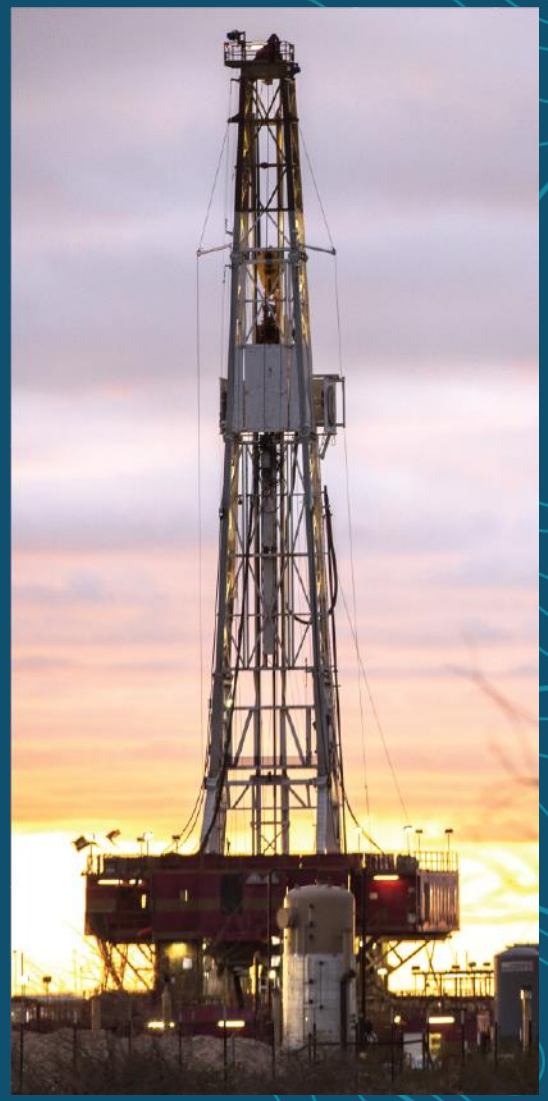
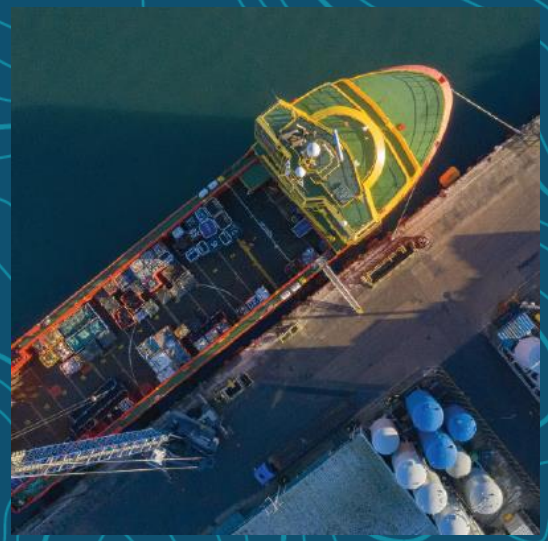
The development of bypassed pay in the Buckland Field: targeting attic, cellar and secondary intervals above and below a prolific horizontal well.

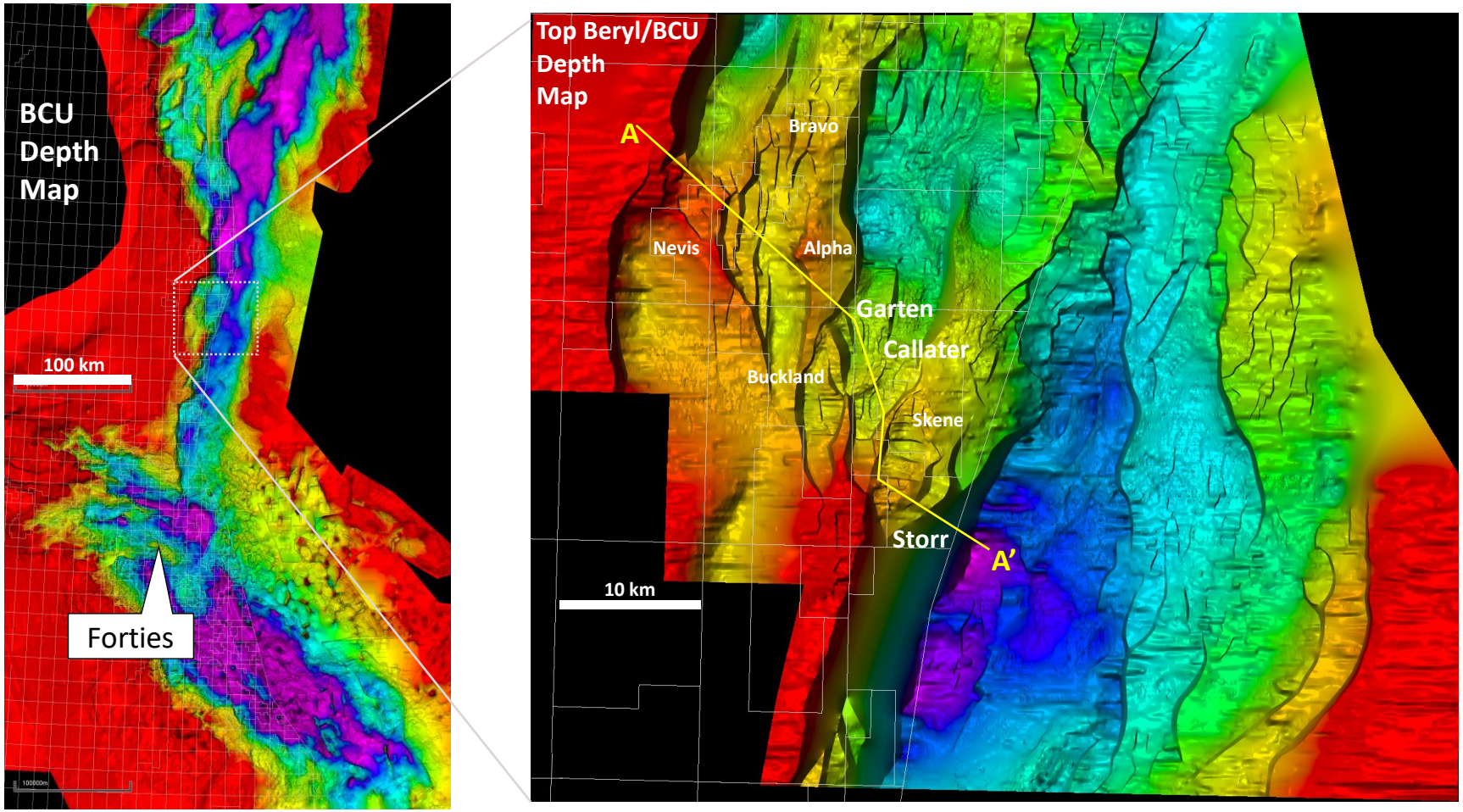
Rachael Crowe, Phil Rose, Prashanth Srinivasan

Apache



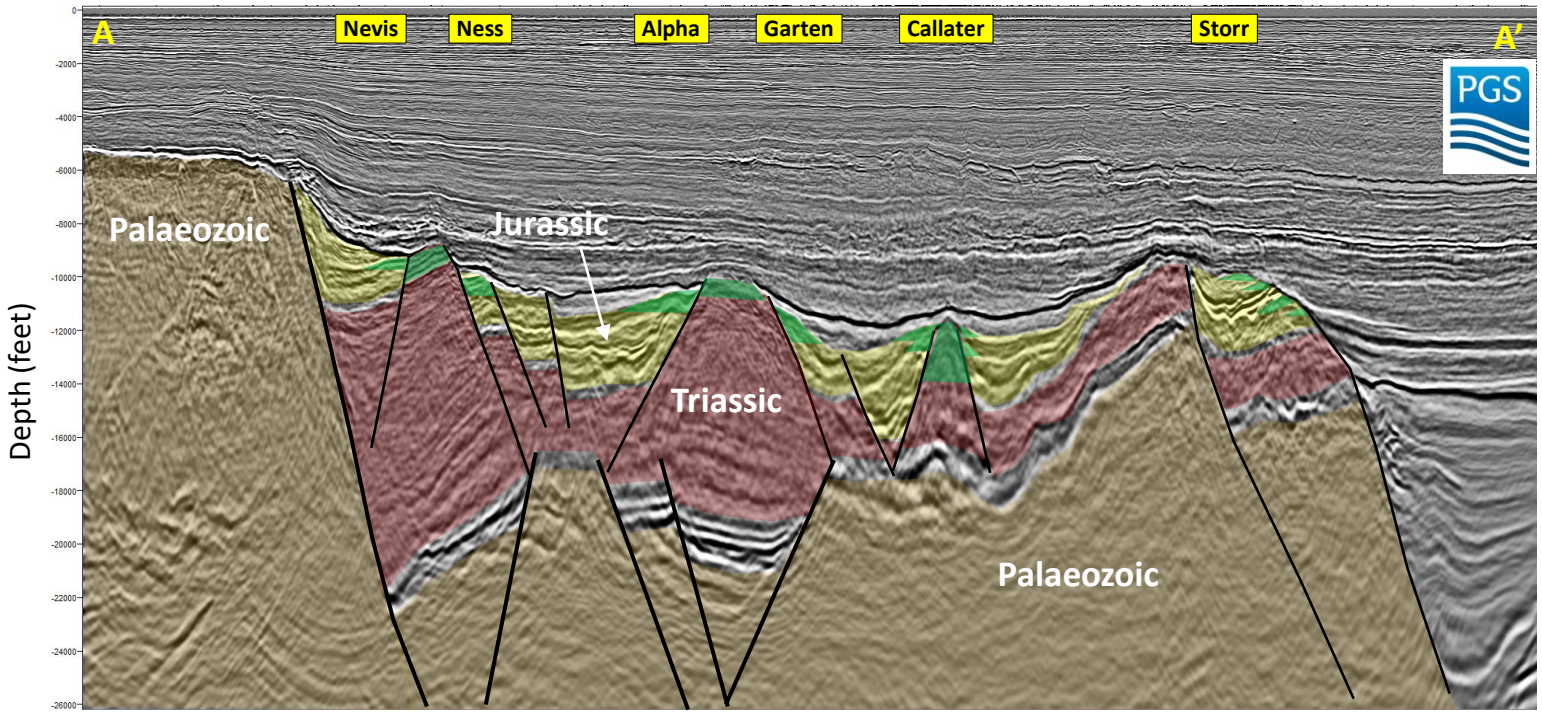


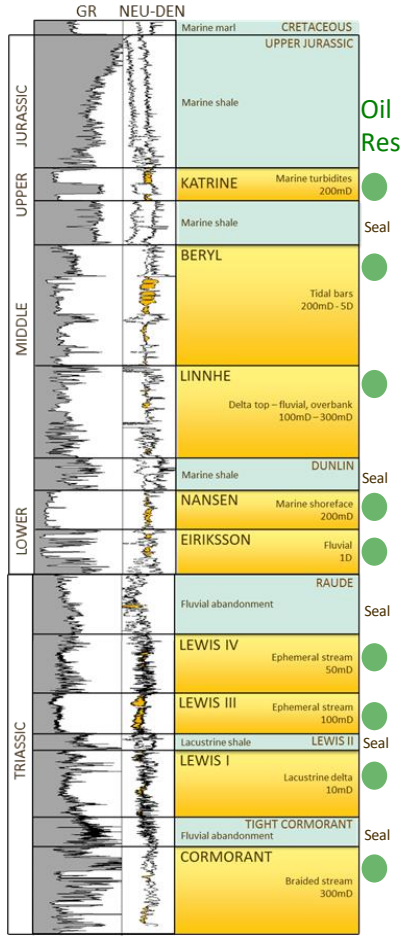
Beryl Embayment – Large Scale Relay Ramp Lots Of Fault Traps



Triassic rifting followed by Jurassic rifting

- Complex structural history

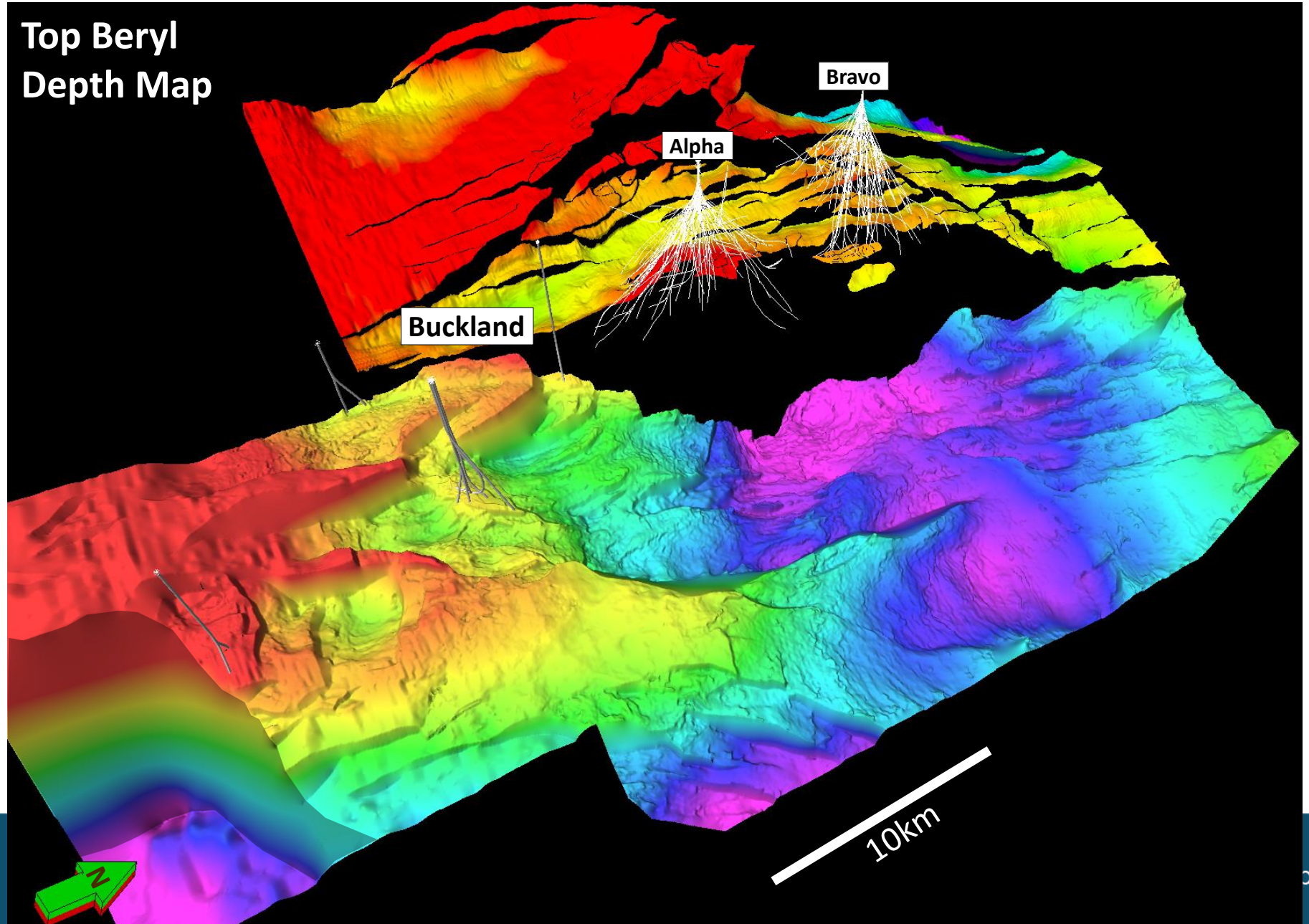




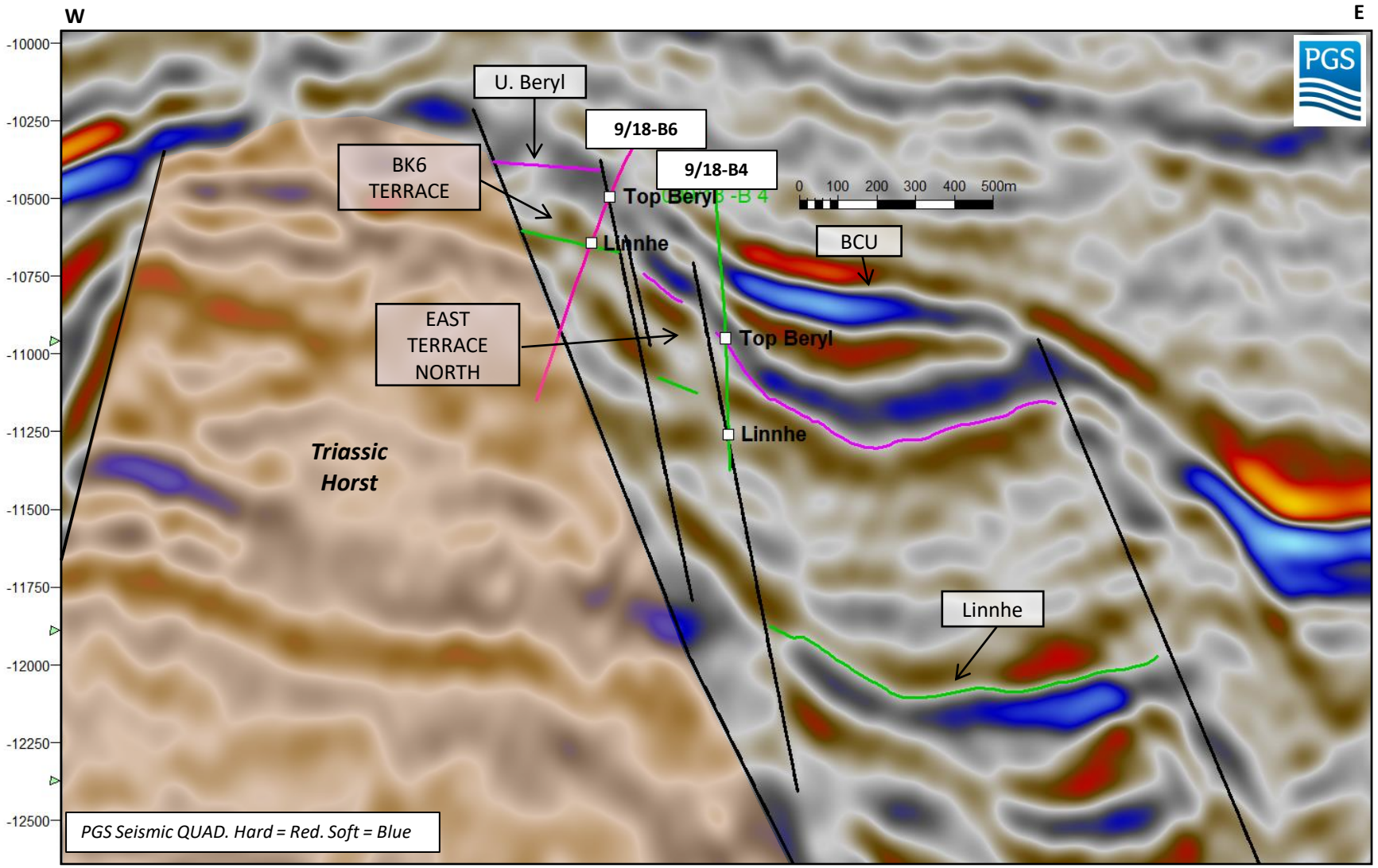
Buckland reservoir

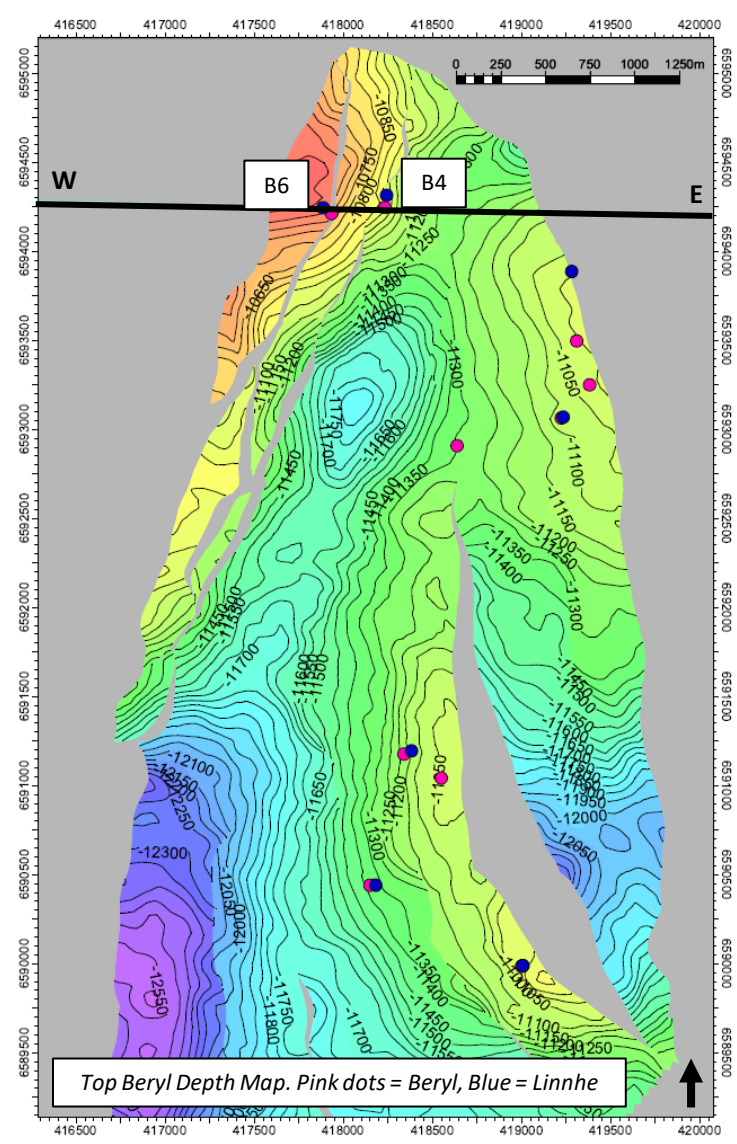
- Traps formed within a large relay ramp – high trap density
  - High Side Jurassic and Triassic fault traps
  - Low side Jurassic fault traps
- Multiple reservoirs and seals provide stacked pay opportunities

Top Beryl semi regional depth from PGS broadband data interpretation

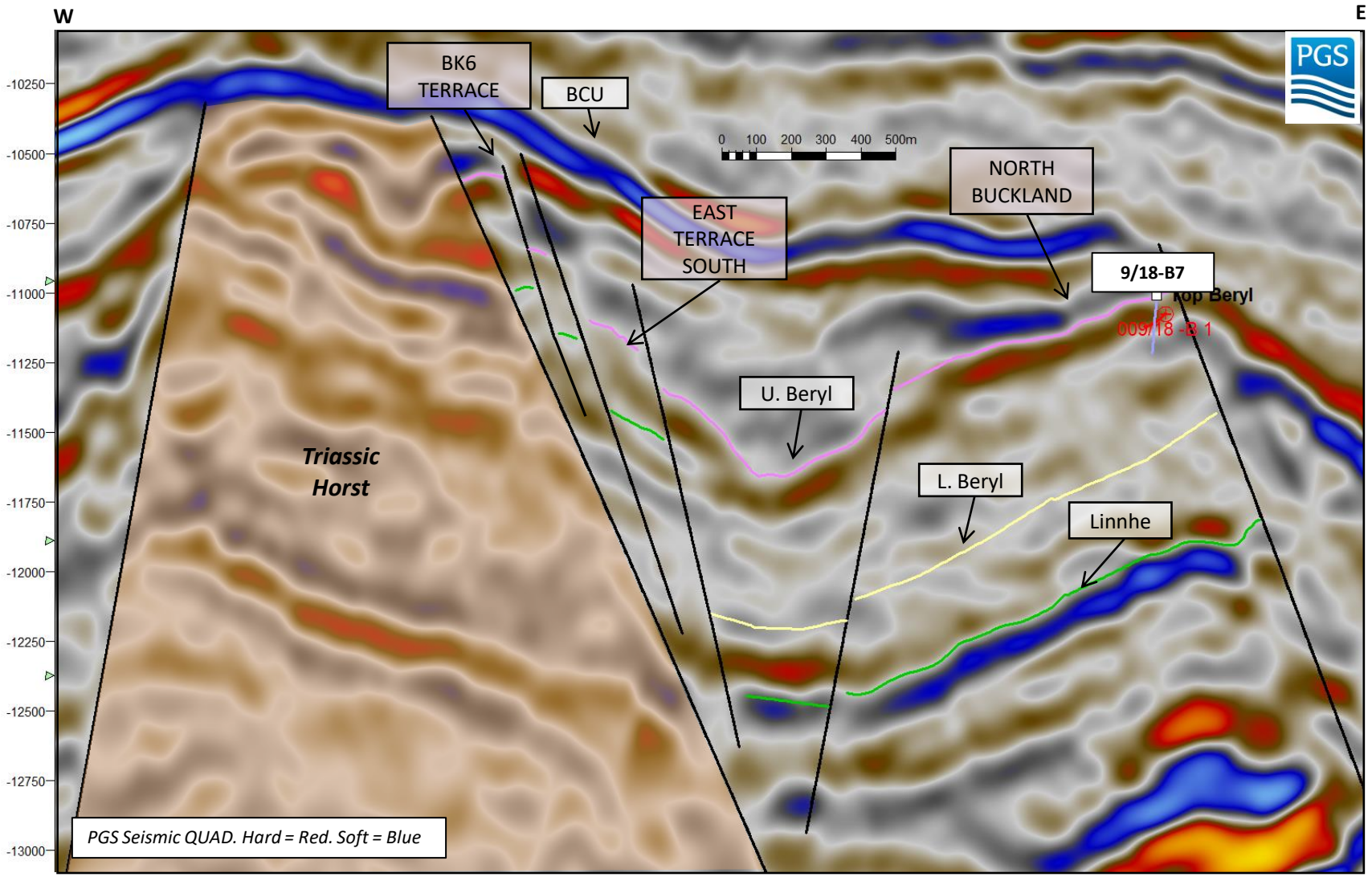


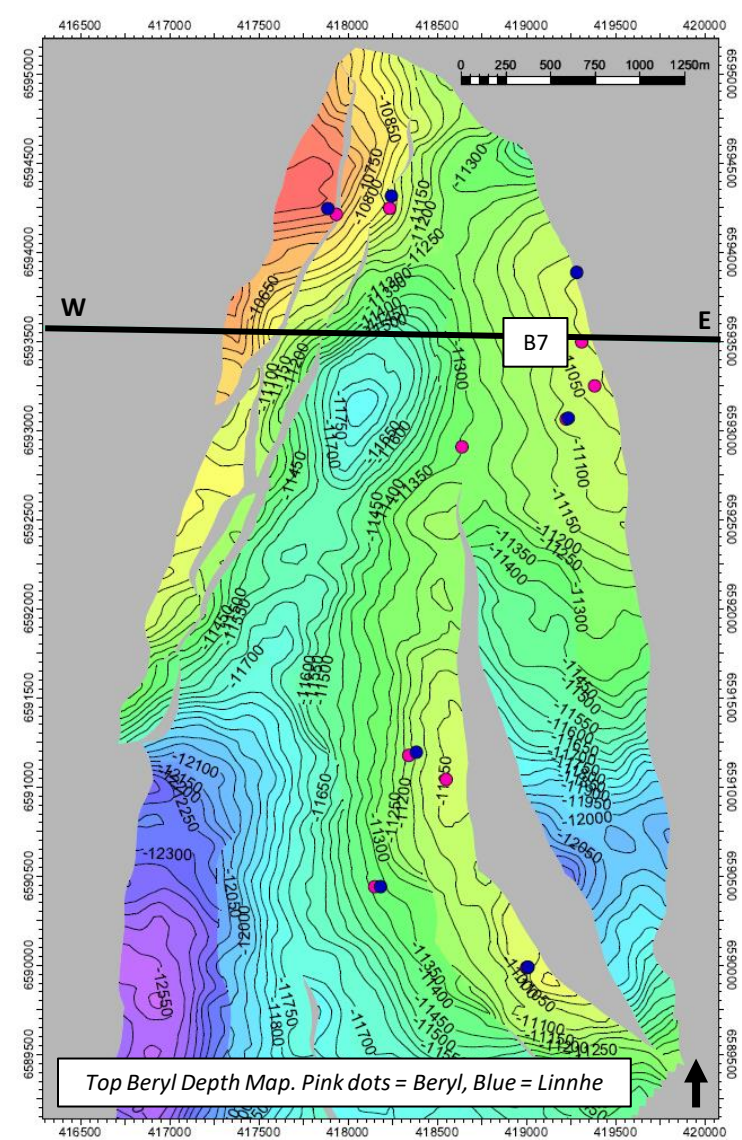
Regional Seismic: W-E



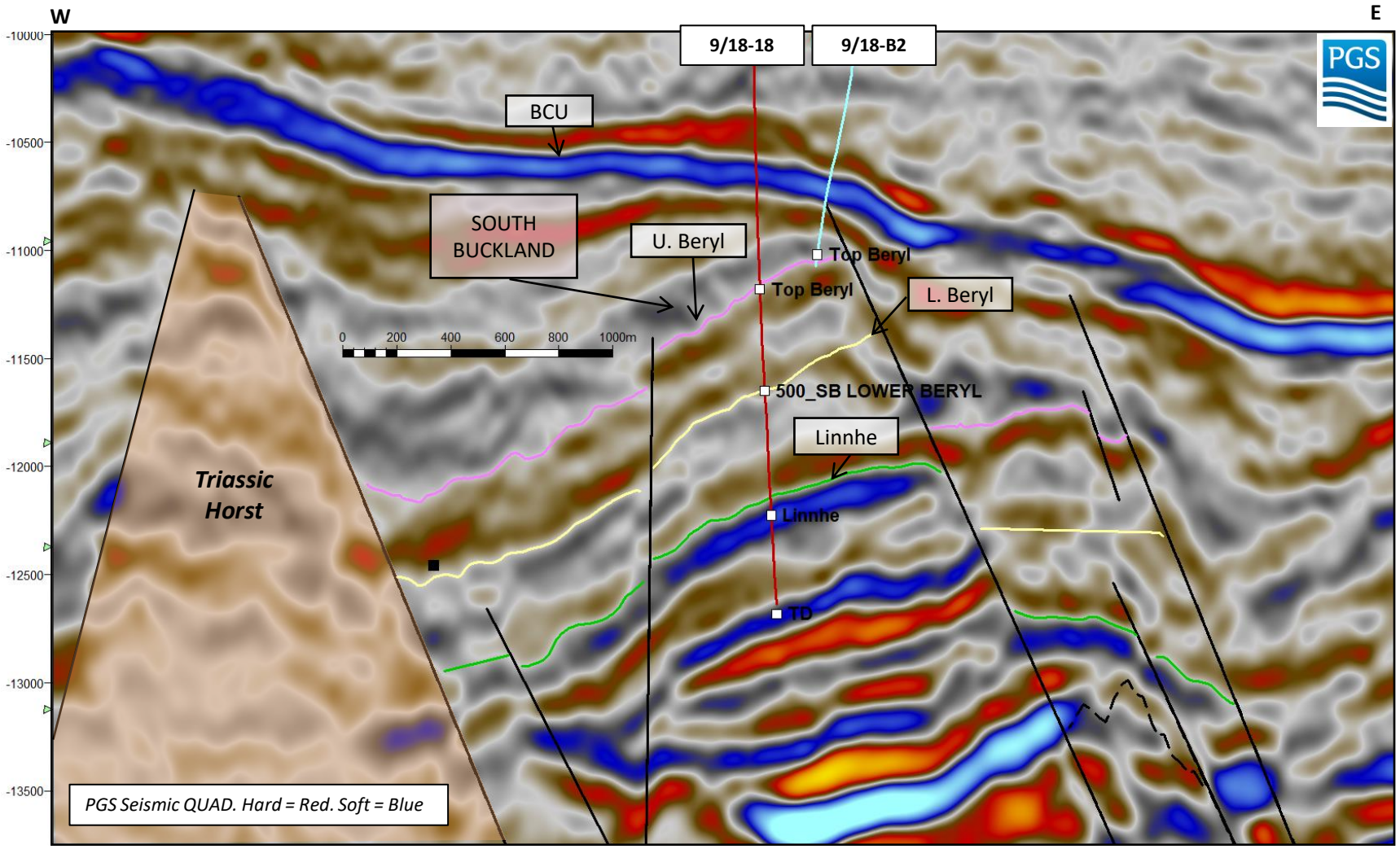


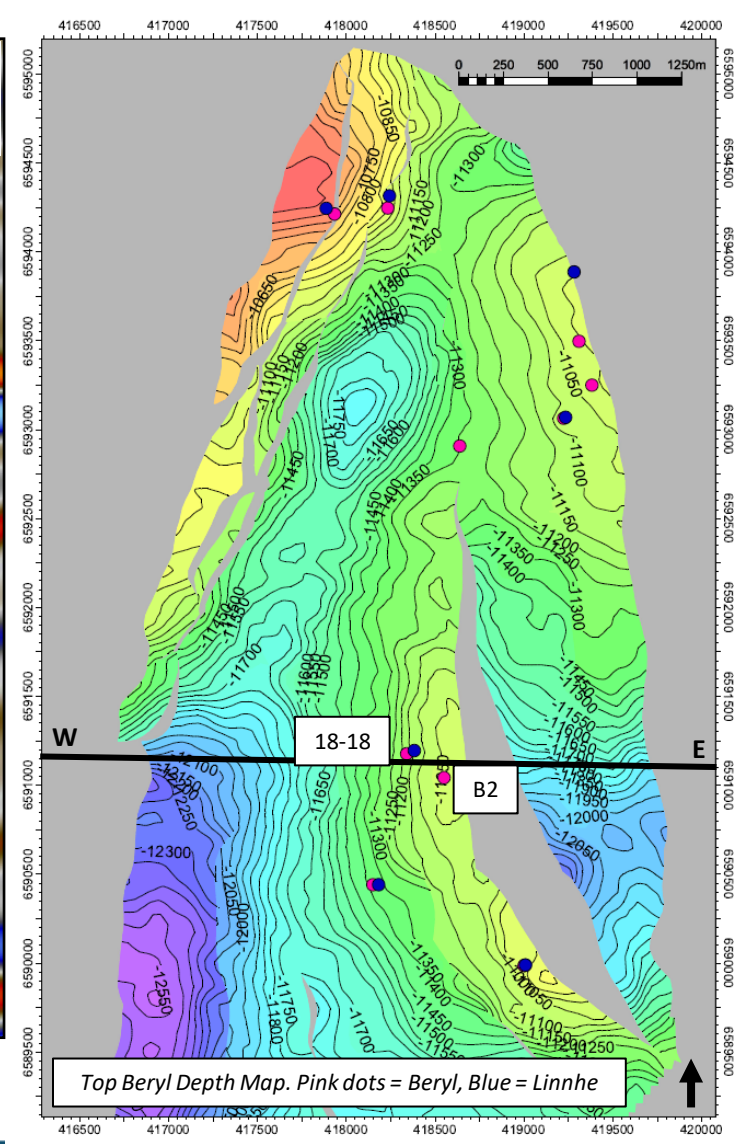
Regional Seismic: W-E





Regional Seismic: W-E





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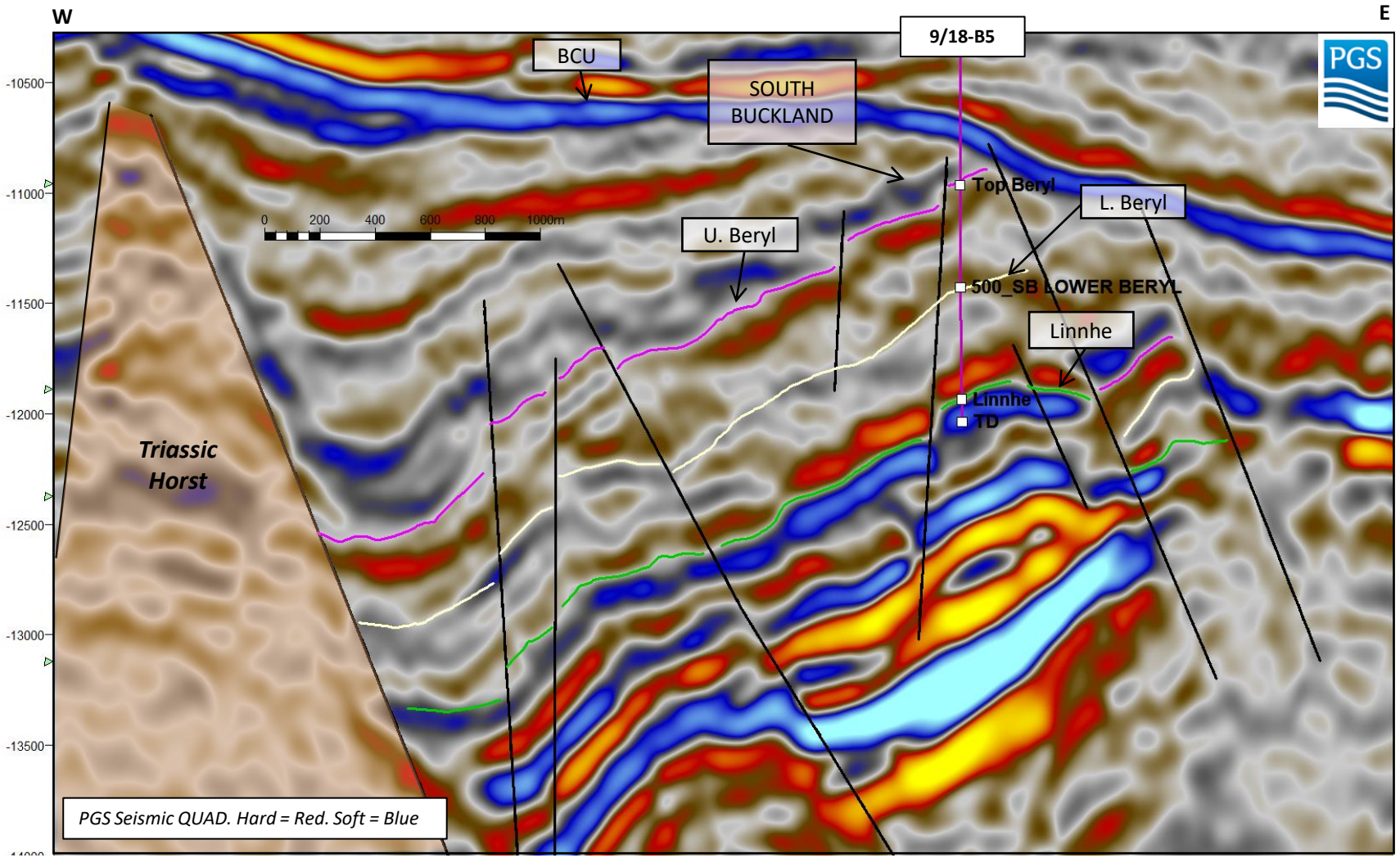
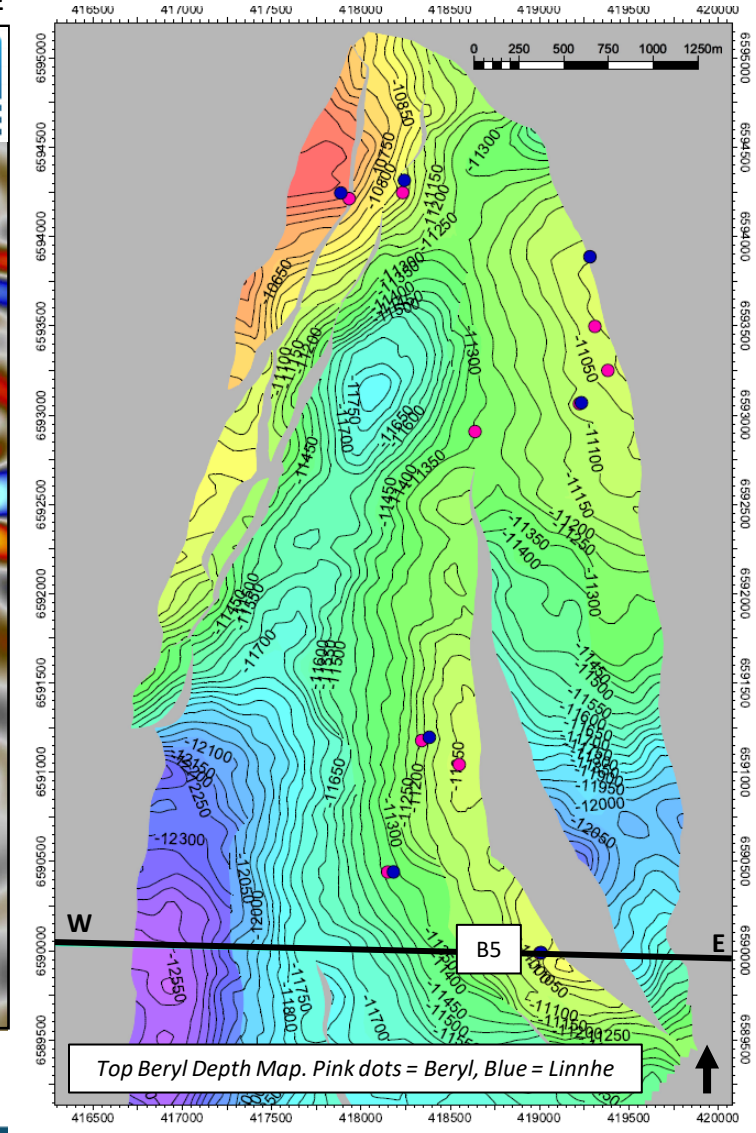
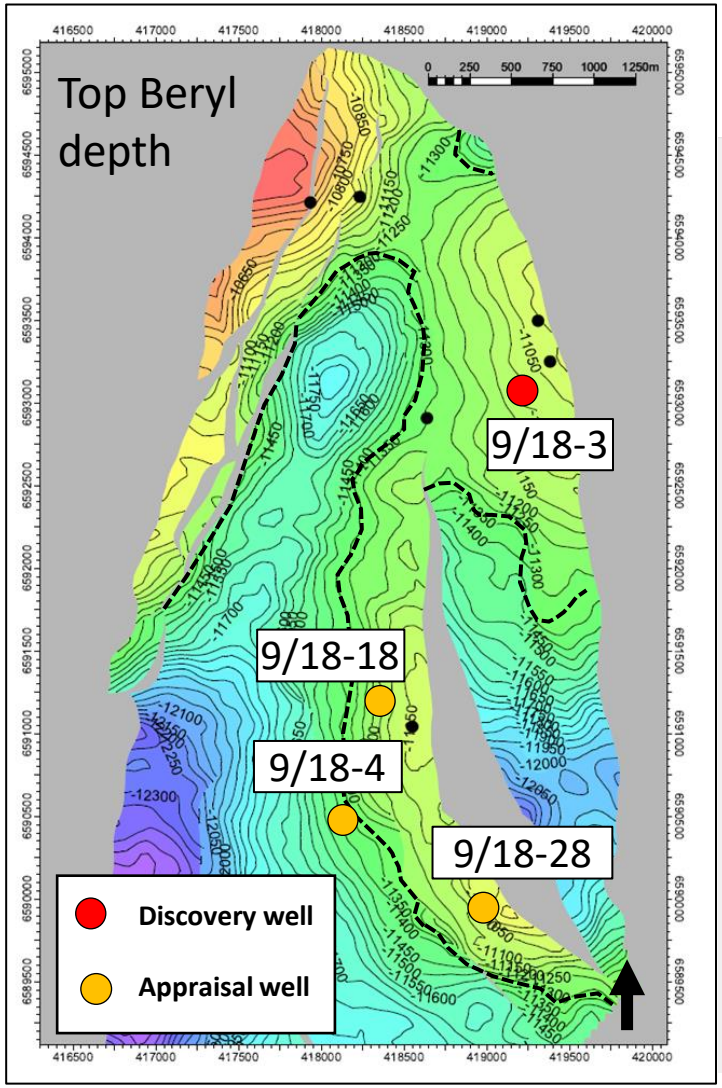
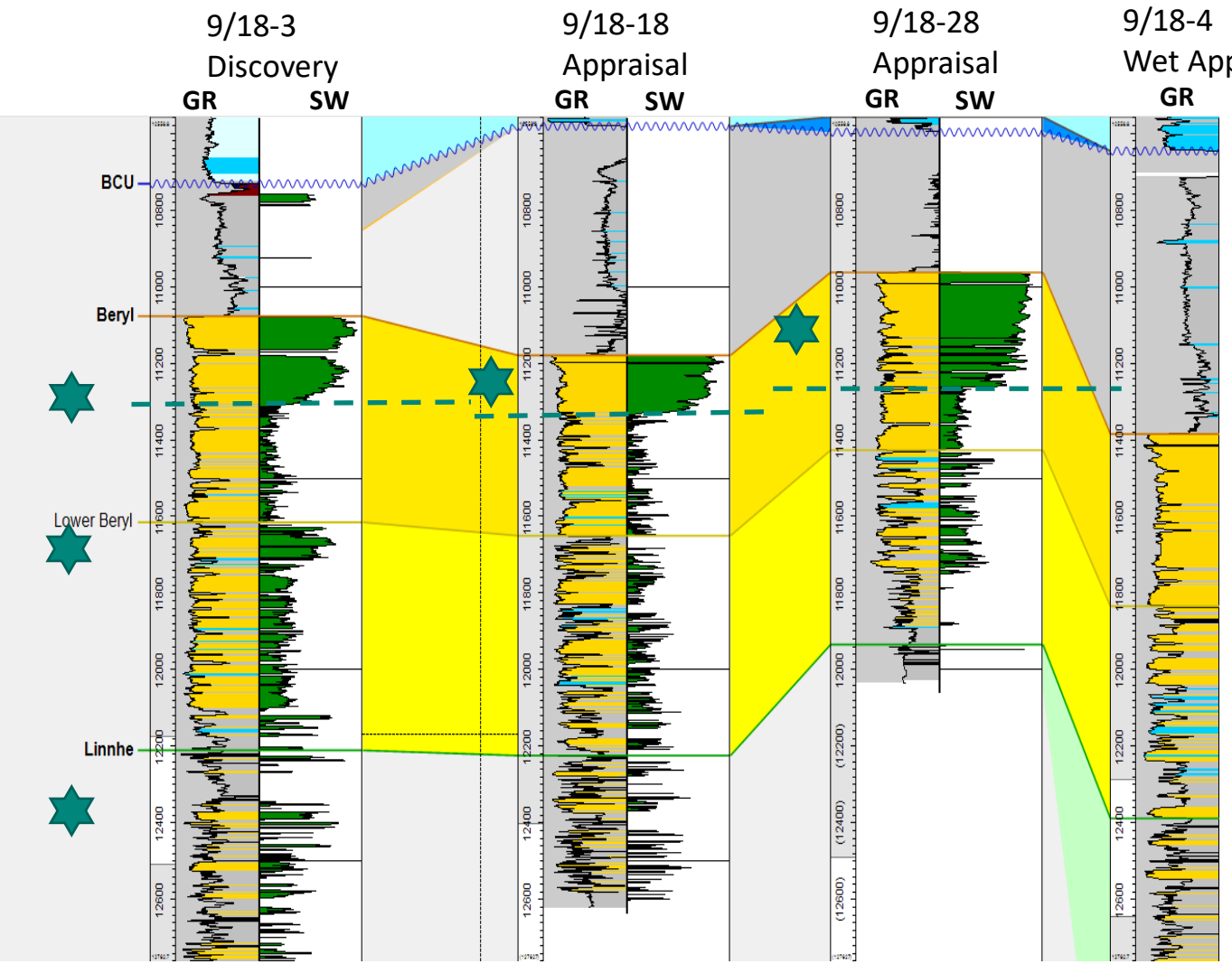




Buckland discovered 1979 – 3 appraisal wells





Hung on depth

High perm Upper Beryl pay
Complex contact distribution

200 ft

Upper Beryl

Lower Beryl

Tested pay

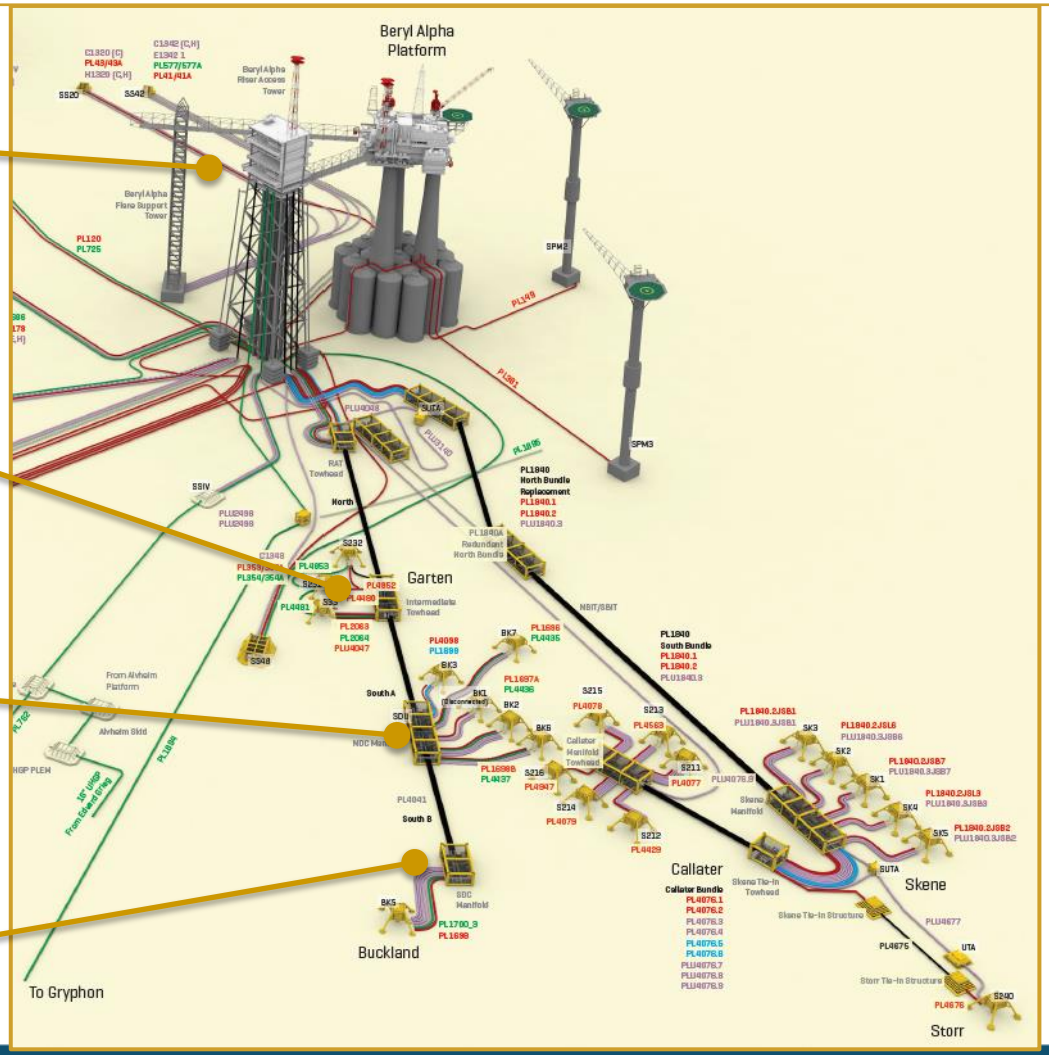
Buckland Subsea development - bundle tied back to Beryl RAT

Beryl Alpha Riser Access tower

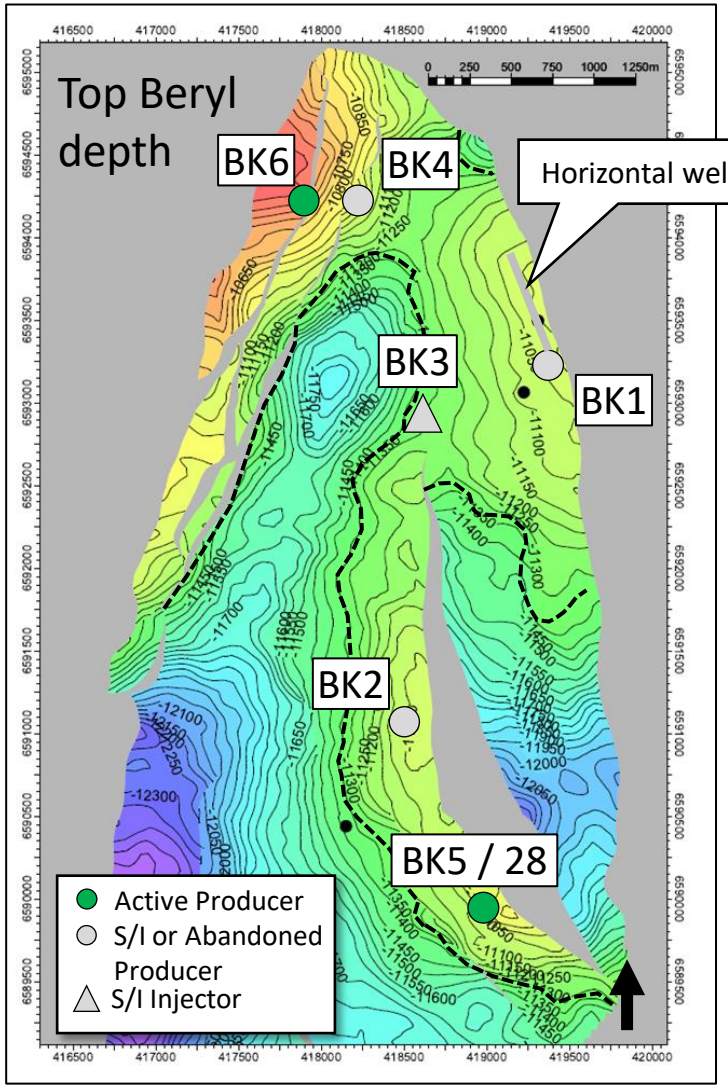
Buckland bundle intermediate tie in point

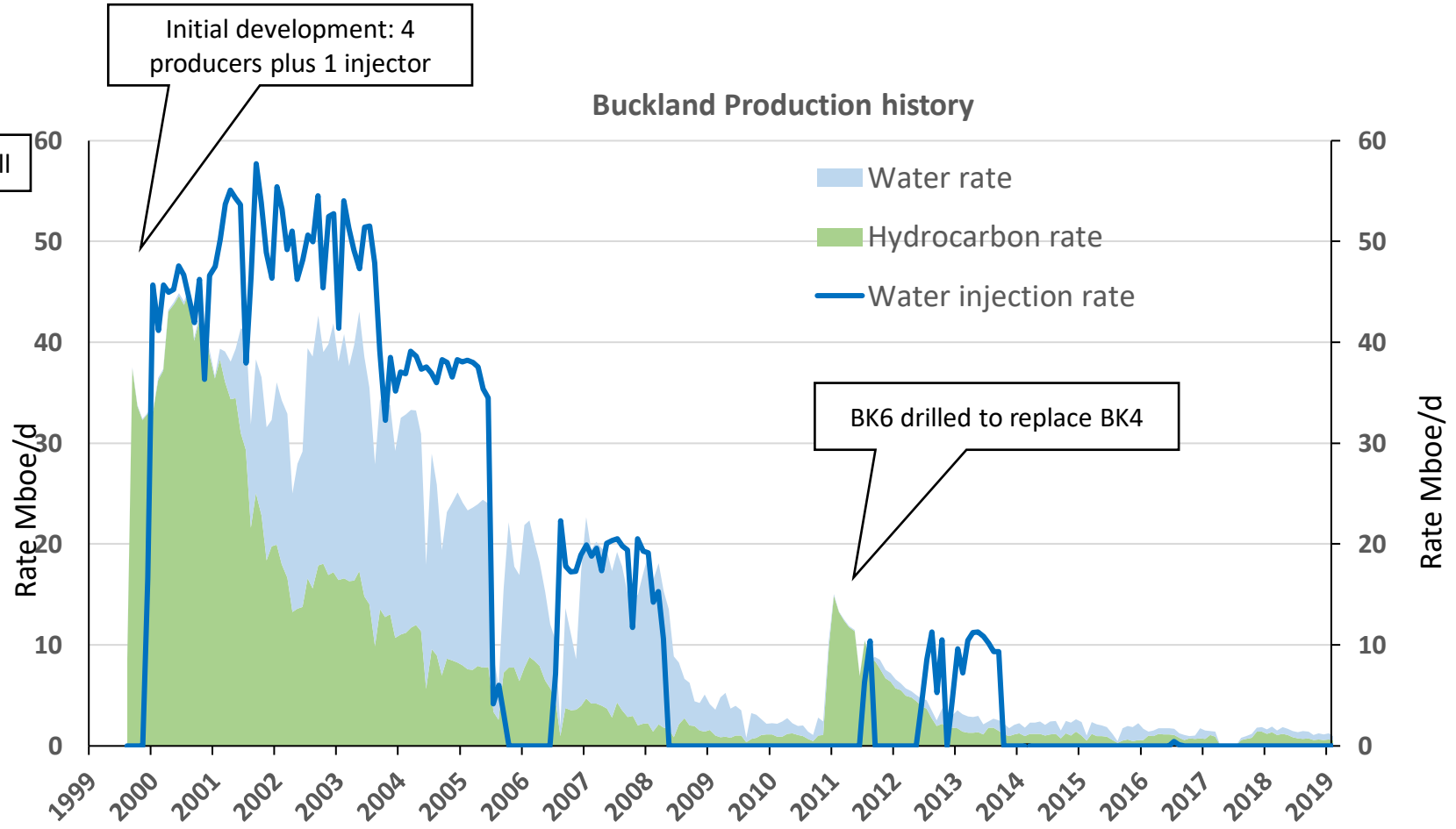
Main Buckland manifold BK1, BK2, BK3, BK4/6, BK7 wells

Buckland South BK5 well



Buckland Field – 5 producers 1 injector, 2 producers online 2018

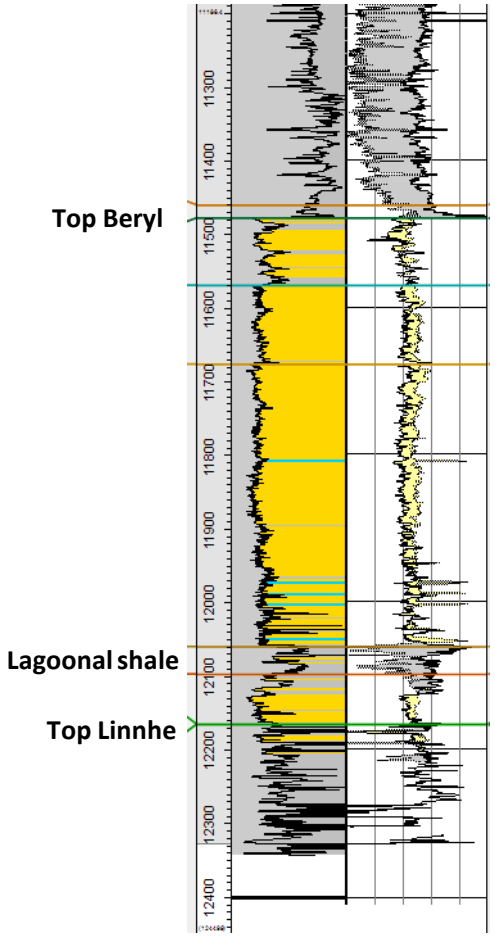




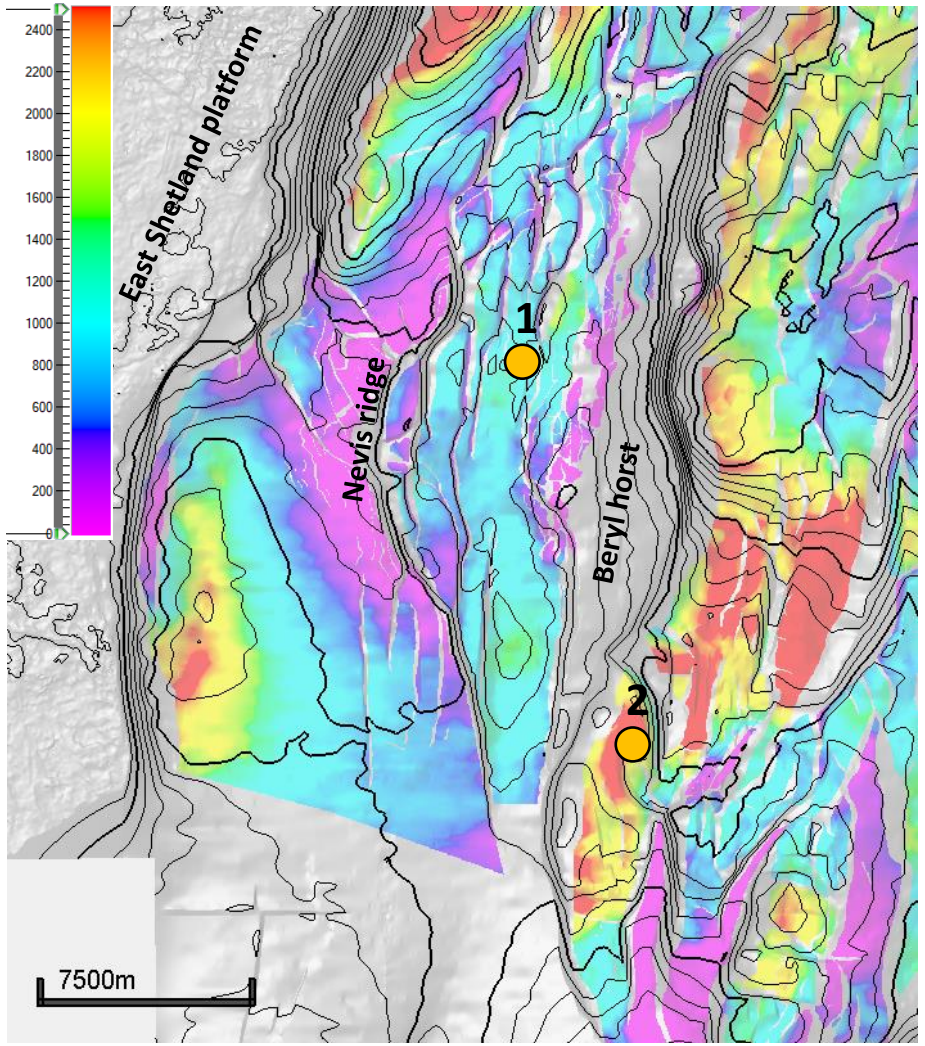
First oil 1999
BK6 infill drilled 2011
Allocated Oil Prod to 06/2018= 45 MMBO

Beryl reservoir:
Bathonian Estuarine system - highs separate areas of contrasting depositional style

1 Beryl Field
Beryl fm type log

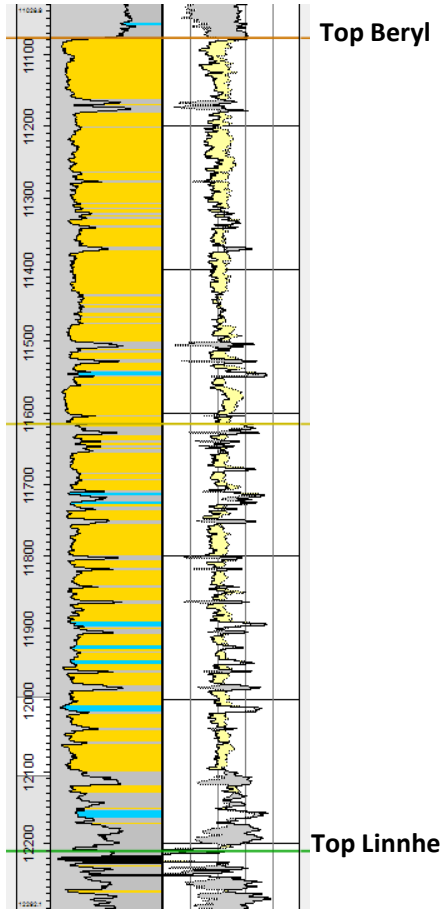


Single thick lagoonal shale
Thick para-sequences



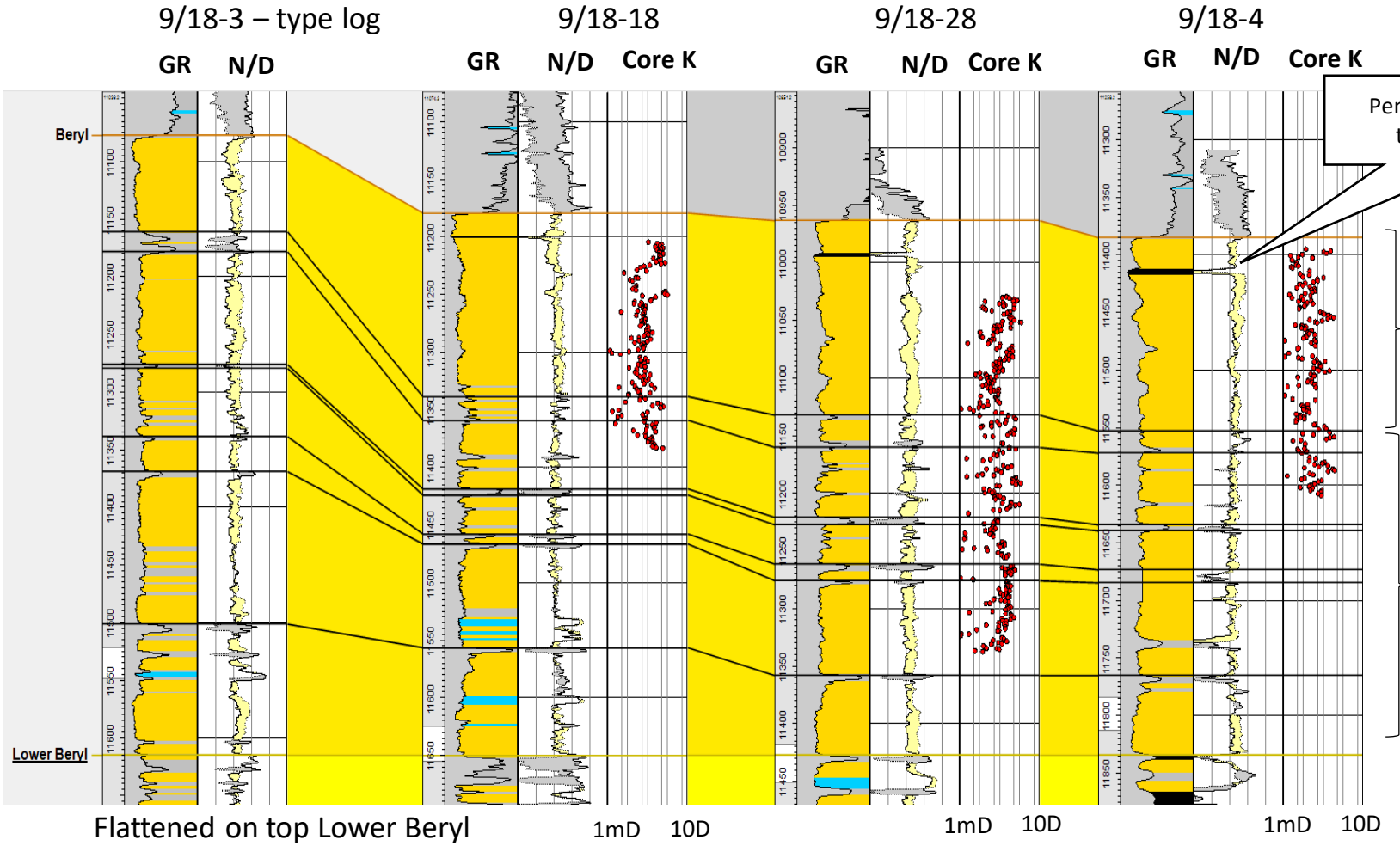
Top Beryl coloured by Beryl + Linnhe thickness (ft)

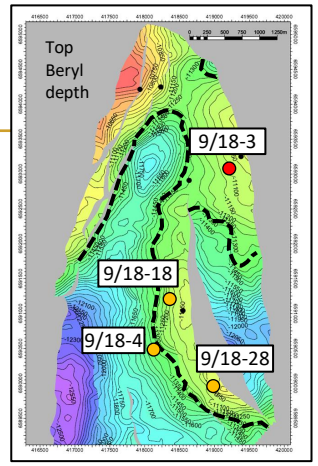
2 Buckland Field
Beryl fm type log



Many thin lagoonal shale
Thin para-sequences

Buckland Field Beryl - Lagoonal shales layer reservoir

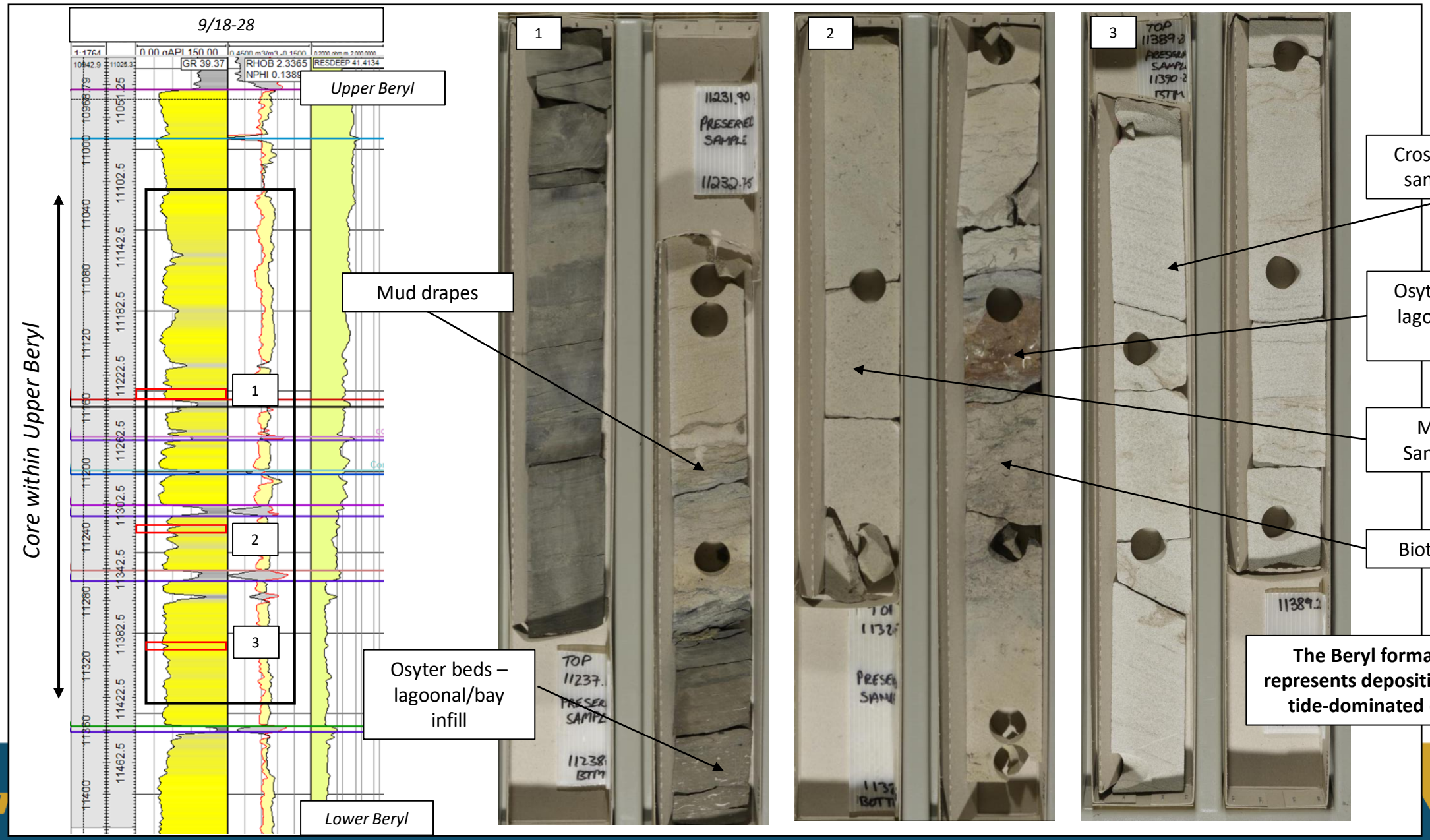




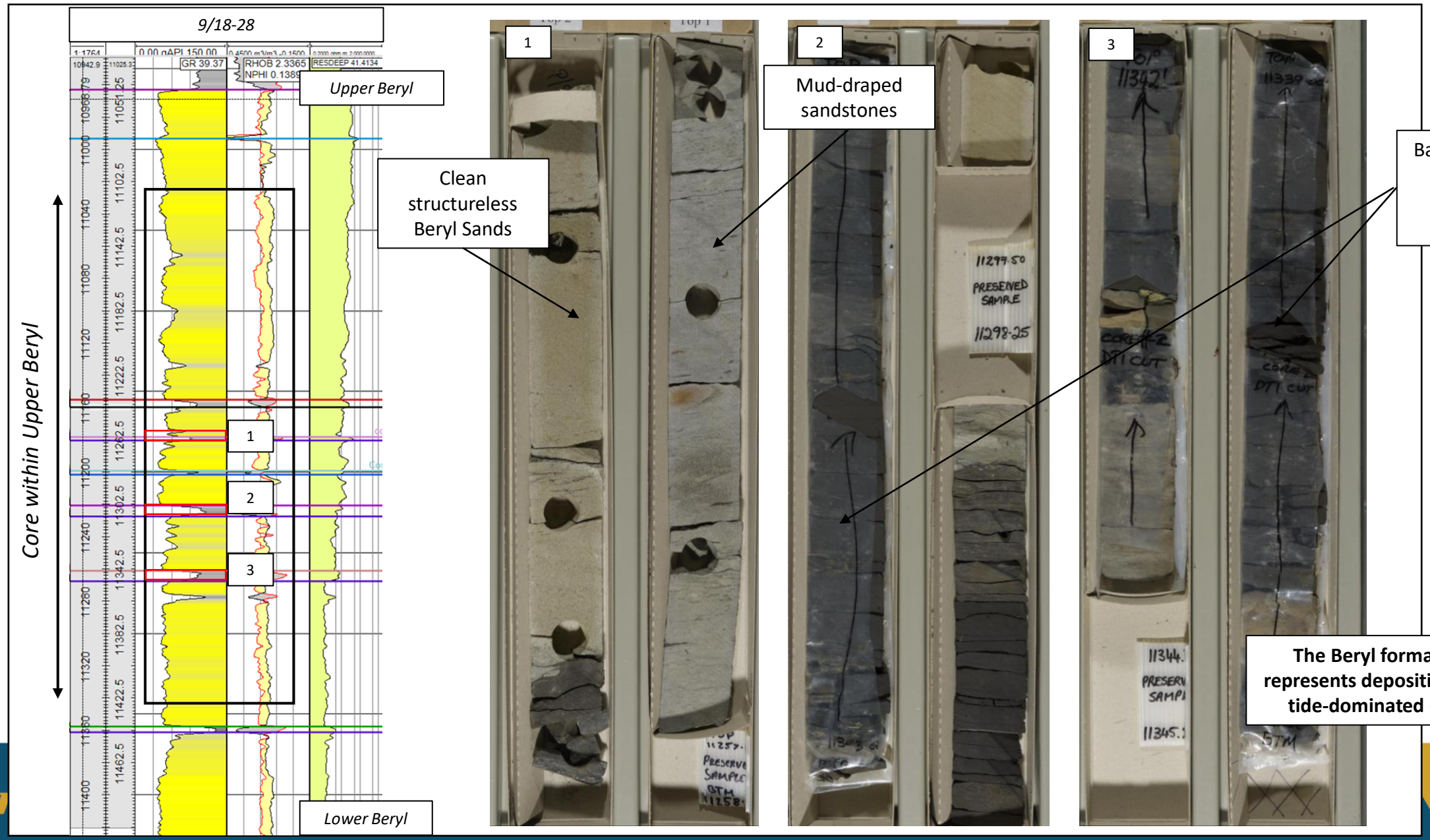
Stacked regressive para-sequences
Bioturbated lower shoreface to clean sand bars

Bituminous shales layer reservoir
Restricted faunas suggest lagoonal deposits
Interbedded with tidal channel, tidal bar and sand flat deposits

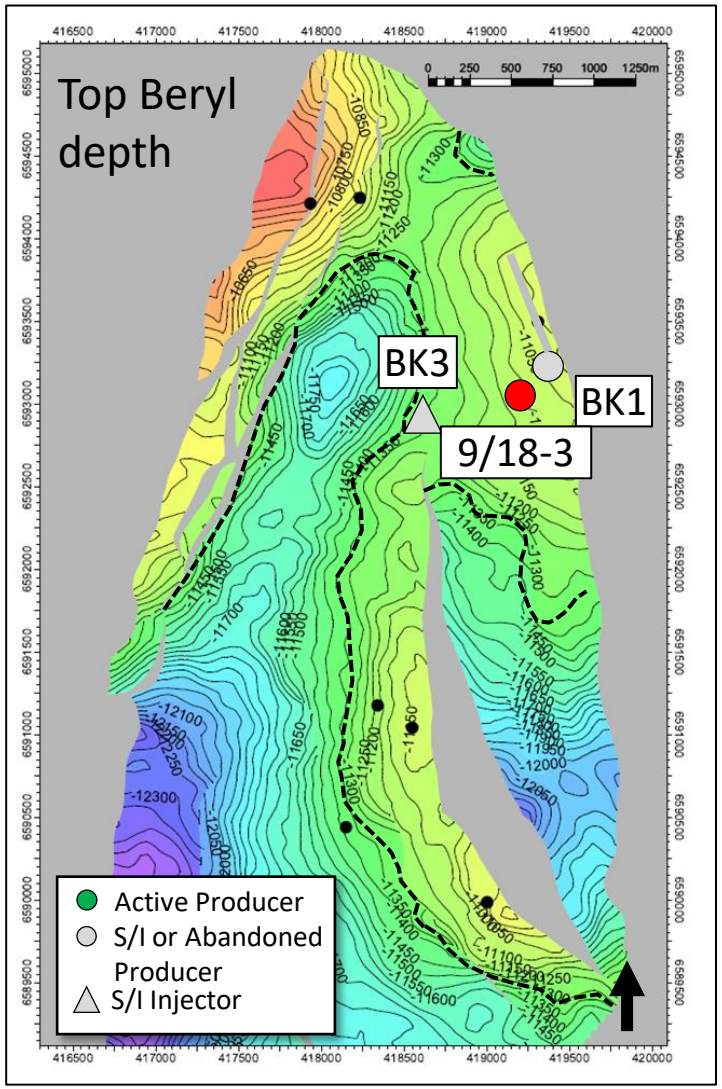
Buckland Core: 9/18-28 Reservoir



Buckland Core: 9/18-28 Bituminous Shales – Baffles to Flow



Layered reservoir – B1 only contacted upper most units

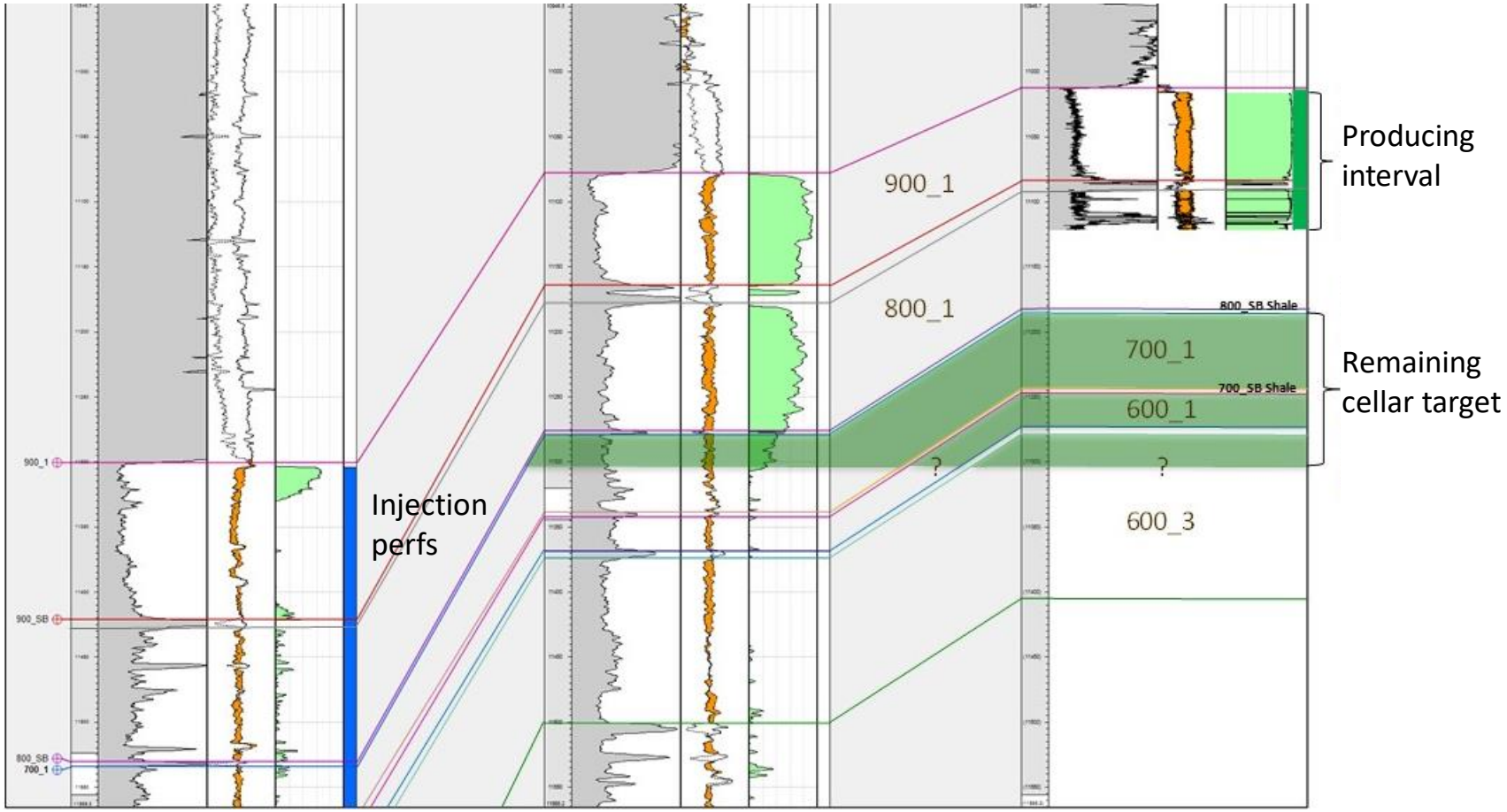


NORTHERN FAULT BLOCK

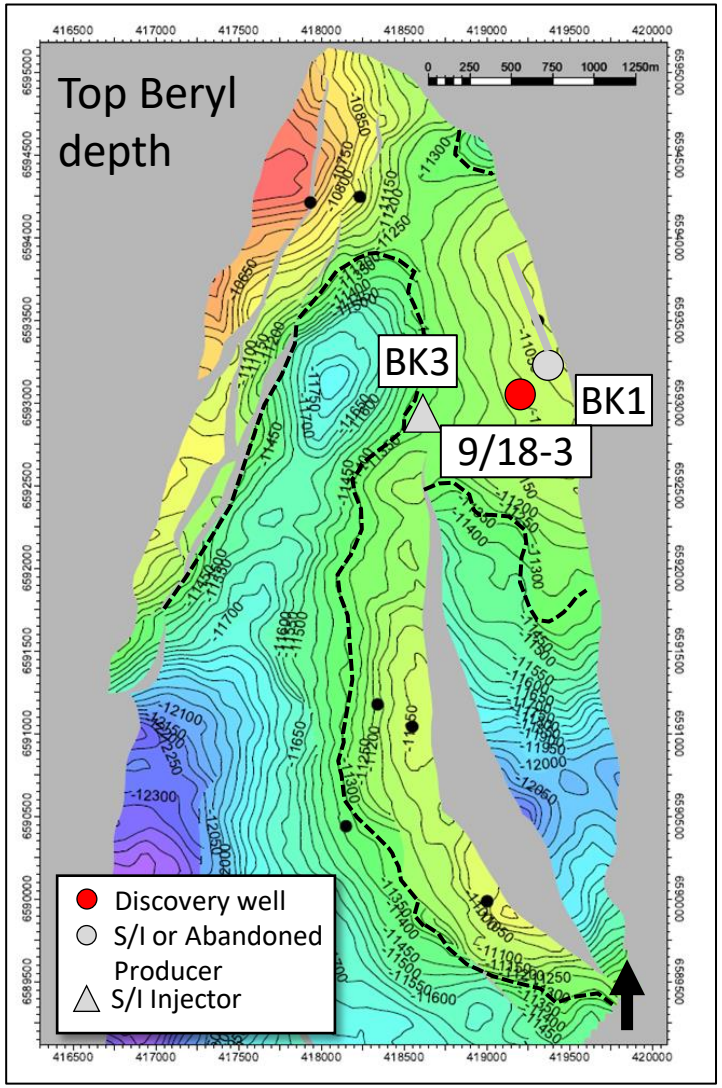
B3 injector

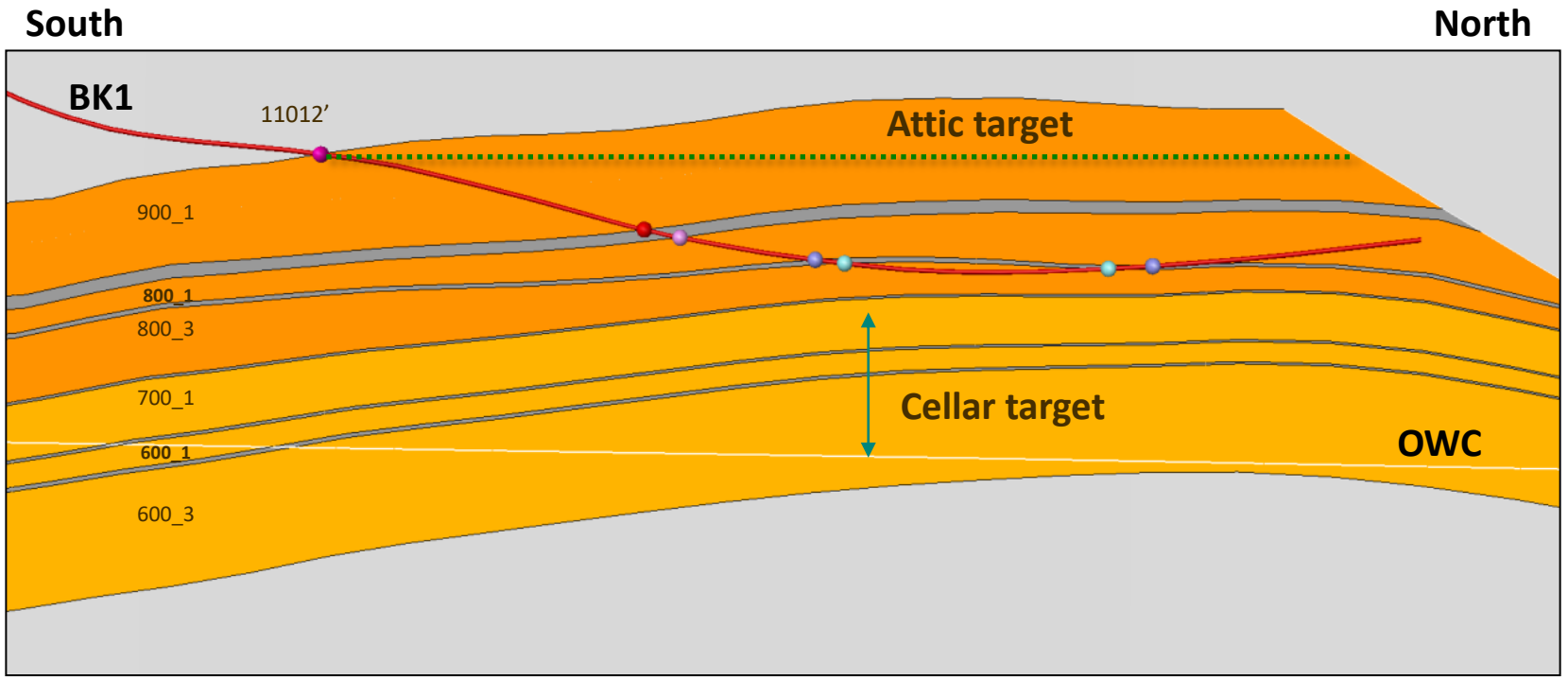
9/18-3 discovery

B1 horizontal producer
Cum. prod. 16 mmbo



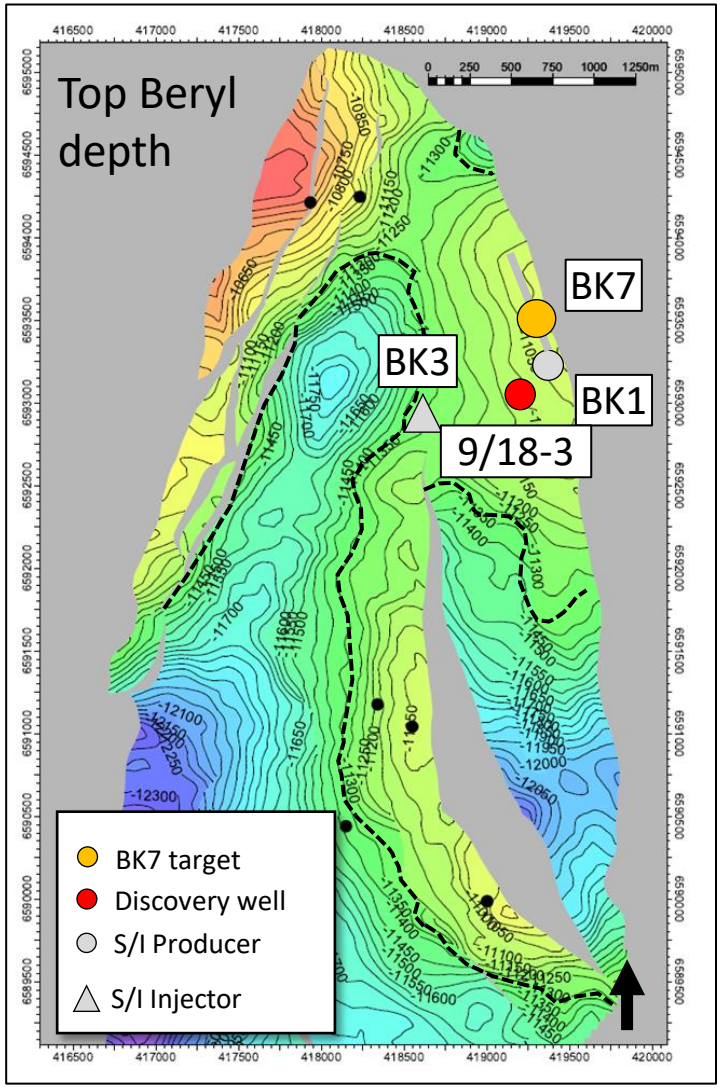
Upper Beryl Attic and Cellar remaining oil

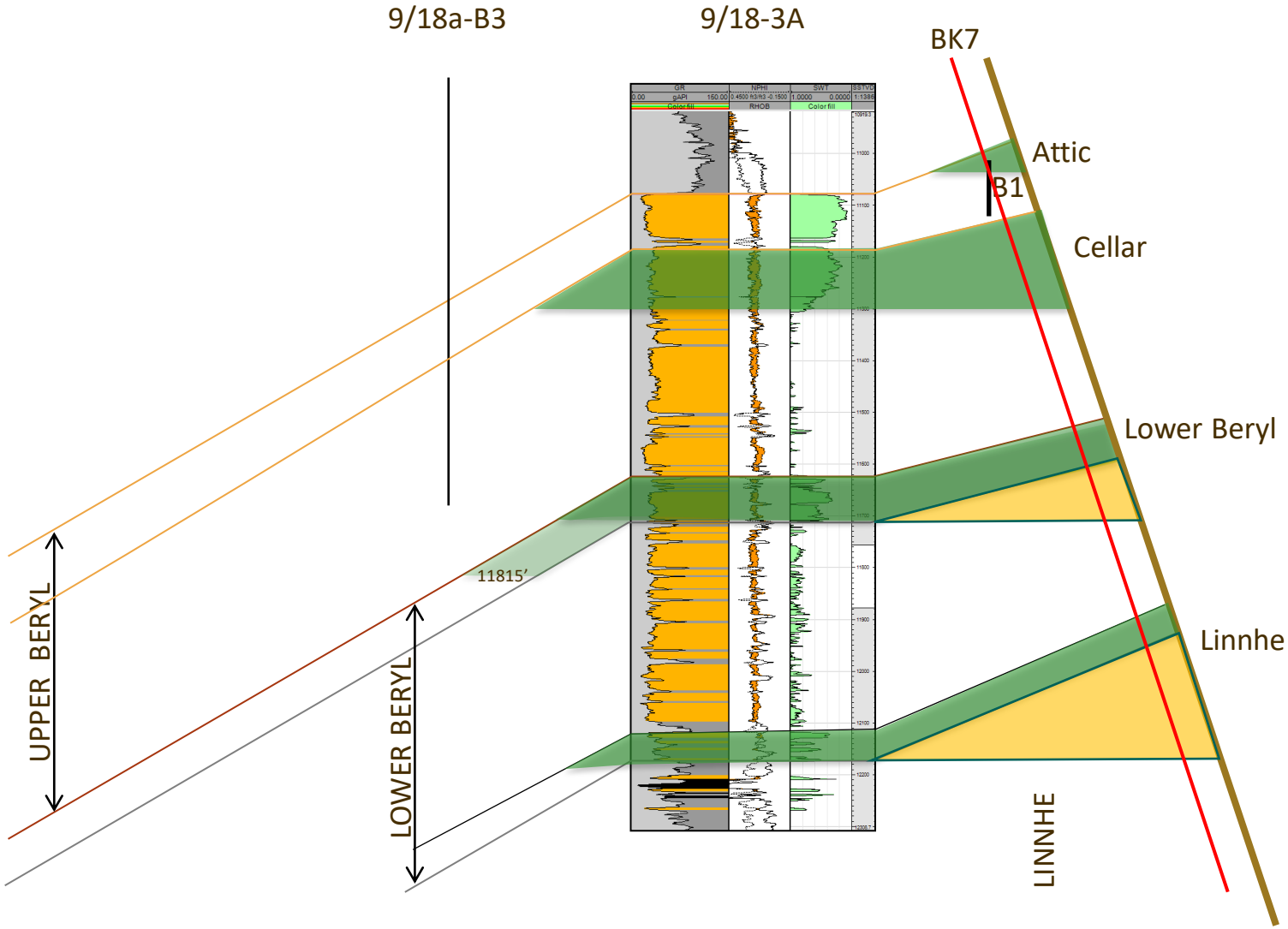




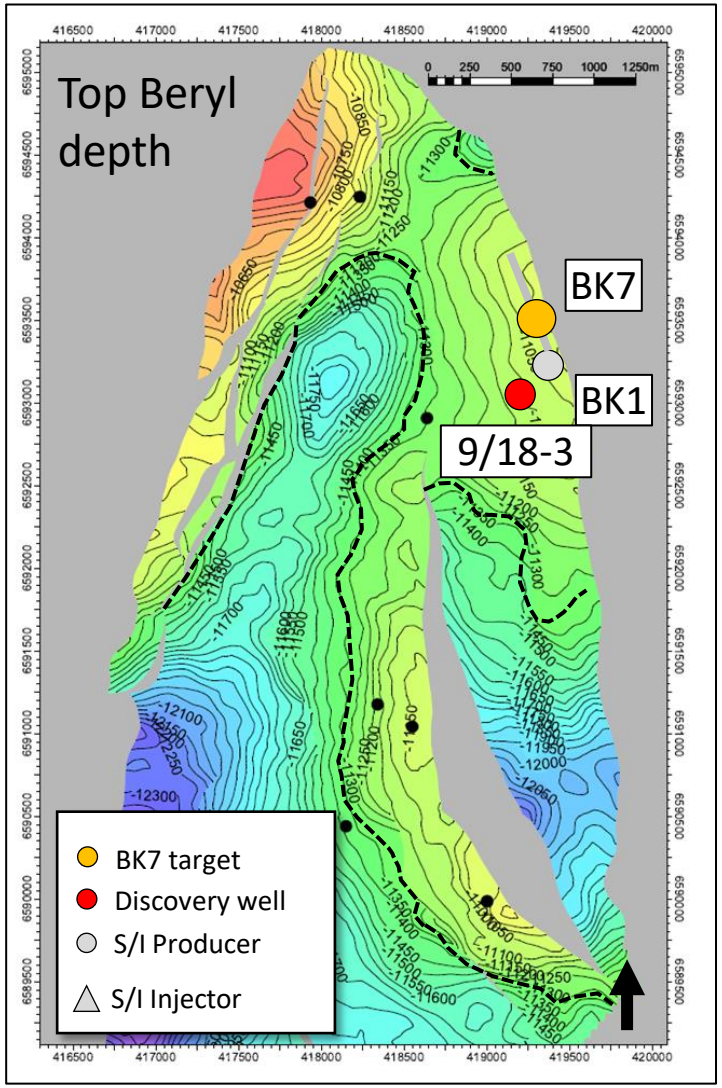
Upper Beryl Cellar and attic targets:
Range of remaining in place oil estimated analytically

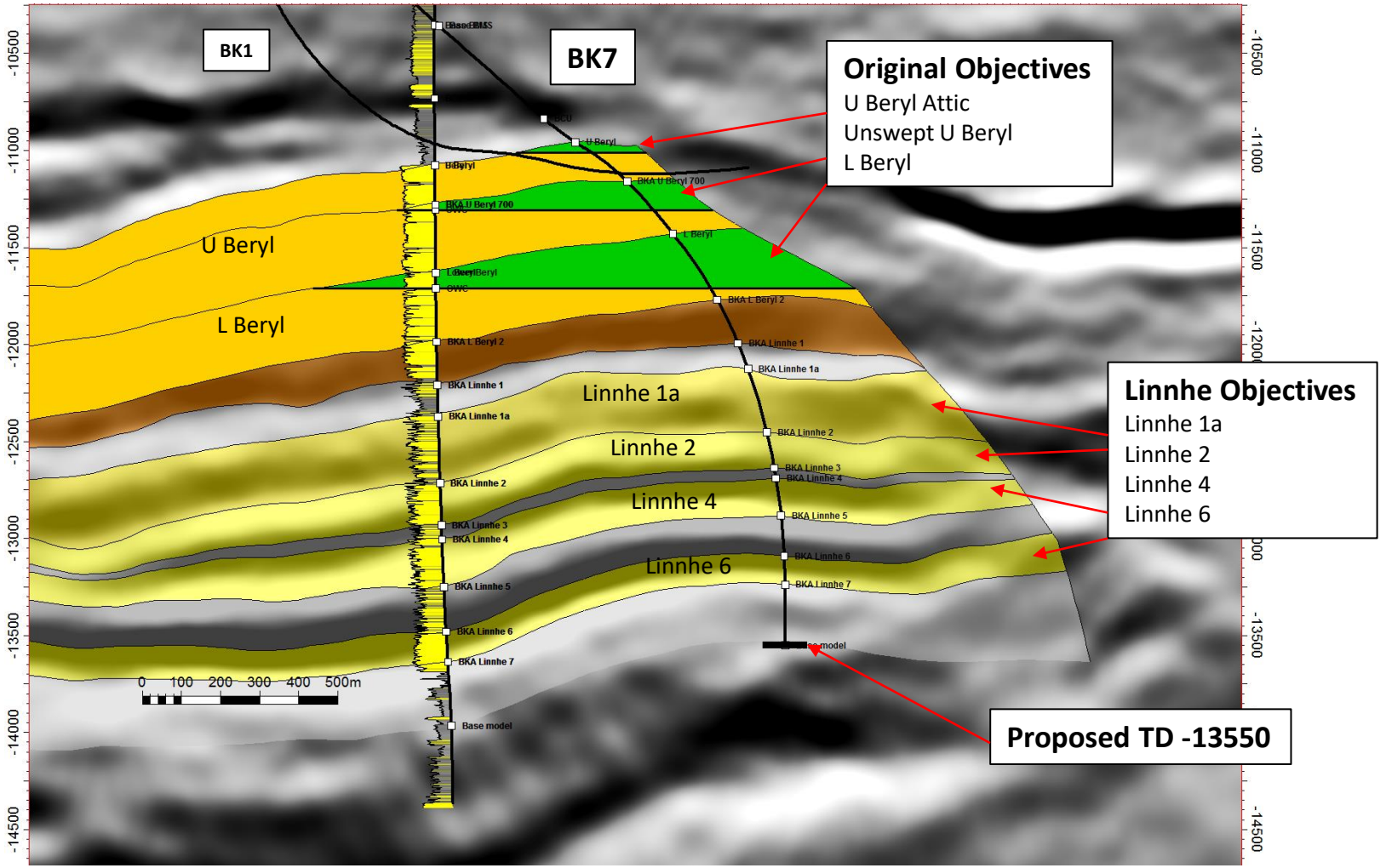
BK7 – Pre-drill 4 stacked targets – pay logged in 9/18-3



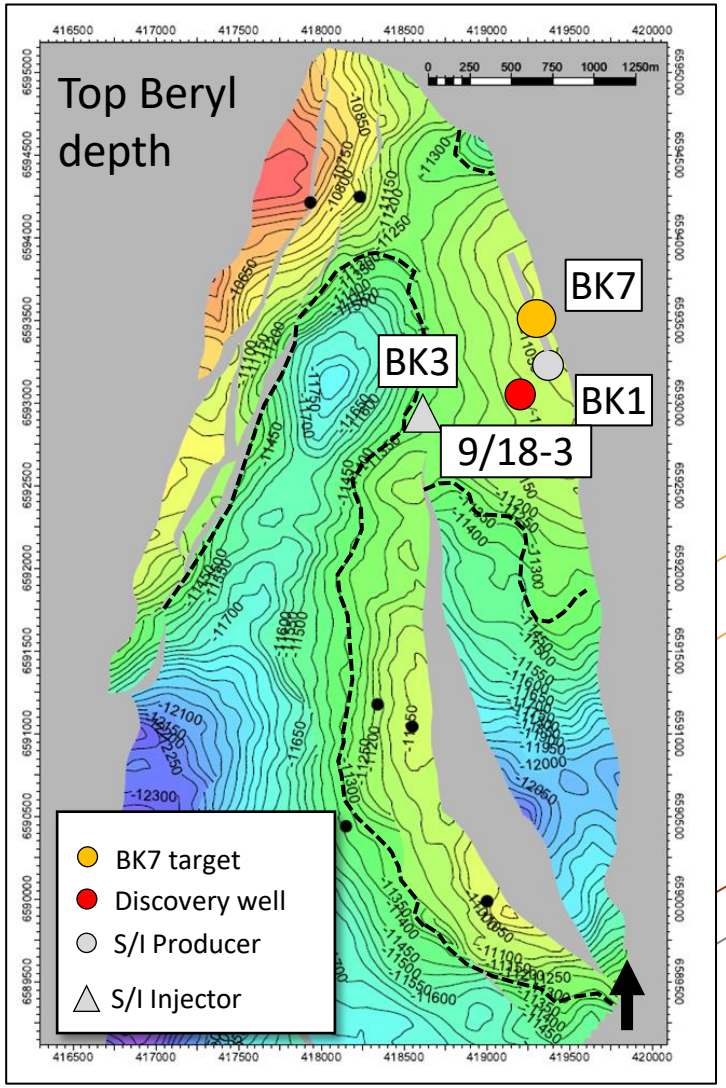


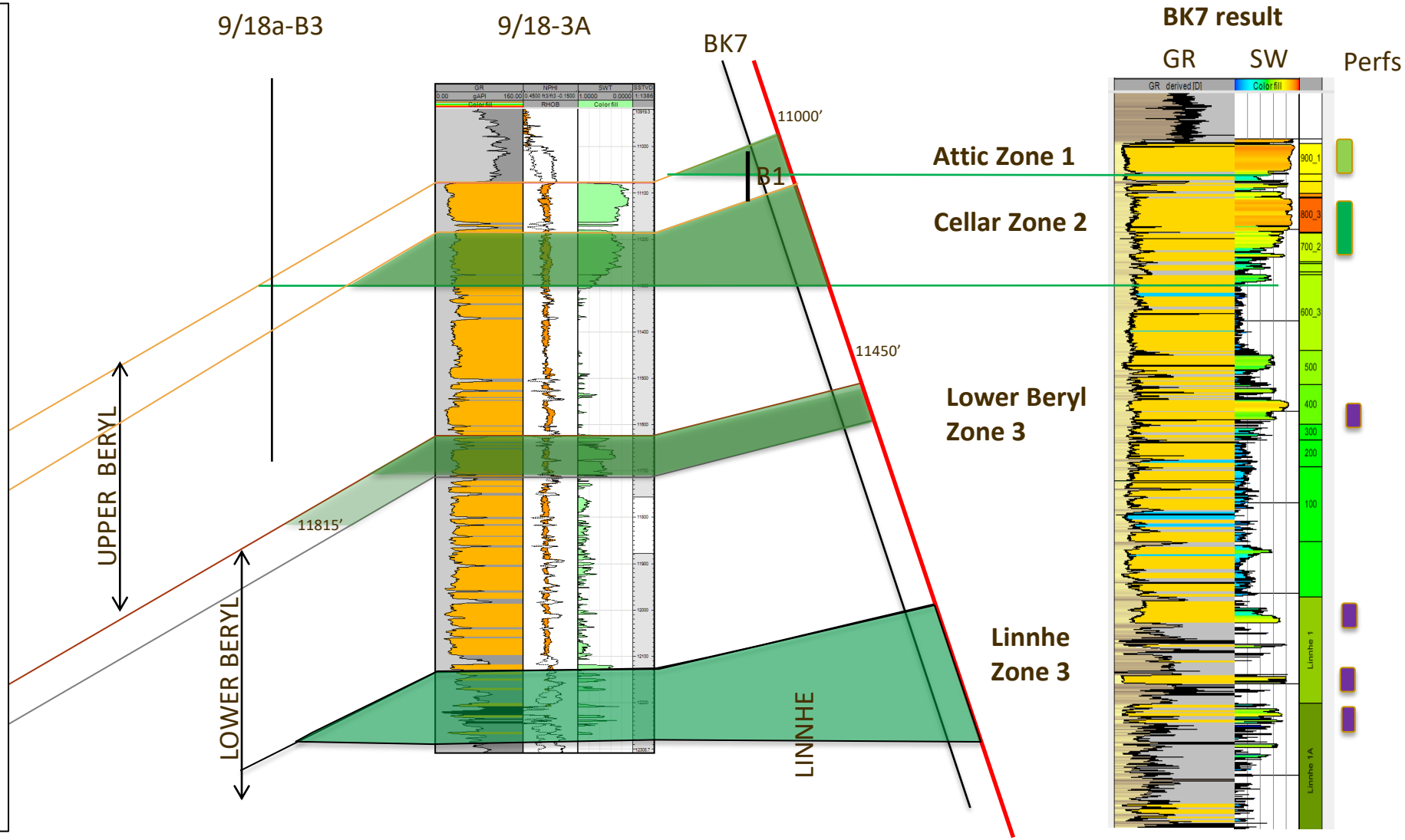
Trajectory crestal attic at all horizons – TD deepened to test all Linnhe attics





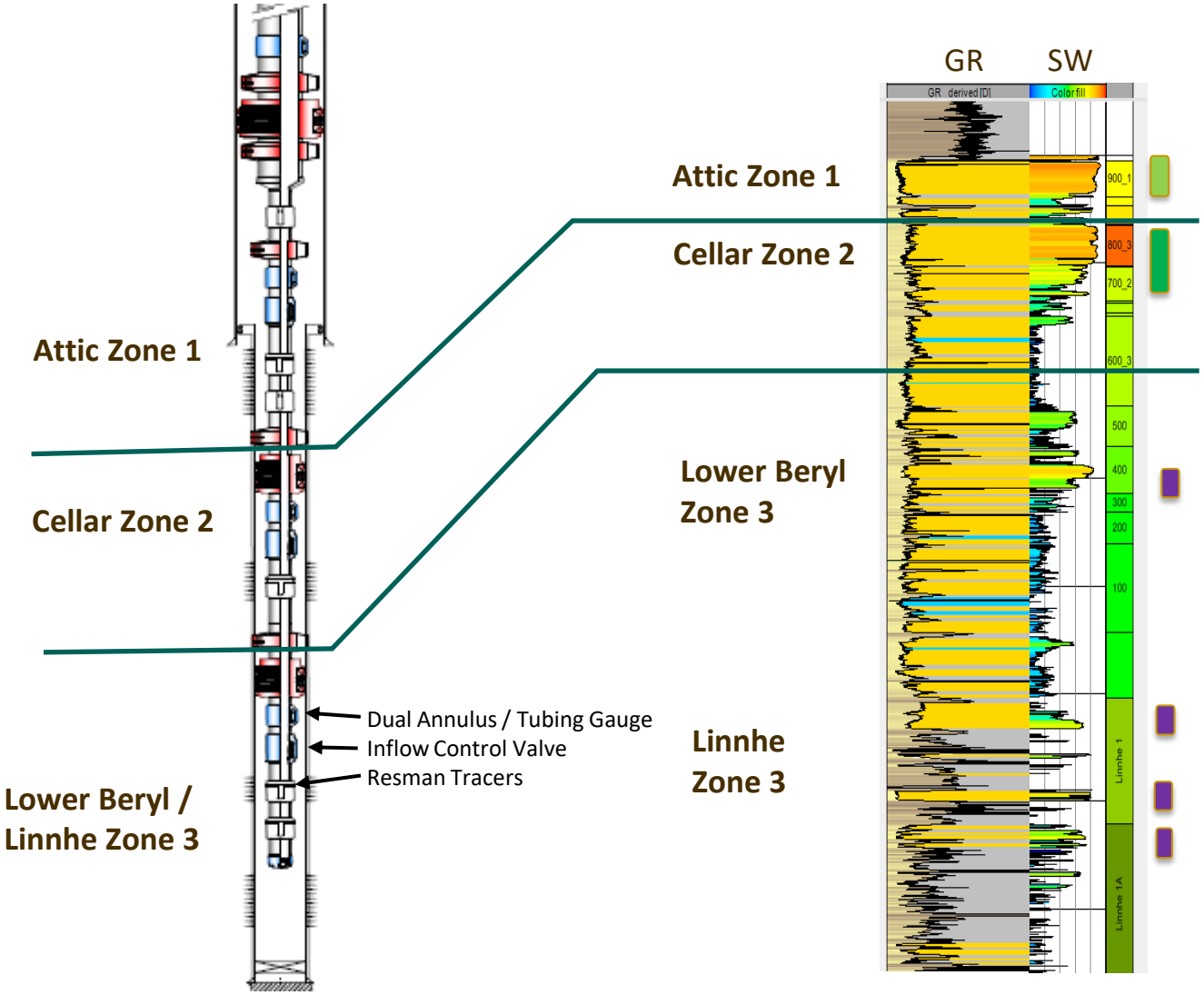
BK7 successful at all 4 primary targets – deep Linnhe wet



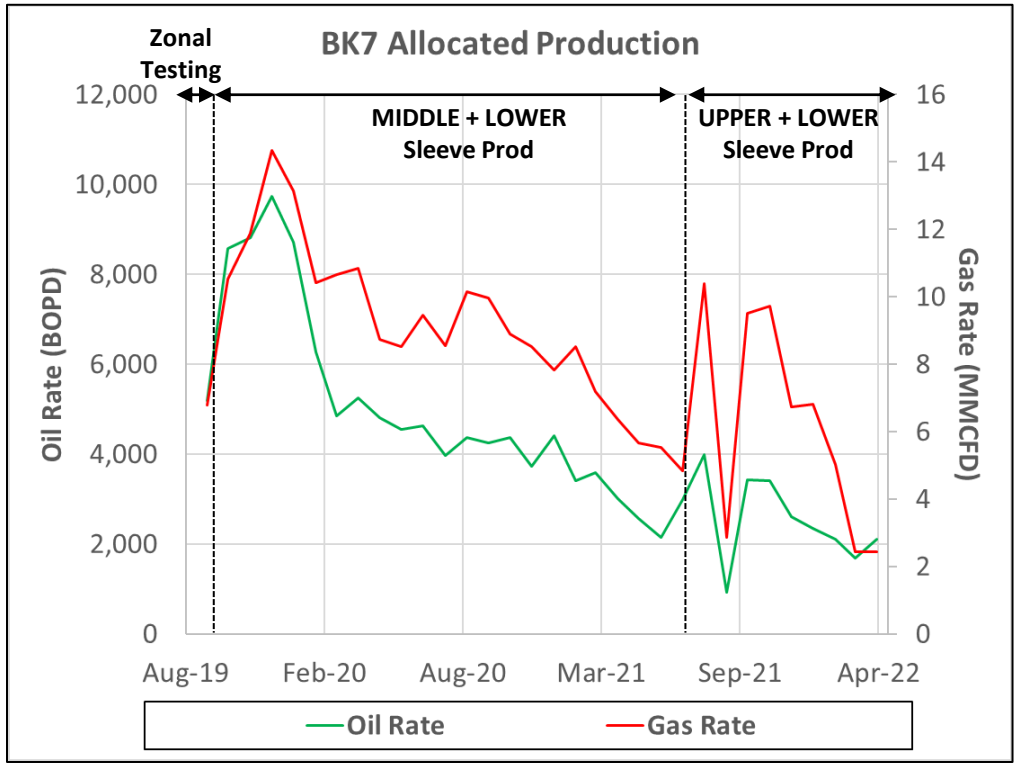


Completed with 3 zone digi-hydraulics smart completion

- Each zone can be flowed independently or co-mingled.
- Unique solution controlling 3 zones with only 3 control lines using "digi" decoder to control valves
- Resman tracers in each zone to aid reservoir modelling
- Sleeves opened by hydraulics controlled from Beryl Alpha
- Each zone equipped with annular and tubing pressure gauge
- Has allowed proper reservoir management and independent assessment of contacted reserve for each zone



Result – BK7 exceeded expectations in the Cellar and Attic zones



Production Summary

- Pre-drill P50 Estimate ~ 2.9 MMBO & 10 BCF
- Cum Prod to Mar-2022 = 4.2 MMBO & 8.0 BCF (Allocated)
- Month-avgd. Peak Rate = 12,123 boe/d (Nov-2019)
- Mar 2022 Rate = 2,519 boe/d

Sequence of Events

1) 10 days of Lower Sleeve production (Zonal Testing)
2) 10 days of Middle Sleeve production (Zonal Testing)
3) 12 days of Lower Sleeve production (Main Prod Period)
4) 22 months of Middle + Lower Sleeve production (Rate Enhancement)
5) 9 months of Upper + Lower Sleeve production (Rate Enhancement)

Production Strategy Rationale

1) In Zonal Testing, only one sleeve opened at a time – Unique Rate & Pressure measurement enabled Contacted OIP computation (used to inform Reserves & Forecast via Sim Model calibration)
2) After Zonal Testing, focus on optimising Production by commingling two or more zones

Next Steps

1) Currently high Water Cut → Either open all 3 Sleeves to maximise offtake or shut Upper Sleeve to improve Oil Rate

Acknowledgments

We would like to express our thanks to our management and our partners - Harbour Energy for permission to present at DEVEX 2022.

Thanks to PGS for permission to show seismic examples from their 2012-2013 geo-streemer acquisition

Finally thanks are due to everyone who has had technical involvement in the Buckland Field over many years.