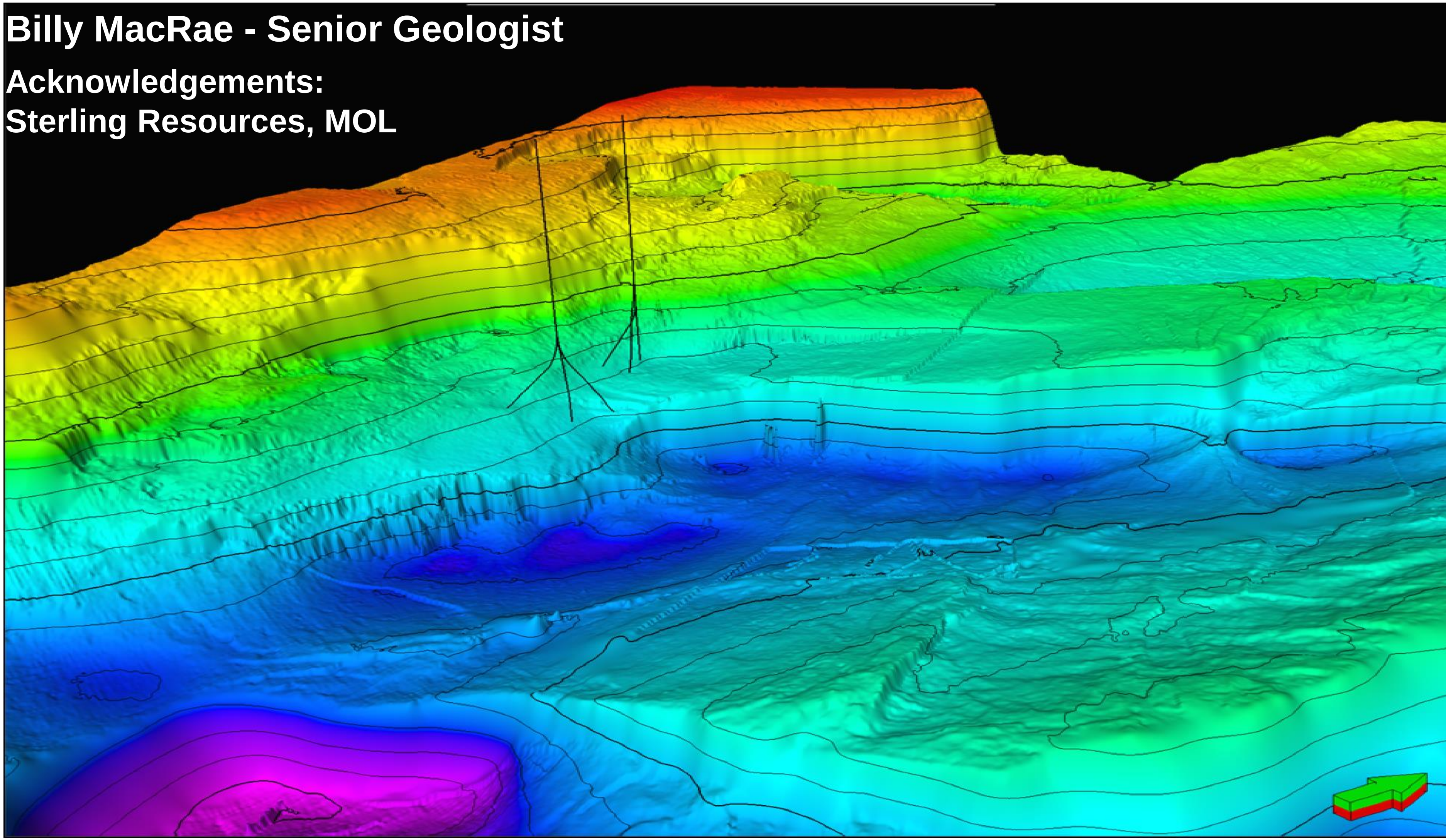
New Field Development Challenges in a Late Life Setting - Cladhan

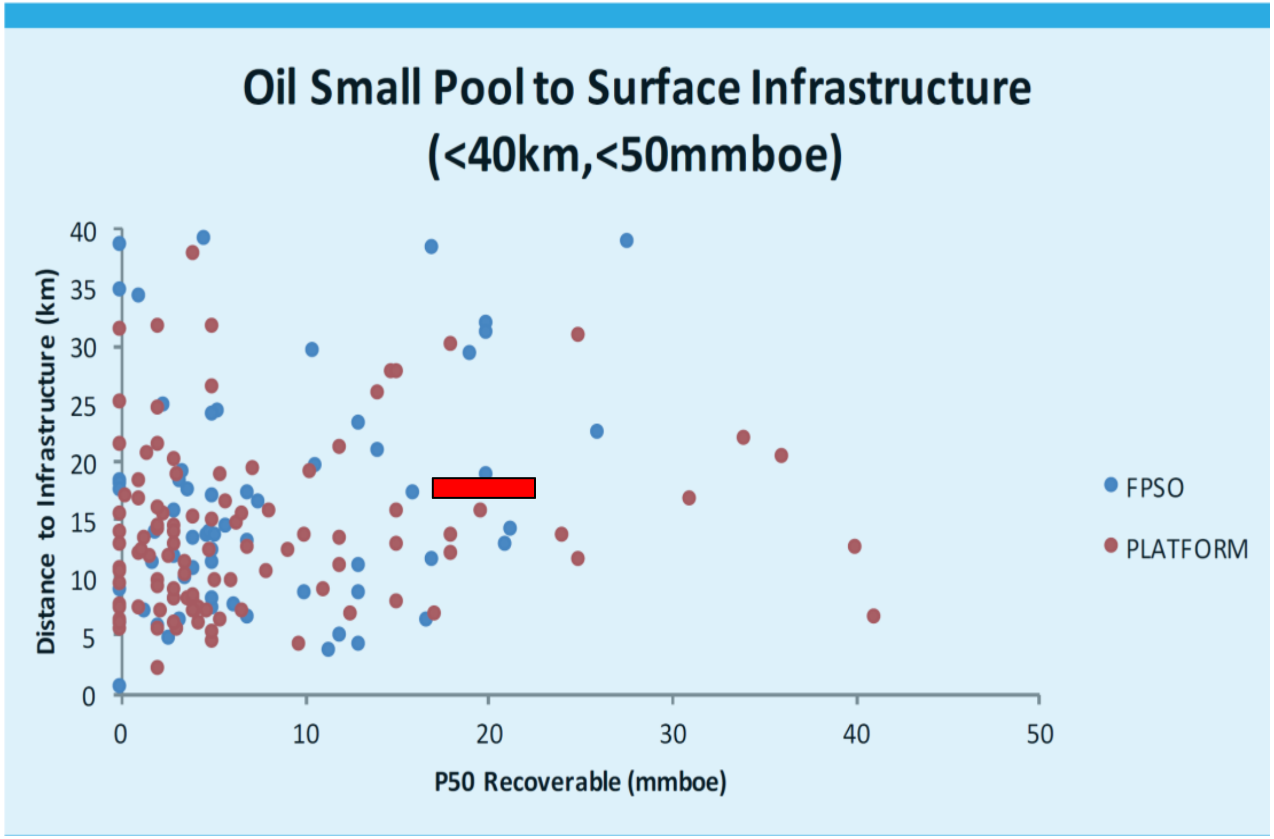
Billy MacRae - Senior Geologist

Acknowledgements:
Sterling Resources, MOL



Outline

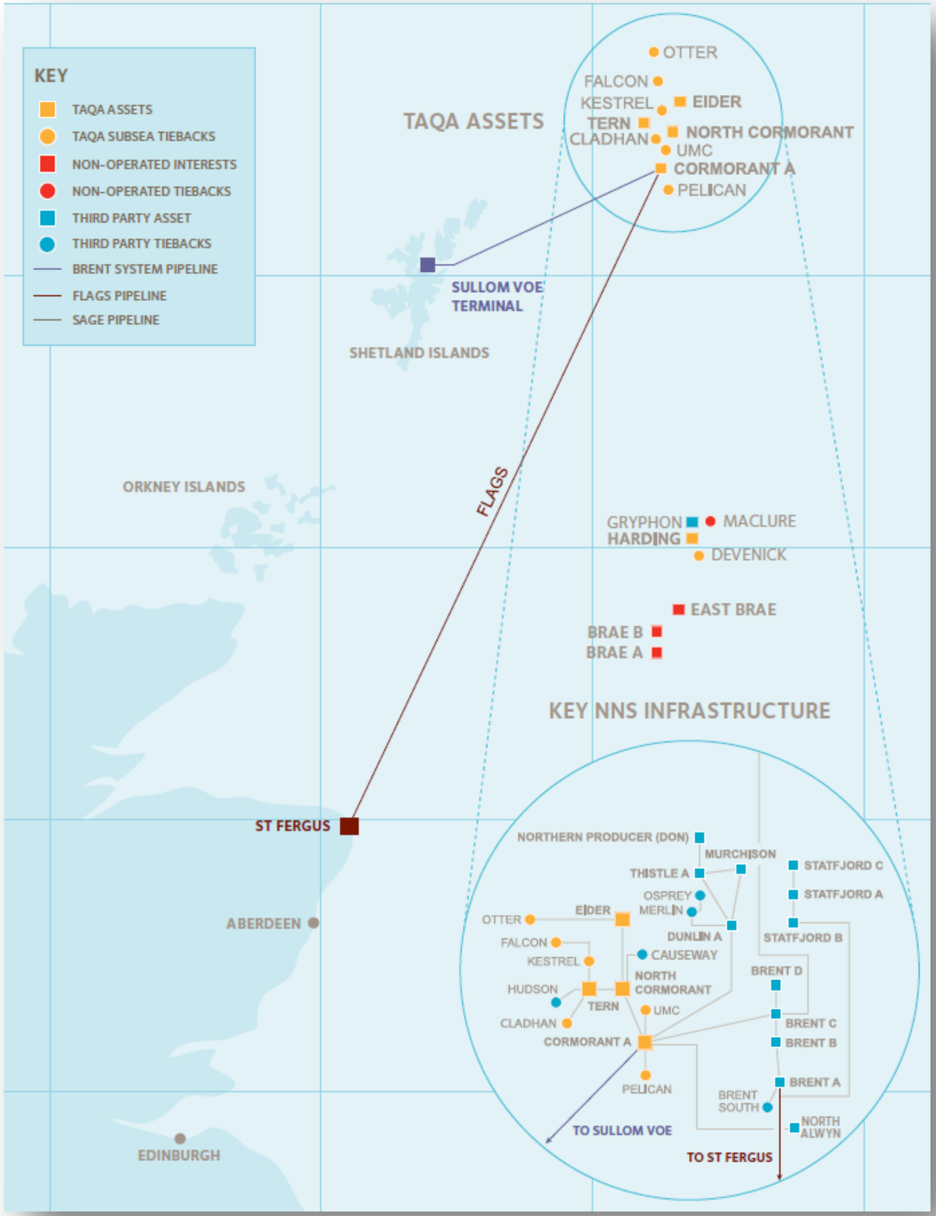
- Introduction
- Cladhan field – Appraisal
- Cladhan field –Development
- Cladhan field – Production
- Lessons learned
- Summary and Conclusion



Source: OGA PARS 2015 data base, CDA

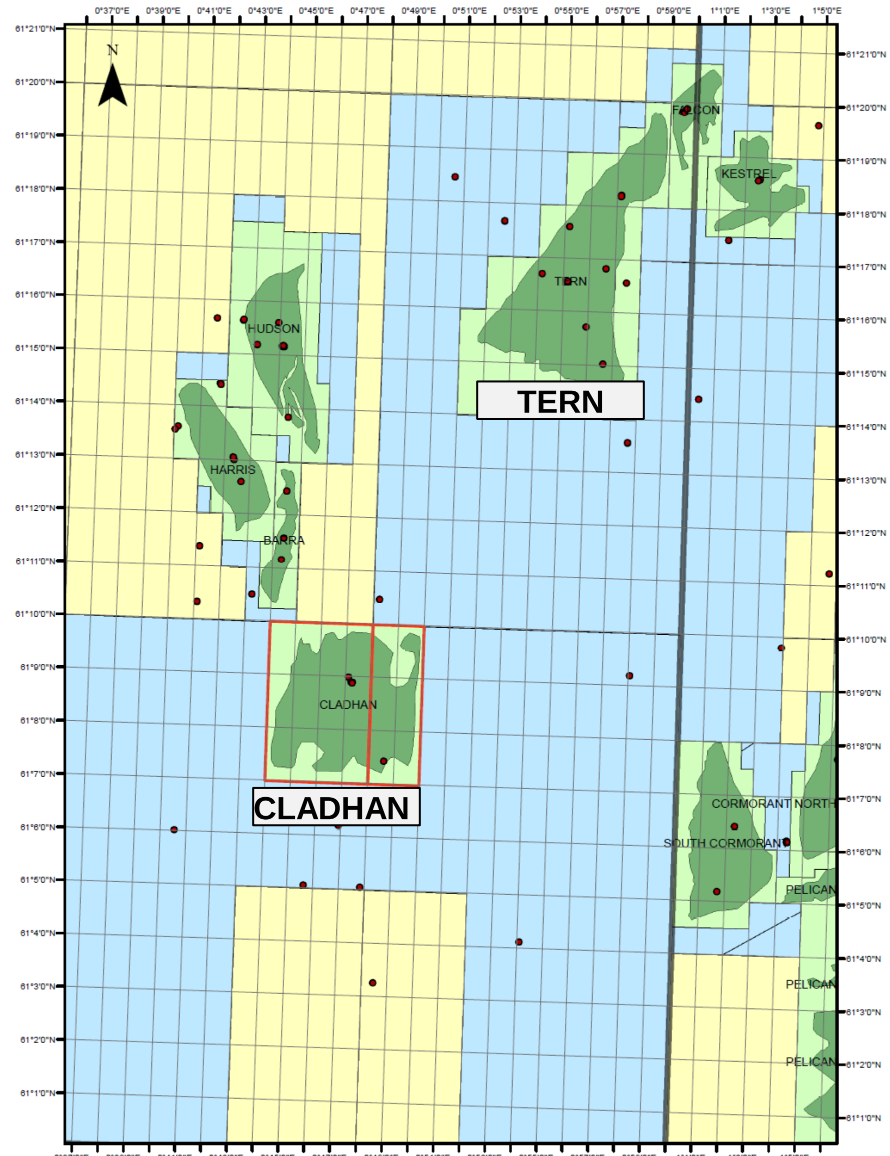
About TAQA in the UK

- Established in 2006, TAQA's UK business is a wholly owned subsidiary of Abu Dhabi National Energy Company.
- Globally TAQA has investments in power generation, water desalination, oil and gas exploration and production, pipelines and gas storage.
- Within the UK, TAQA is an exploration and production company working in the North Sea.
- TAQA operates five platforms which produce from 13 fields spread across the Northern North Sea and Central North Sea and it also owns equity in fields which are operated by others in the Central North Sea.
- TAQA is the operator of the Brent Pipeline which connects its operated Cormorant Alpha platform back to the BP-operated Sullom Voe Terminal..

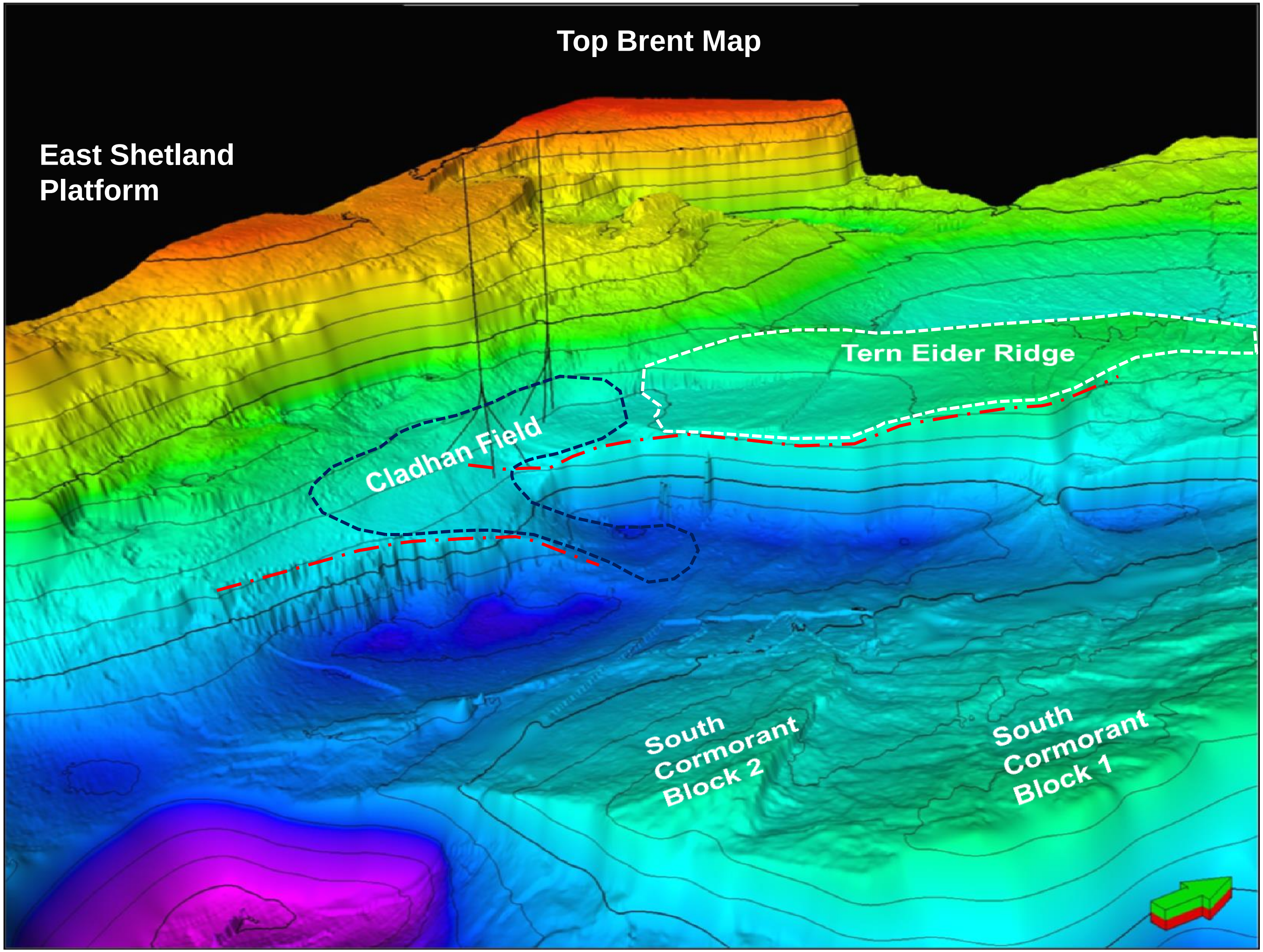


Cladhan Field Overview

- Promote licence awarded to Sterling and Encore in 2003
- Current partnership
  - TAQA – 64.5%
  - Sterling Resources – 2%
  - MOL Group – 33.5%
  - Tern come online mid 1980’s, COP expected mid 2020’s
- Located 16km south west of Tern and tied back to the platform
  - 8 wells in total
  - 1 discovery and 7 appraisal wells



Petroleum System Overview



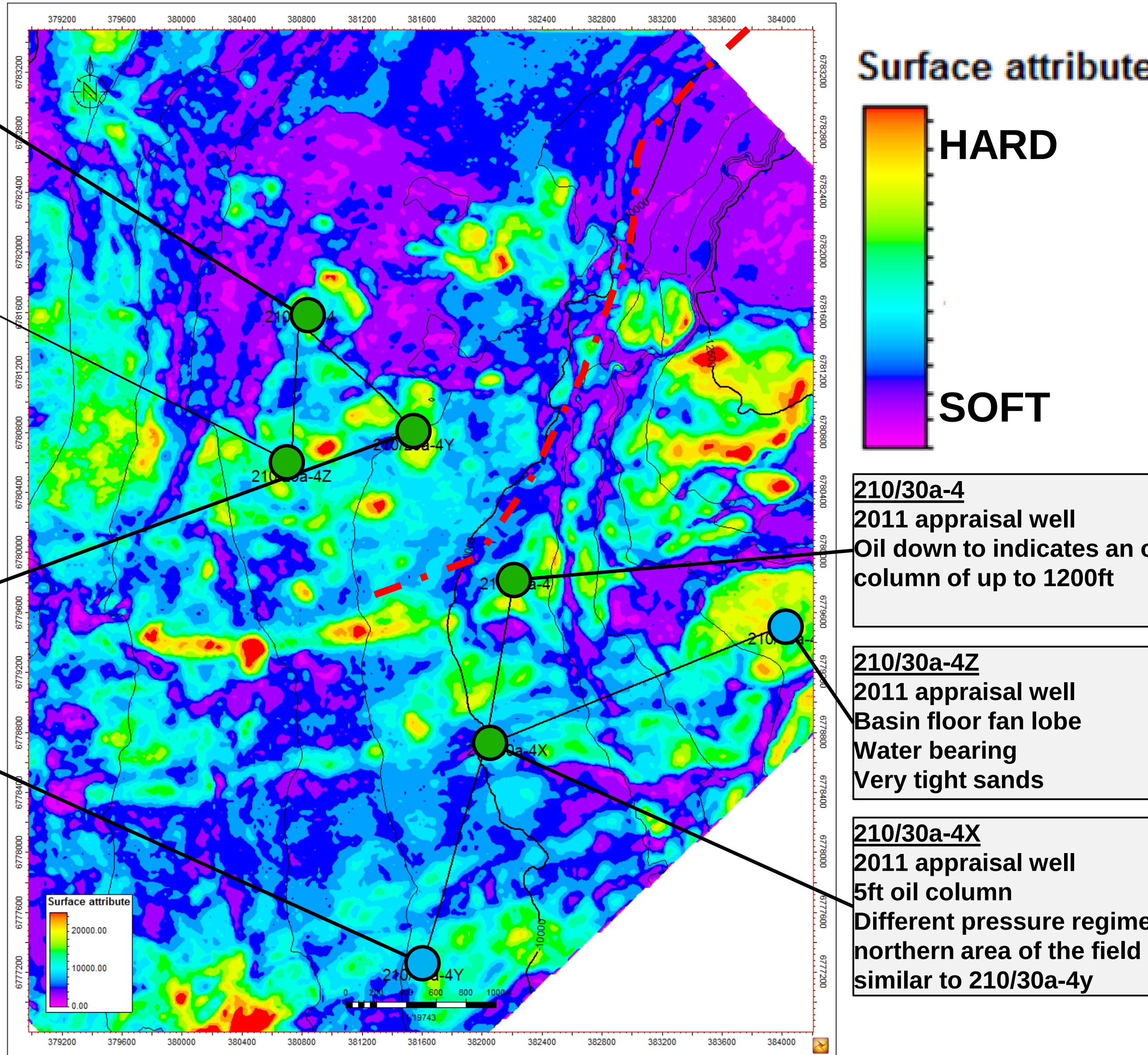
Exploration and Appraisal History

210/29a-4
2008 discovery well
27ft Column
38° API oil
Approximately 1600psi overpressure

210/29a-4Z
2010 appraisal well
106ft Column
Tested 6490 bopd

210/29a-4Y
2010 appraisal well
108ft Column

210/30a-4Y
2011 appraisal well
Water wet
Separate pressure regime to 210/30a-4

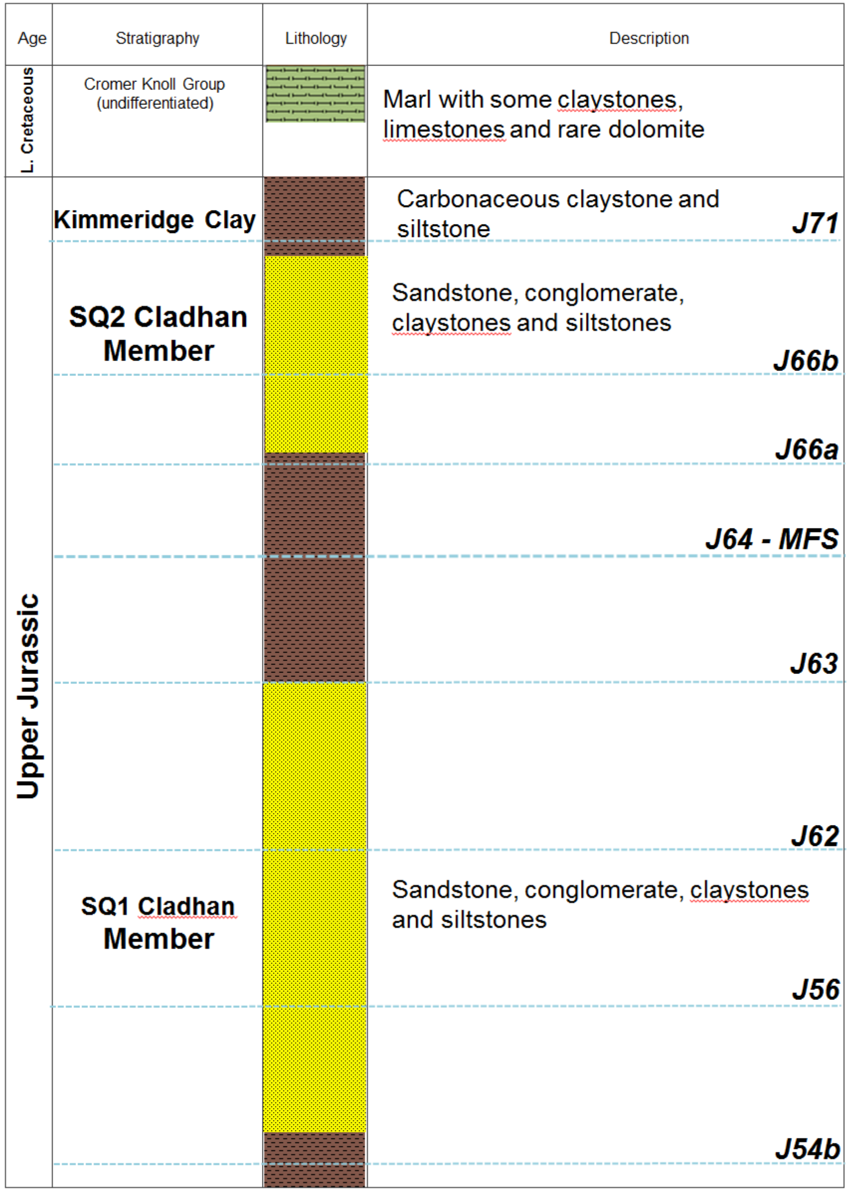


210/30a-4
2011 appraisal well
Oil down to indicates an oil column of up to 1200ft

210/30a-4Z
2011 appraisal well
Basin floor fan lobe
Water bearing
Very tight sands

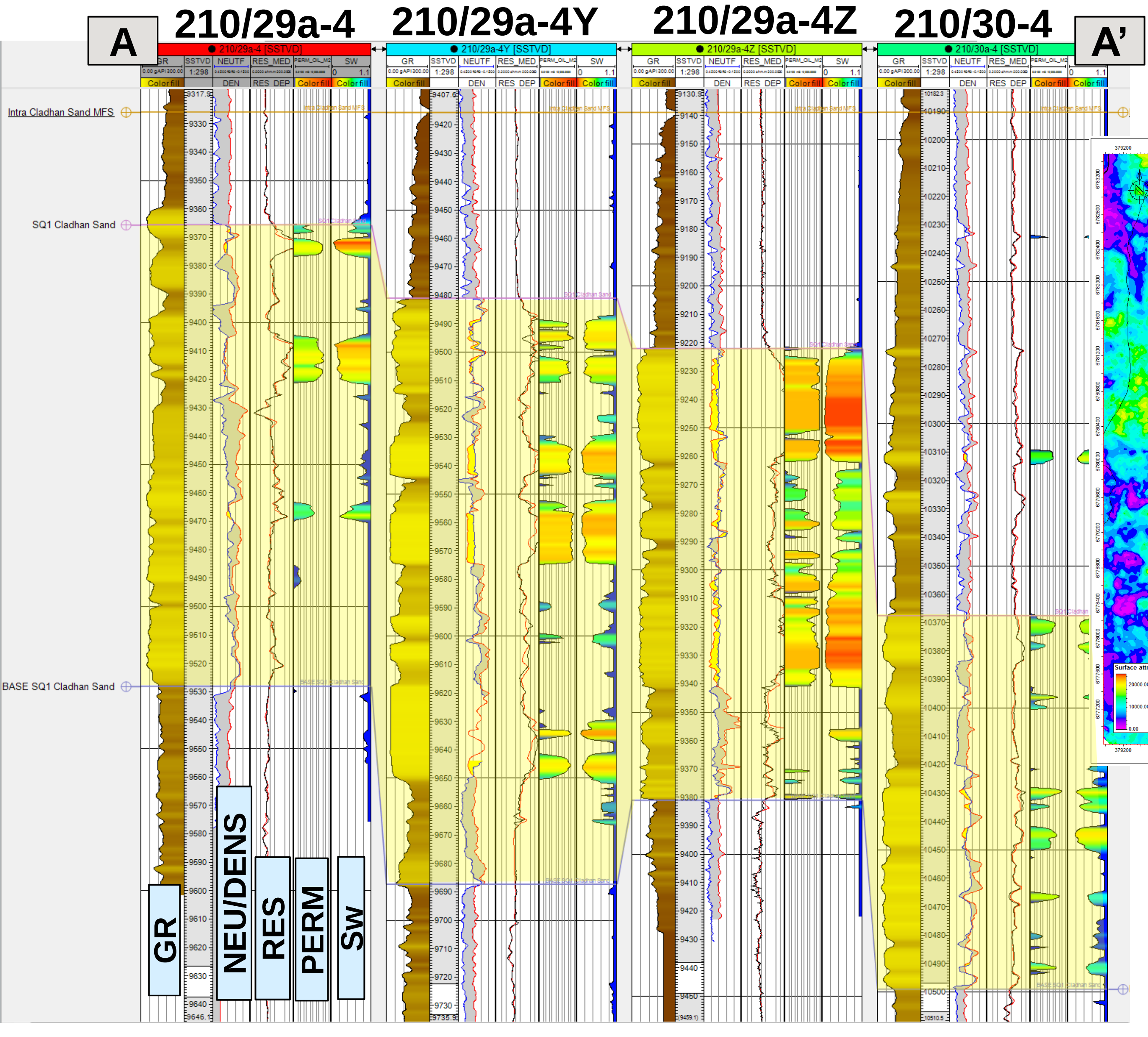
210/30a-4X
2011 appraisal well
5ft oil column
Different pressure regime to northern area of the field but similar to 210/30a-4y

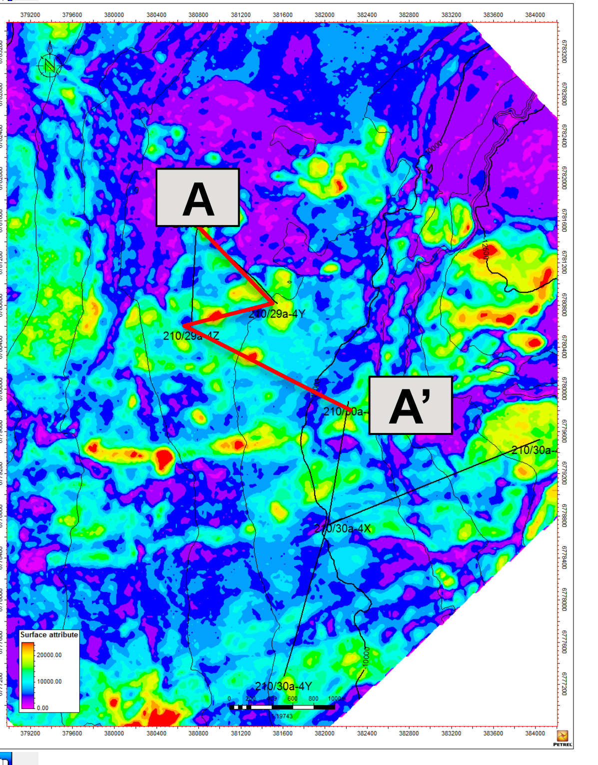
Stratigraphy



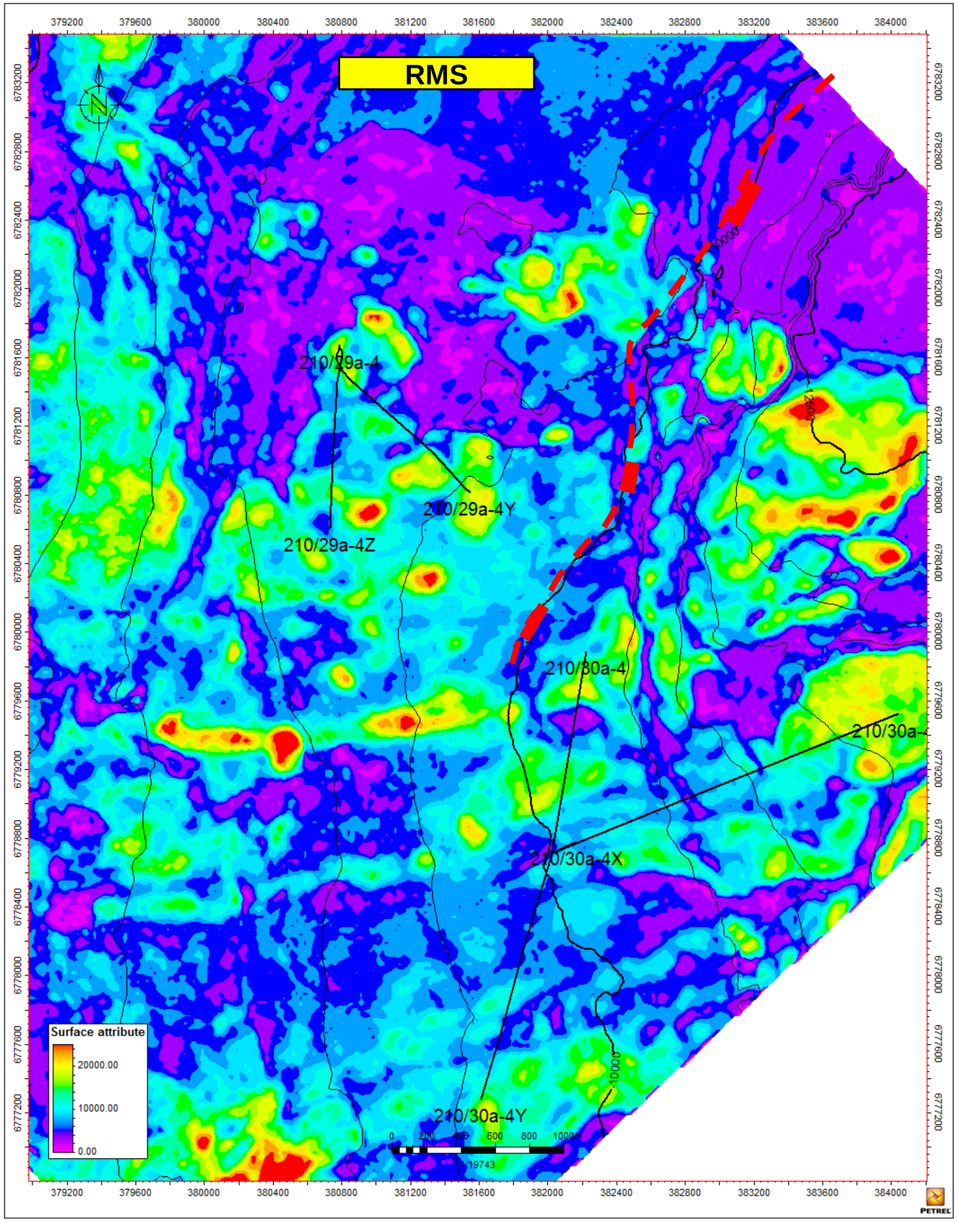
- 2 main reservoir packages identified at Cladhan named Sequence 1 and Sequence 2
- These are both turbidite reservoir sands and they are differentiated on the basis of age
- Sequence 1 is the only producing unit in the Cladhan field

Sequence 1 Correlation



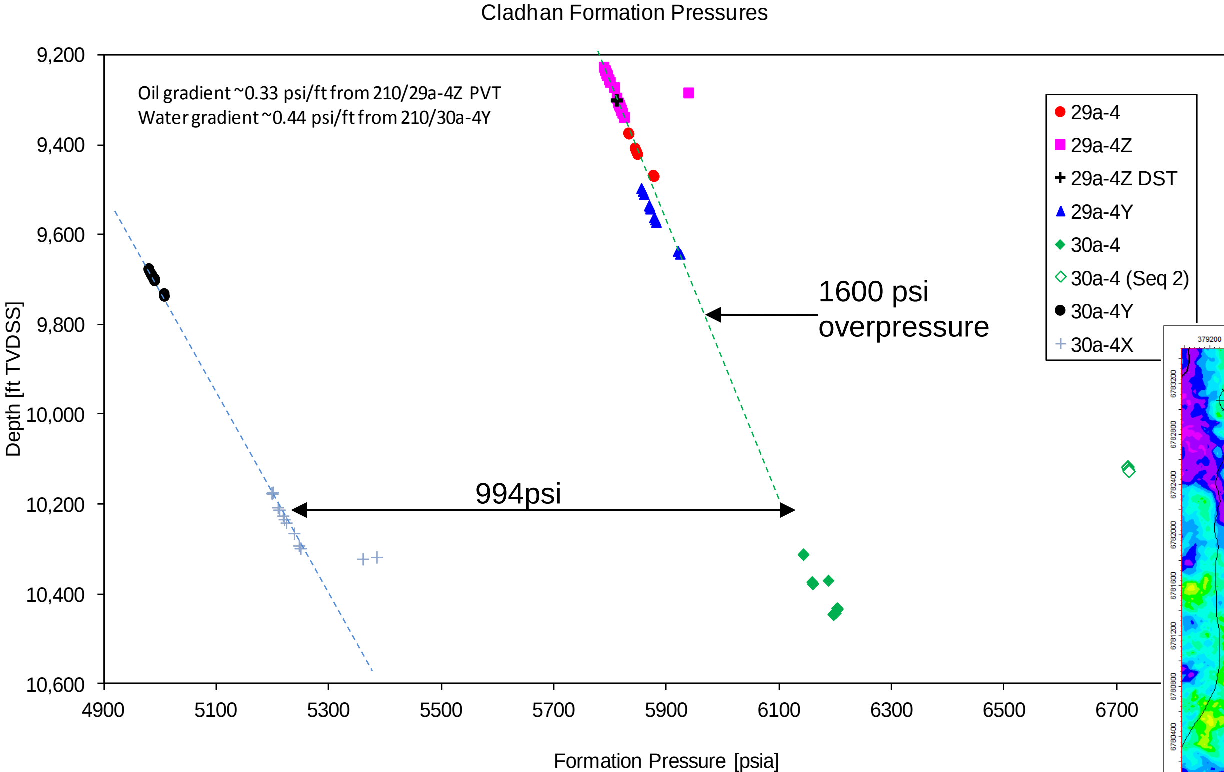


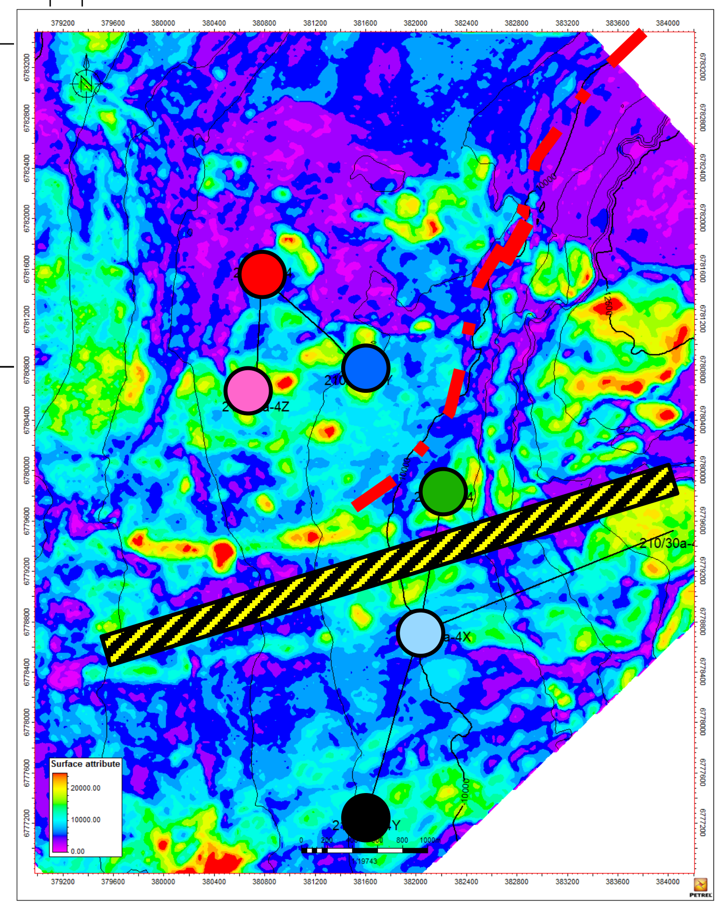
Cladhan Field Depositional Models



- Southern sector of the field, sands interpreted to be more channel than lobate
- Compartmentalisation between wells in this region of the field suggest more channelised system
- Character of Sequence 1 sand units in the north appears less linear and more diffuse
- Lobate type geometries leading to higher chance of better connectivity

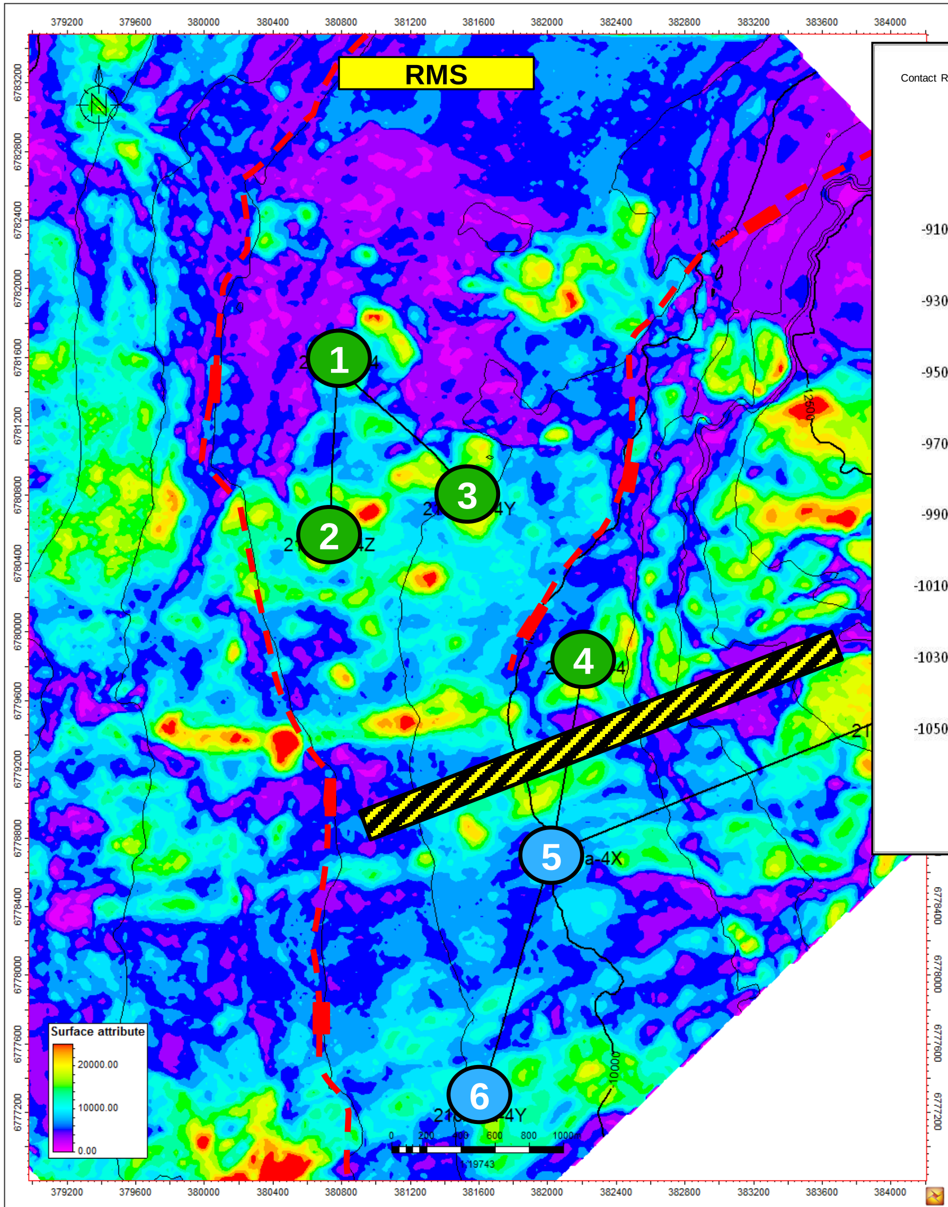
Cladhan Field Pressure Trends

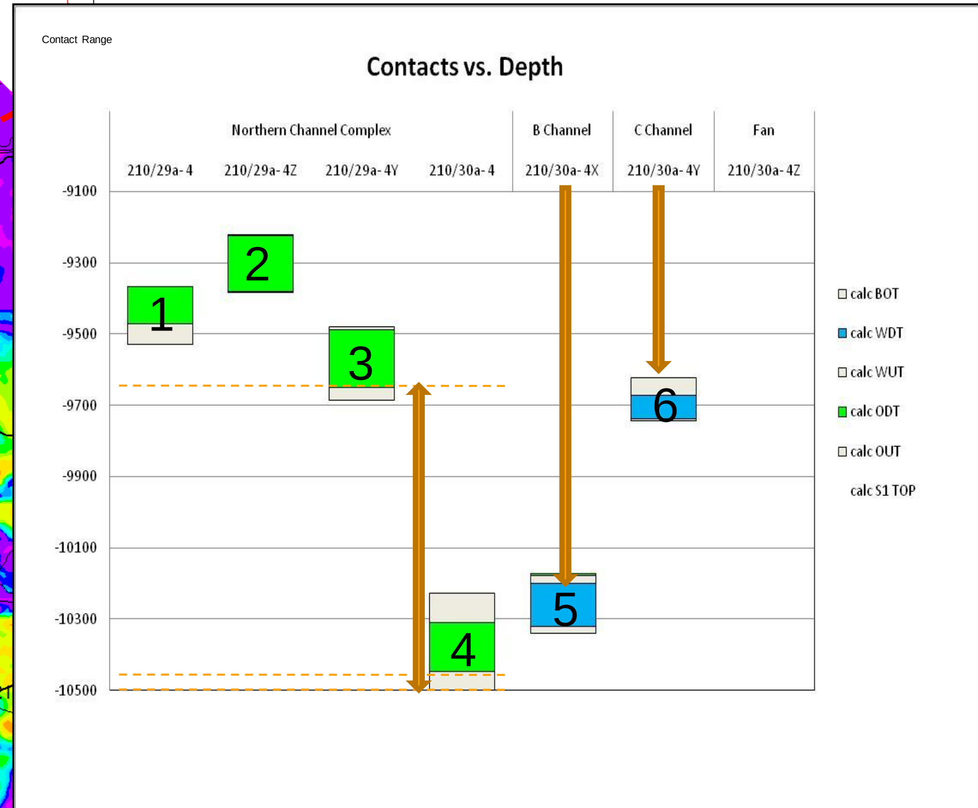




- Northern sector of the field around the 210/29a wells and the 210/30a-4 well are hydraulically separate from the Southern sector
- Both areas are over pressured
- Highest pressure observed is in Sq2 in the 20/30a-4 well. Sq2 in the 210/29a-4 well is hydrostatically pressured

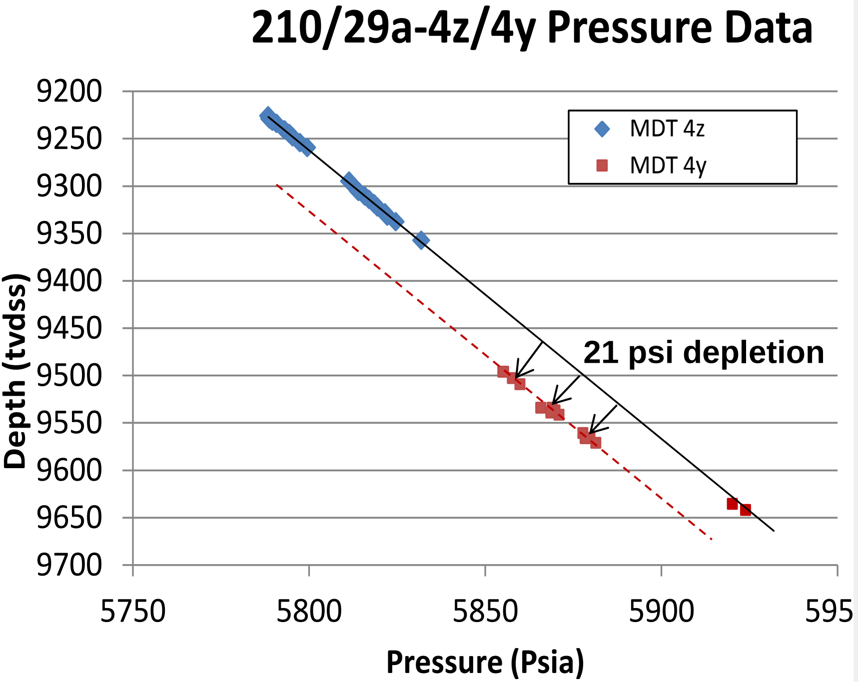
Cladhan Field Contacts

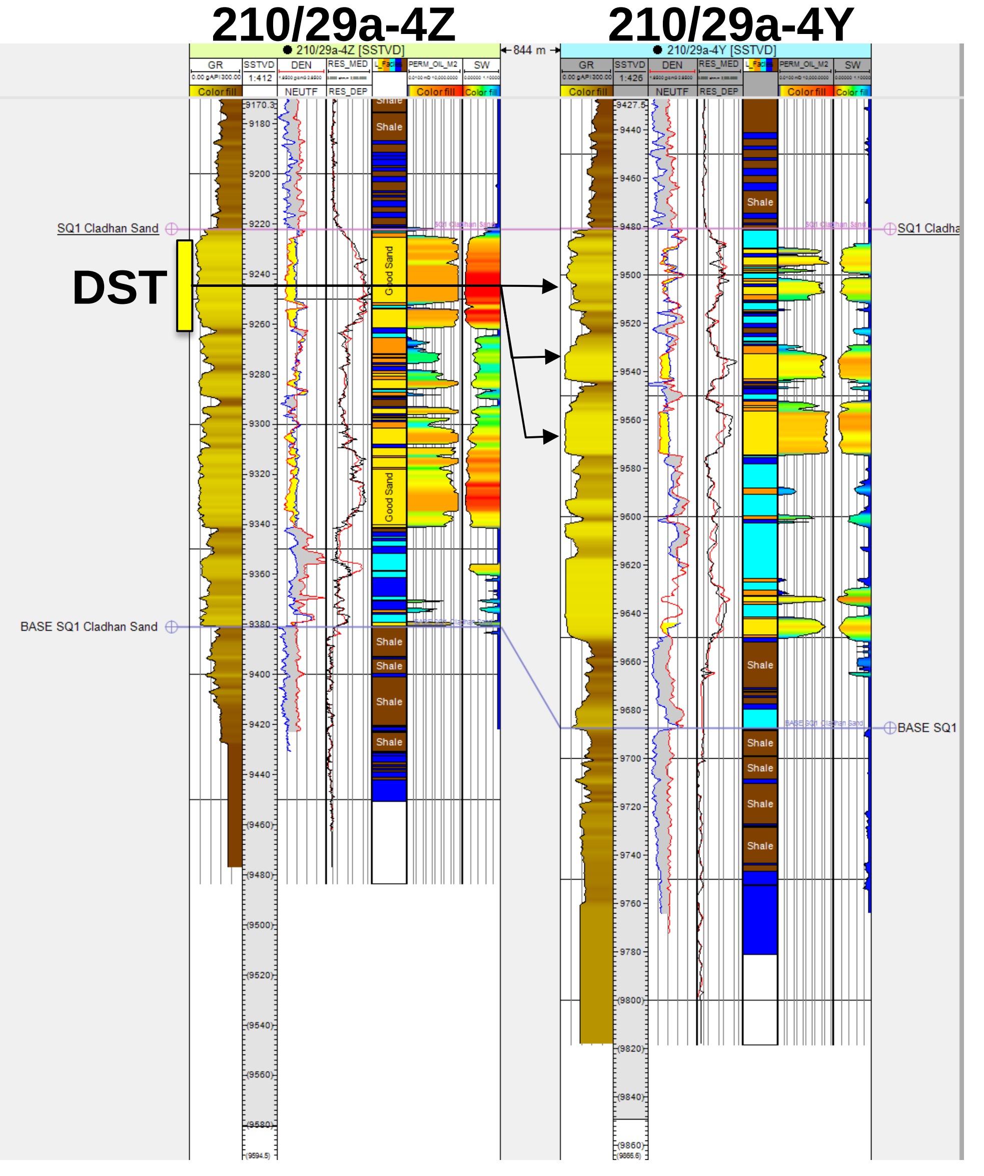




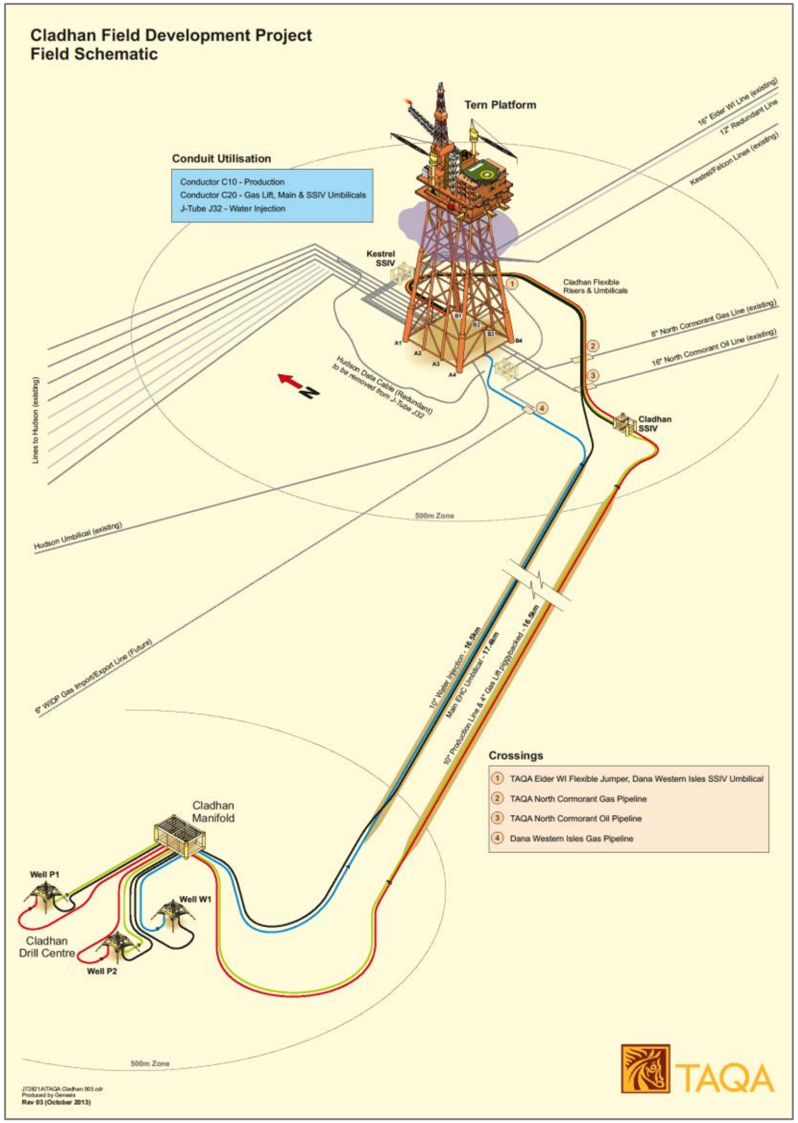
Reservoir Connectivity and Compartmentalisation

- Well test was performed on 210/29a-4Z – September 2010
- 4148 barrels produced, max rate 6,490 bbls/d giving the well a PI of 35
- Depletion observed (from MDT) later at 210/29a-4Y was estimated at 21psi 6 weeks after well test
- However not all sands in 210/29a-4Y were depleted, the lower most sands were still at virgin pressure
- Connected volume for the 210/29a-4Z assessed to be between 10mmstb and 18mmstb



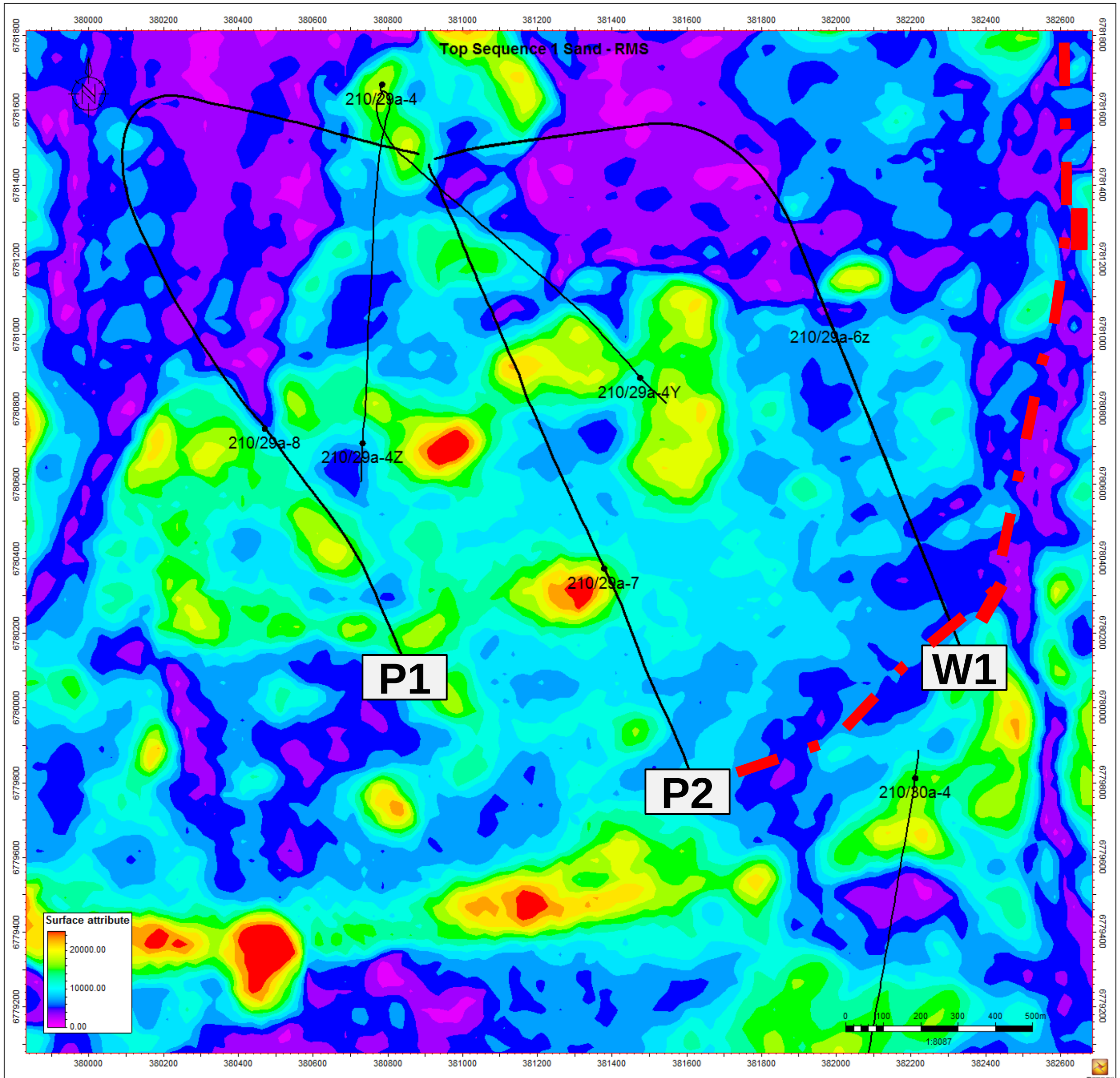


The Cladhan Project – Subsea and Topsides



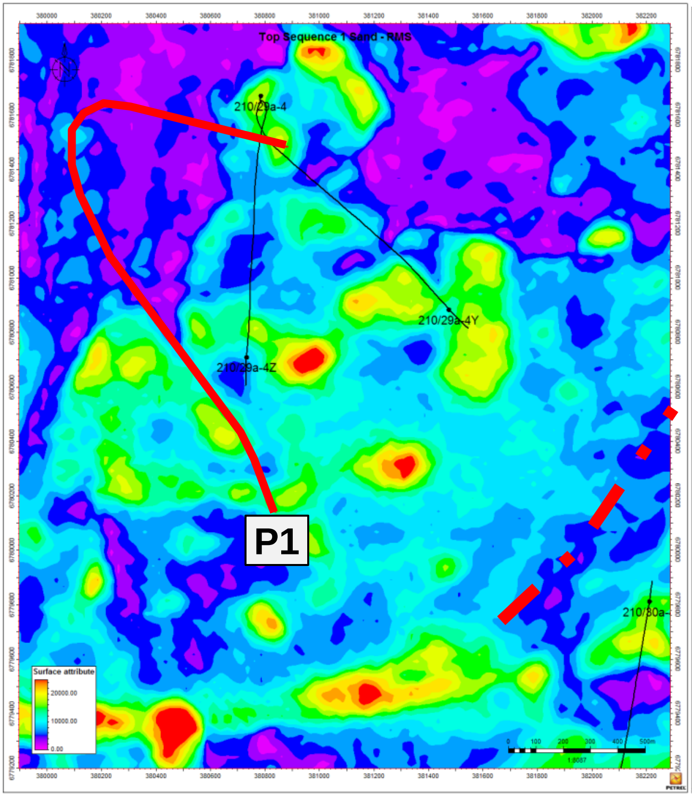
- Subsea tie-back to Tern infrastructure
- Two sub-horizontal producers plus one injector
- New risers for production, gas lift and water injection
- Reconfiguring plant to dedicate A train separator to Cladhan
- New subsea control system
- Subsea manifold
- 17km of production and injection flowlines
- FID cost - ~£390MM

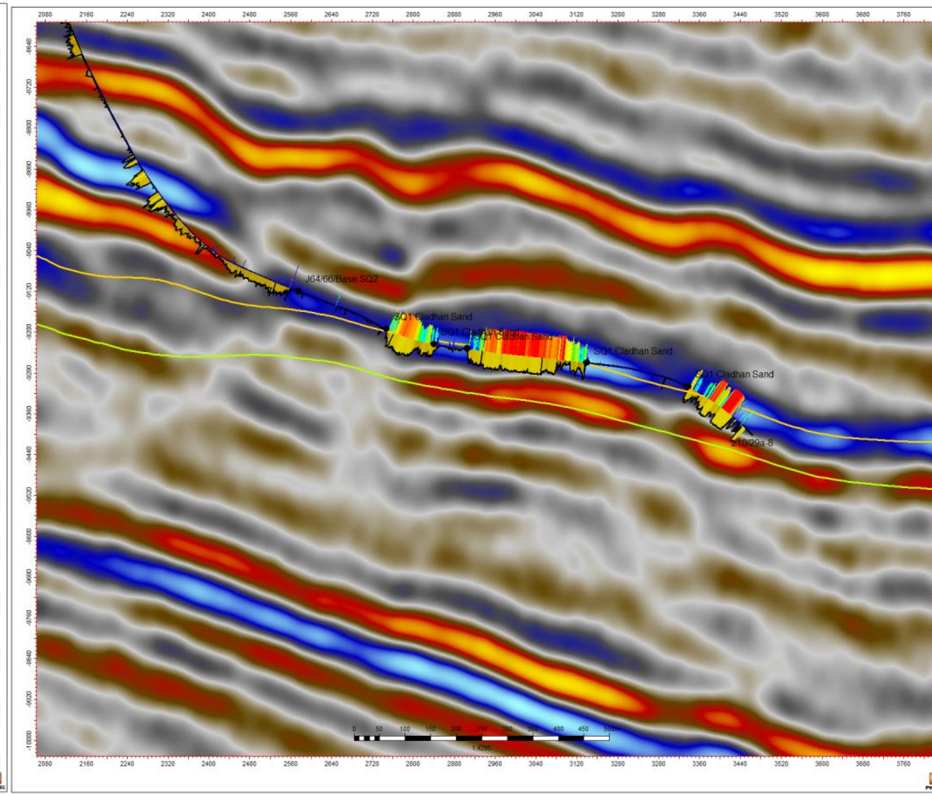
Cladhan field development strategy

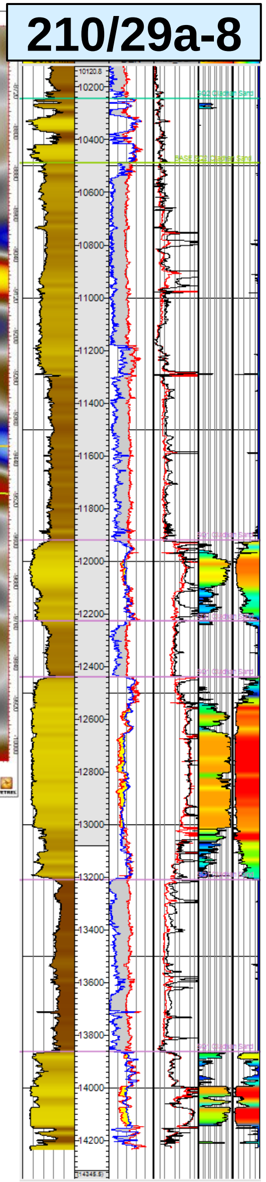


- Development area
  - Core area targeted for development
  - 2 producer 1 injector strategy
  - Only Sequence 1 targeted
- Batch Drilling
  - Initially planned but quickly abandoned
  - Uncertainty in the subsurface made this impossible
- Wells
  - All 3 development wells would be high angle targeting the upper half of the reservoir due to observed poorer reservoir in lower sections of appraisal wells
  - Sand screen completions fitted with RESMAN tracer technology

Well results – 210/29a-8 (P1)

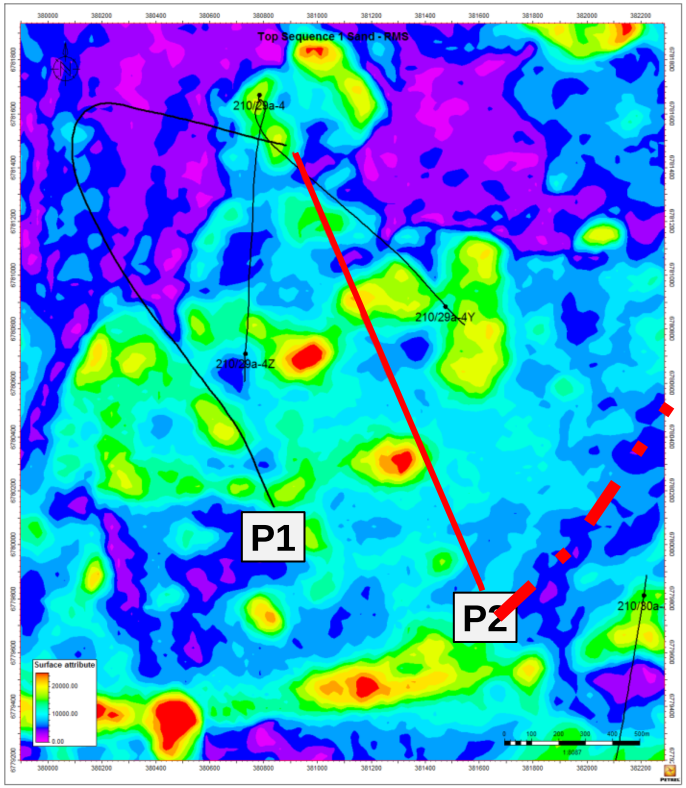


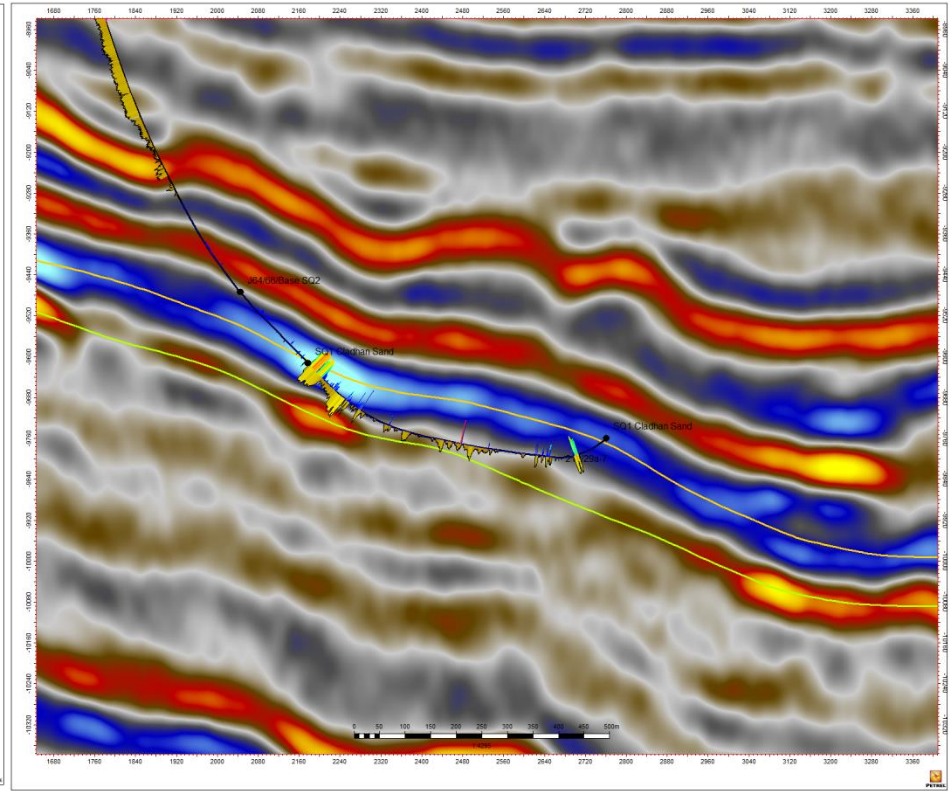


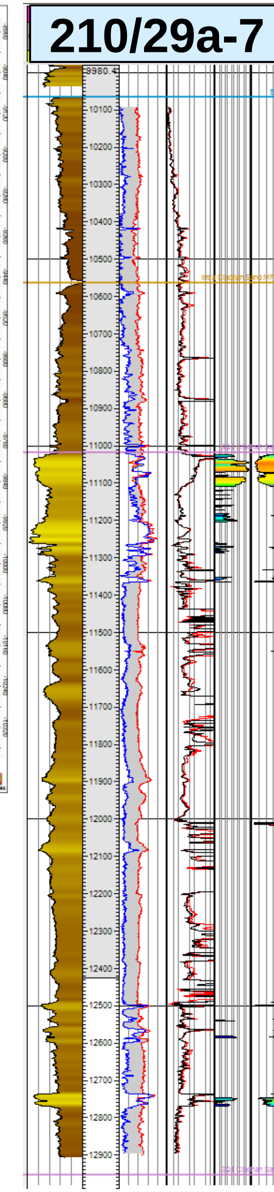


- Used 210/29a-4Z as a control point for landing in reservoir
- Targeted to maintain position in the upper half of the reservoir
- The well was positioned to be close to the 4Z well to target volume accessed by the well test

Well results – 210/29a-7 (P2)

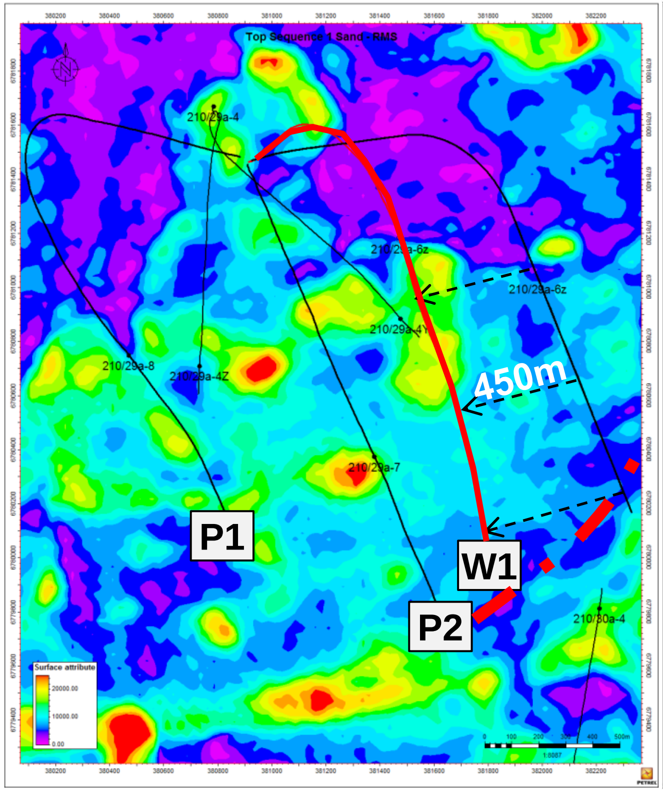


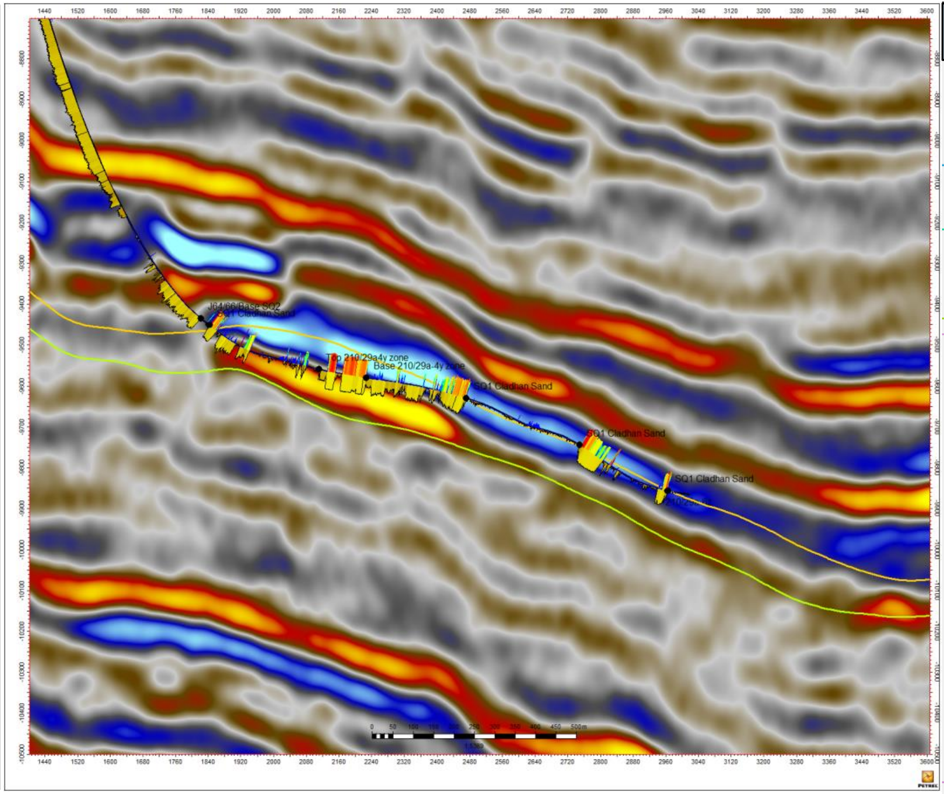


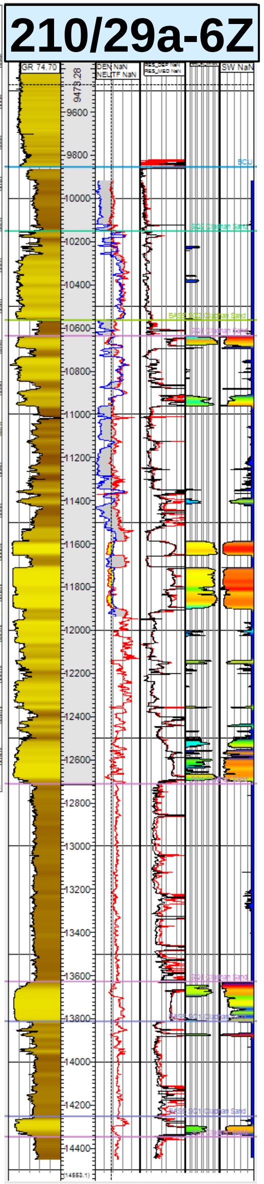


- 210/29a-7 was designed to sit high in the reservoir as at 210/29a-8
- Was positioned to exploit sands that the 210/29a-8 would not access
- Lack of well control for landing the well resulted in the reservoir coming in shallow meaning the well being placed to low
- Uncertainty remained about sand presence in this sector

Well results – 210/29a-6Z (W1)



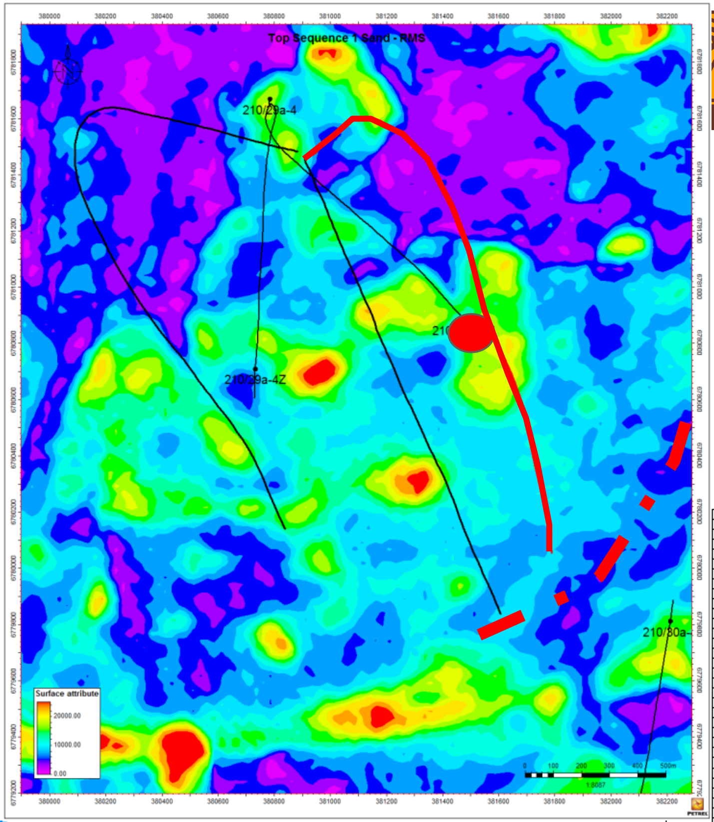


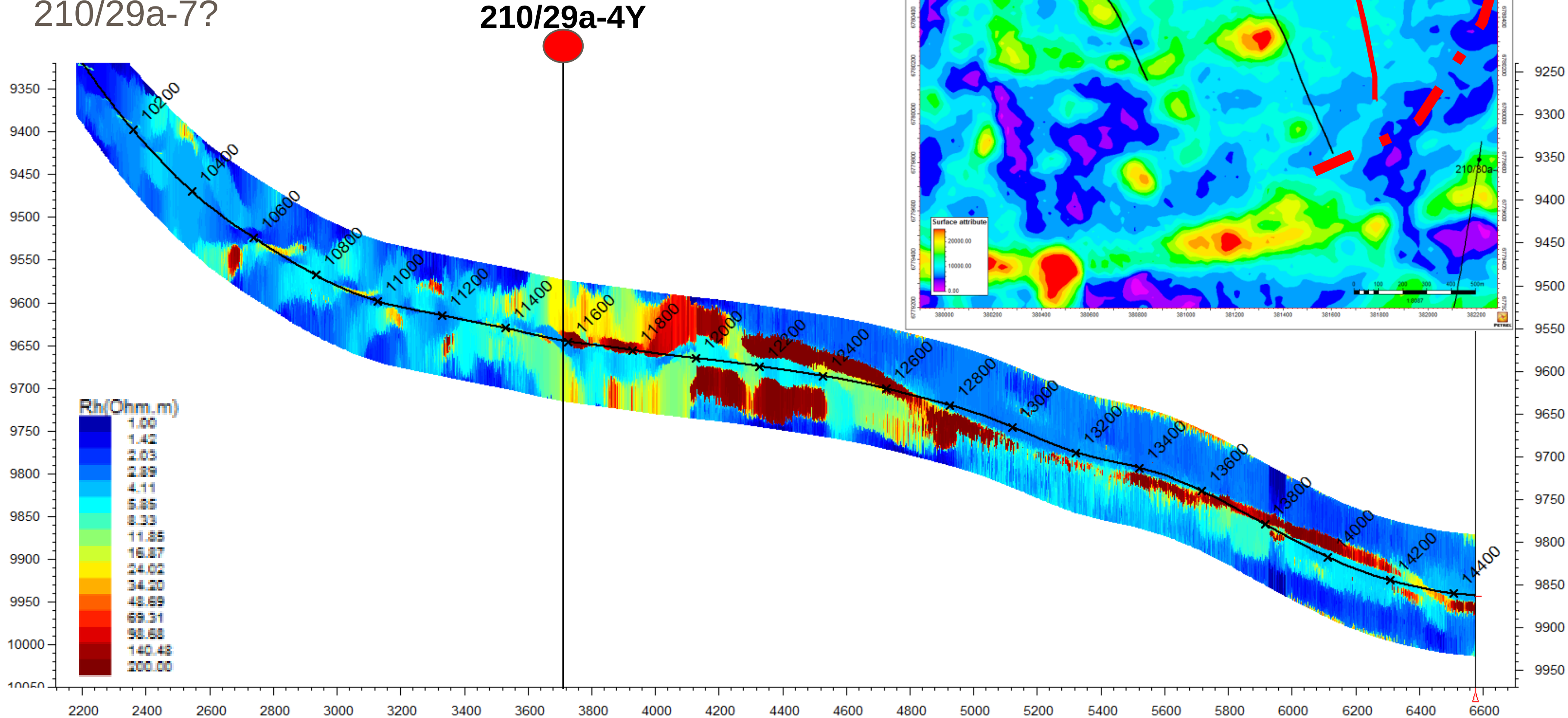


- 210/29a-6Z moved updip to use 210/29a-4Y as a control point to ensure accurate landing of the well
- De risked injector connectivity with the 210/29a-8 well
- A deep reading resistivity tool was employed
- Thin sands were encountered at the toe of the well as observed in 210/29a-7

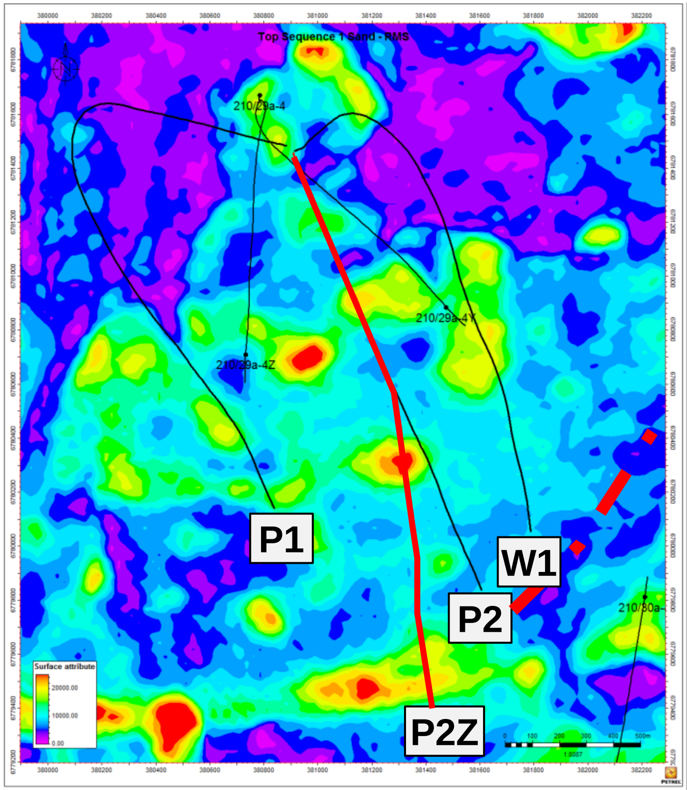
W1 DDR

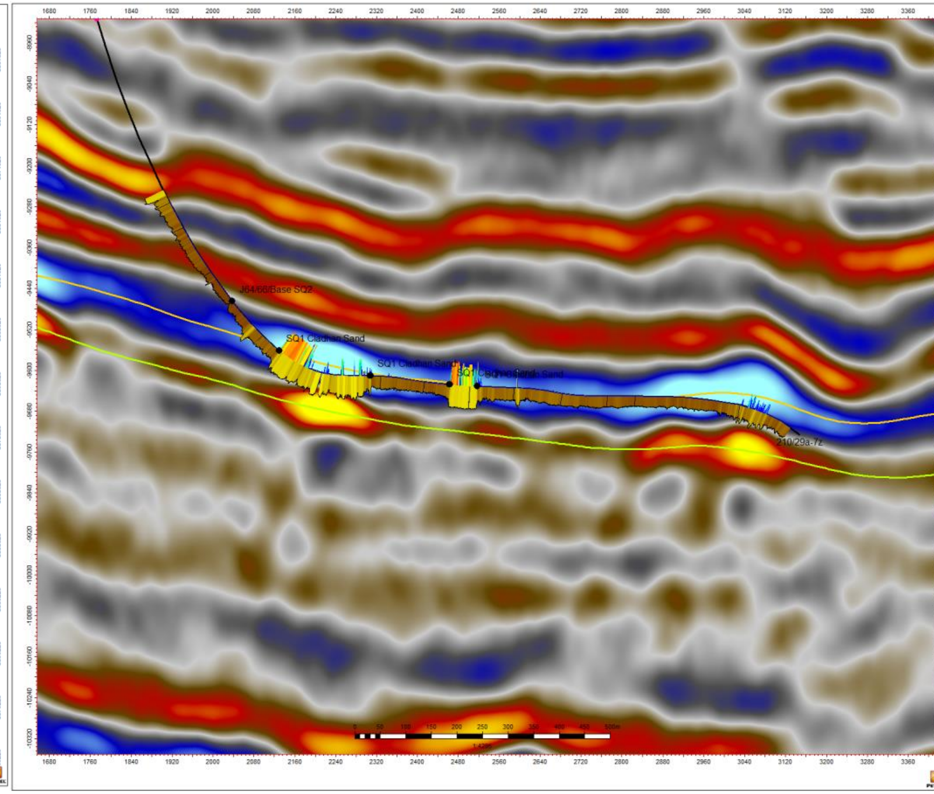
- Good accumulations of hydrocarbon bearing sands were observed around 210/29a-4Y
- Reservoir was observed to be thinning to the south
- Were these sands responsible for the pressure trend observed at 201/30a-4? Did they continue up dip to 210/29a-7?

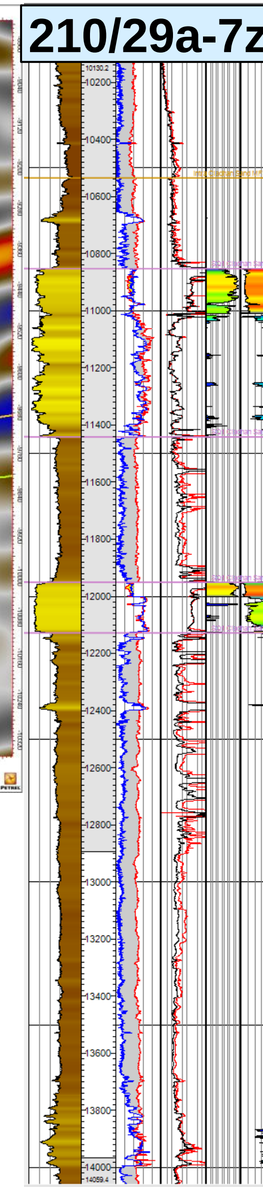




Well results – 210/29a-7Z (P2Z)



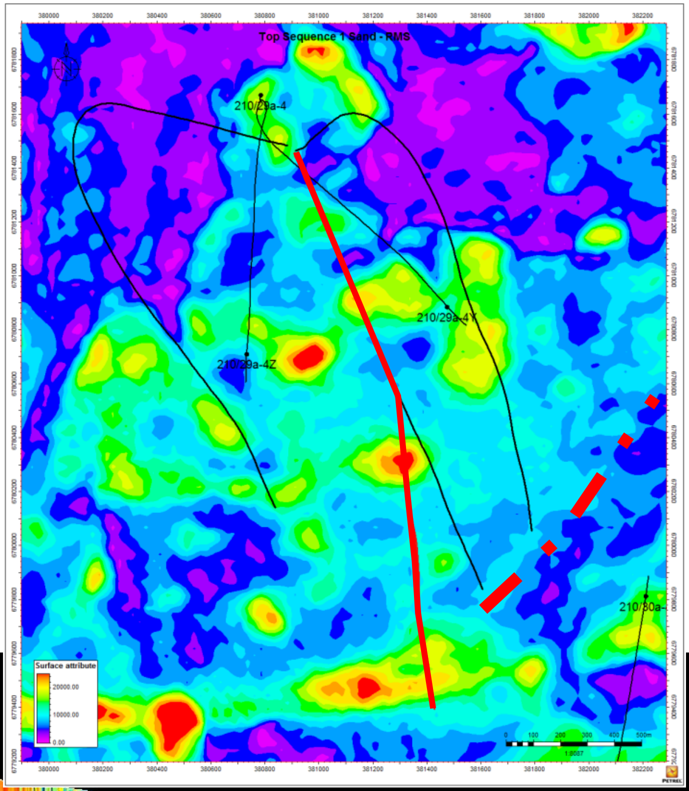


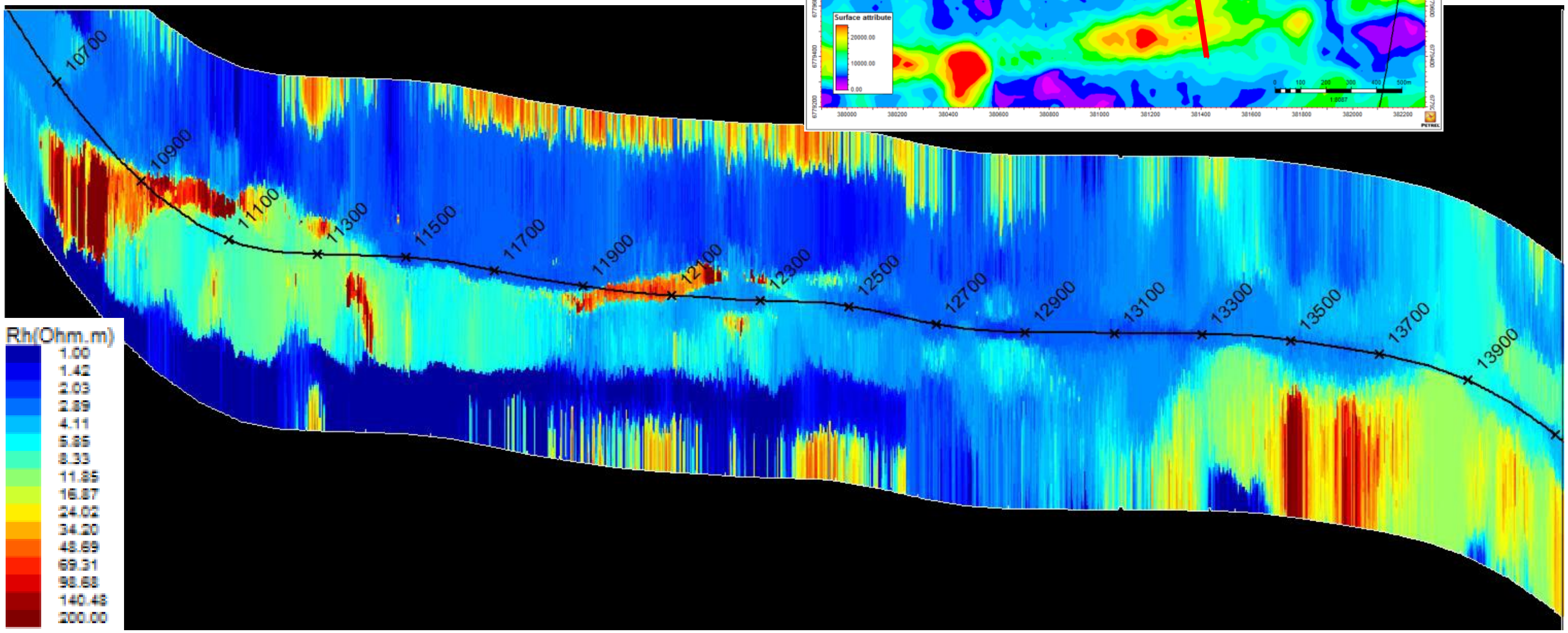


- 210/29a-7Z targeted the sand encountered by the heel of 210/29a-7 and the thinning sands encountered at the toe of 210/29a-6Z and potential upside in the 210/30a-4 channel
- Thin sands encountered were interpreted to be the updip equivalent of sands at the toe of 210/2a-6Z

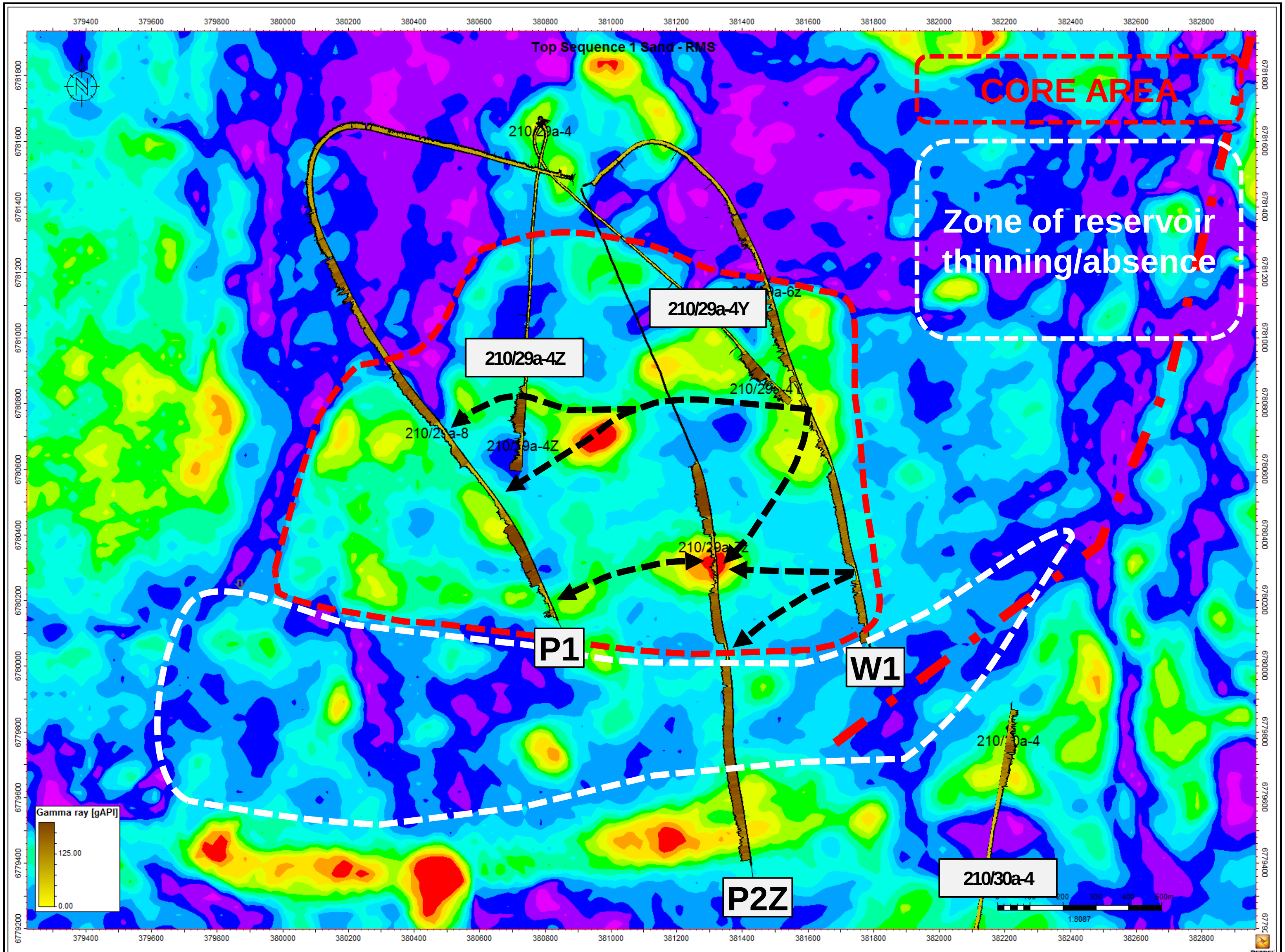
P2Z DDR

- The first sand encountered displays a thicker signature than previously thought.
- Thinning of reservoir is evident to the South again here.
- DDR results in both 210/29a-6Z and 210/29a-7Z help delineate extent of primary reservoir interval to the South.
- Strong hydrocarbon response in the channel targeted by the toe.





Cladhan – Connectivity

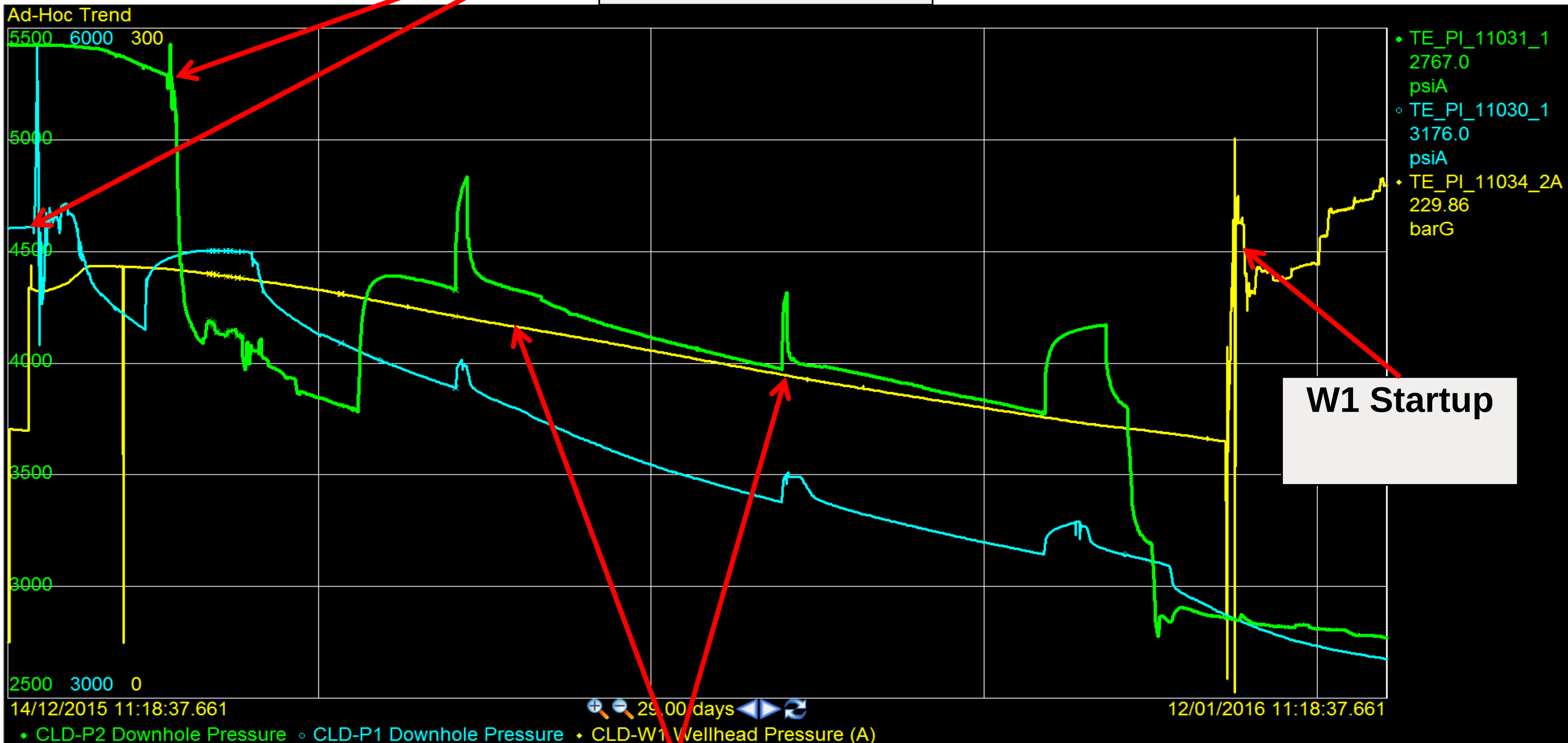


Post Drill Conclusions

- The Cladhan wells achieved their initial development objectives. All targeted sands now had drainage points within them with high confidence of injection support
- Significant thinning to the south of the core area had negatively impacted potential upside resources.
- The decision to move the 210/29a-6Z injector updip had reduced risk but impacted accessible volumes
- Reservoir encountered significant cemented sands and coupled with potential for high permeability streaks, sweep efficiency increased in uncertainty
- Connectivity between the wells seemed good
- Cost of developing the subsurface had been impacted by:
  - Winter drilling
  - Scope changes
  - Delays in running complex completions
  - Dealing with uncertainties associated with having to appraise while drilling

Cladhan Start up

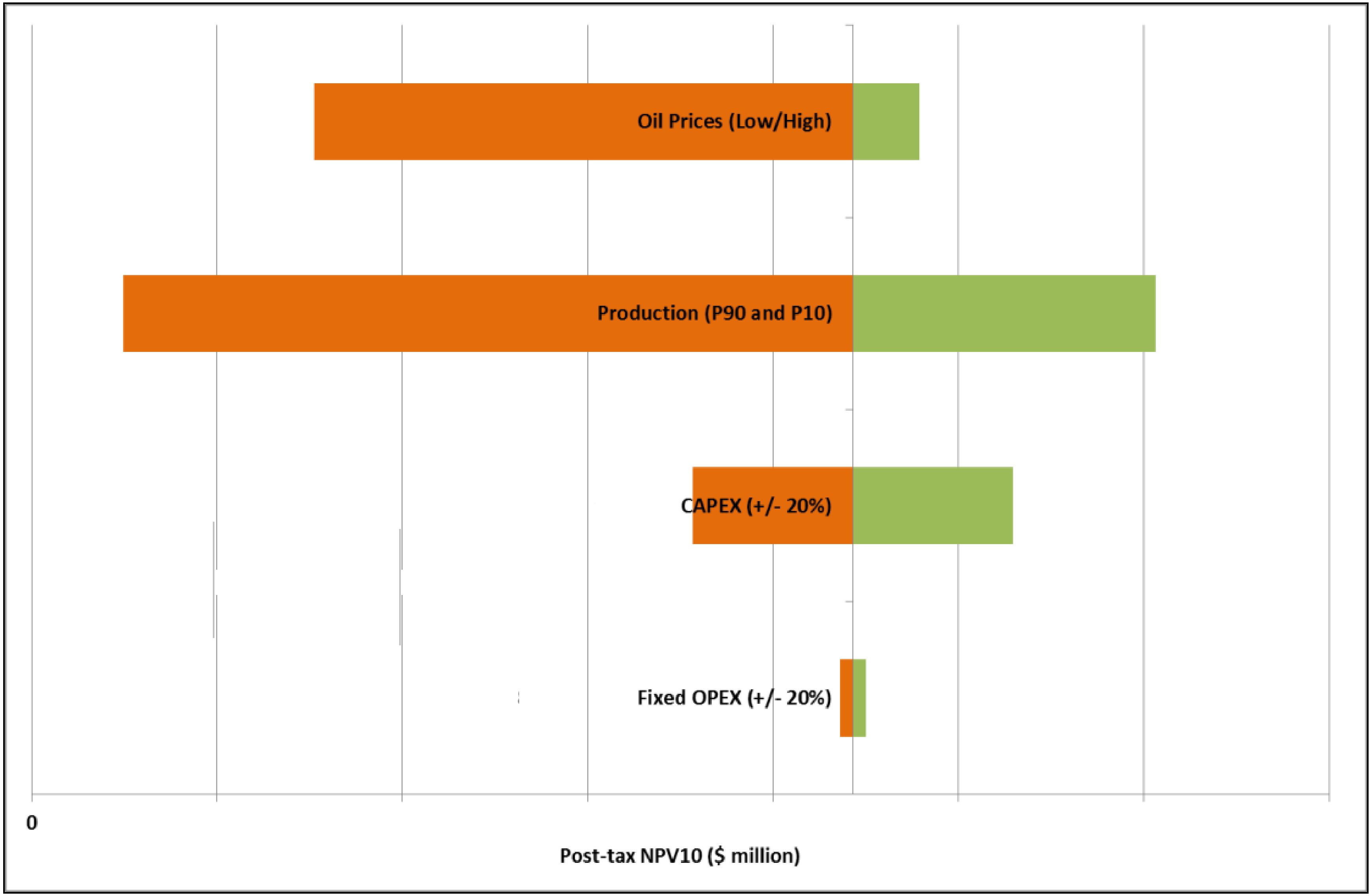
P1 startup - depletion observed at P2Z



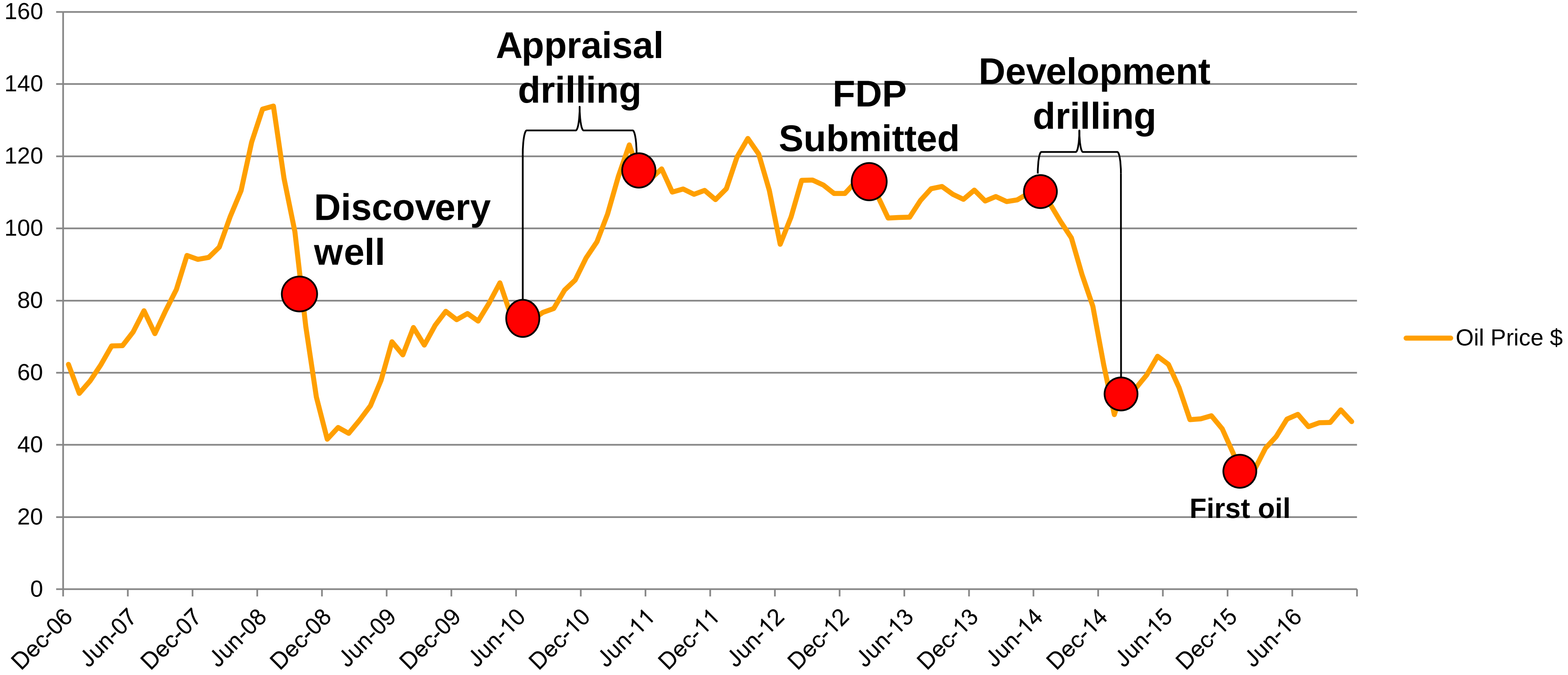
W1 Startup

Gradual decline in injector well head pressure due to offtake from P1 and P2Z

Cladhan Project Uncertainties 2013

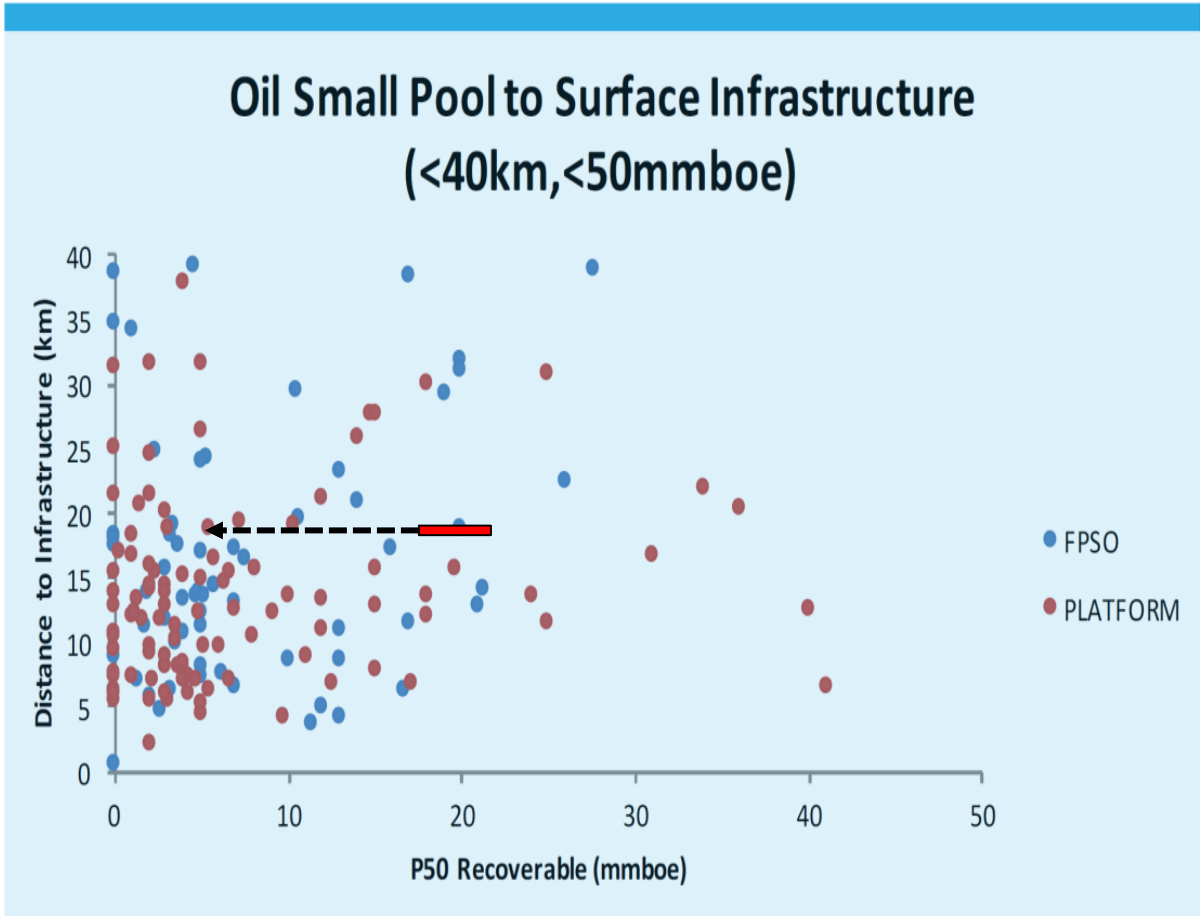


Cladhan Project Evolution v Oil Price



- All projects are susceptible to oil price Cladhan is no different
- Development decision made at over $100 dollars, first oil at $27

SMALL POOLS – Revisited with Cladhan Results in Mind



Source: OGA PARS 2015 database, CDA

- How marginal is the project?
- How likely is it to yield poorer results (and how poor)?
- Appraising while drilling carries risk that needs to be factored in
- Structure the development to take advantage of what you know you have and protect against disappointing results
- Does this new price climate make these developments more attractive?

TAQA