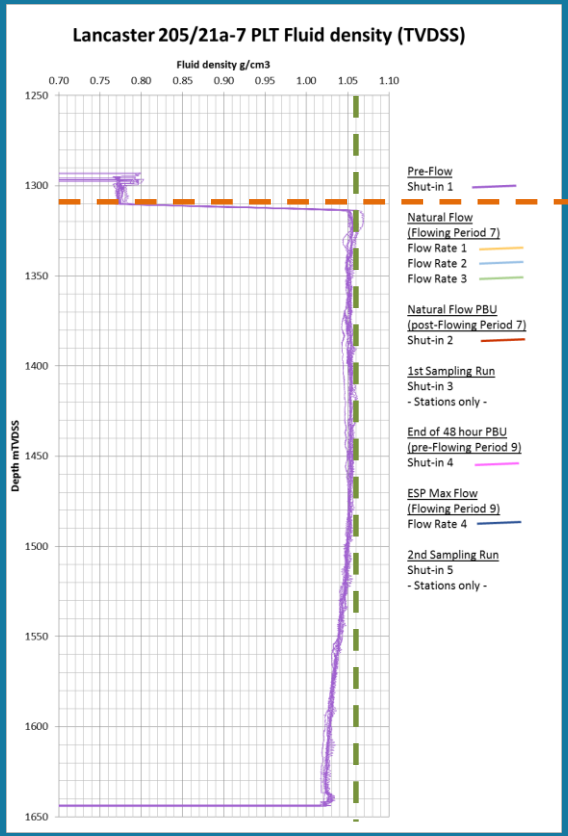
- Schlumberger have interpreted the deepest point where oil bubbles were found as 1730m MD
- Bubbles of oil indicates oil moving through the brine column in the wellbore

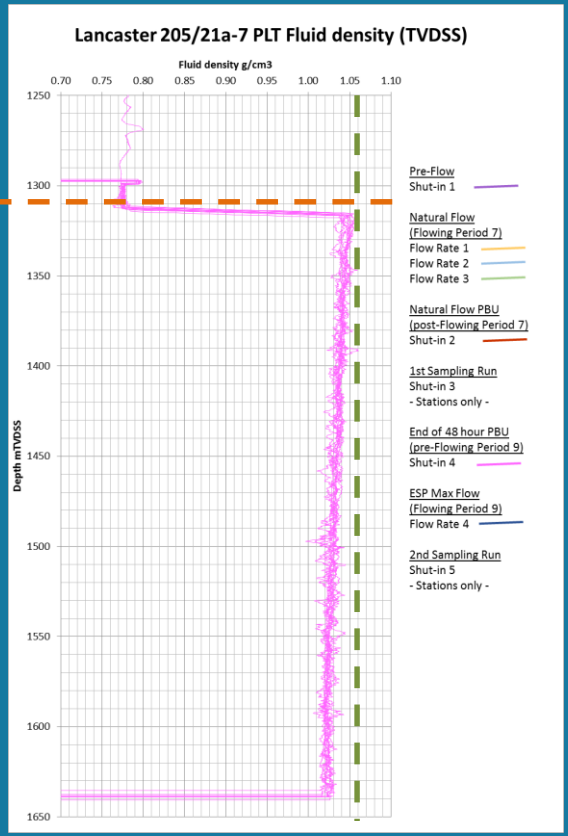
Gradio Density Changes



Brine / formation water mixing

- Hurricane performed a number of shut-in PLT passes as well as flowing ones, to try and establish the static conditions within the wellbore
- Shut-in conditions changed throughout the course of the test
  - Brine interface deepened
  - Density profile changed, indicating heavier brine mixing downwards with lighter formation water





Conclusion

- Fractured basement remains an under-explored play in the UKCS and Hurricane is utilising a number of innovative techniques with existing technology to evaluate the reservoir

- This well presented a confusing dataset that required Hurricane staff offshore (including the CEO) to work closely with Schlumberger wireline staff, both offshore and onshore, to optimise the data acquisition programme

- Early interpretation of the wellsite data provided Hurricane management sufficient confidence to raise funds and progress the drilling of Lincoln and Halifax