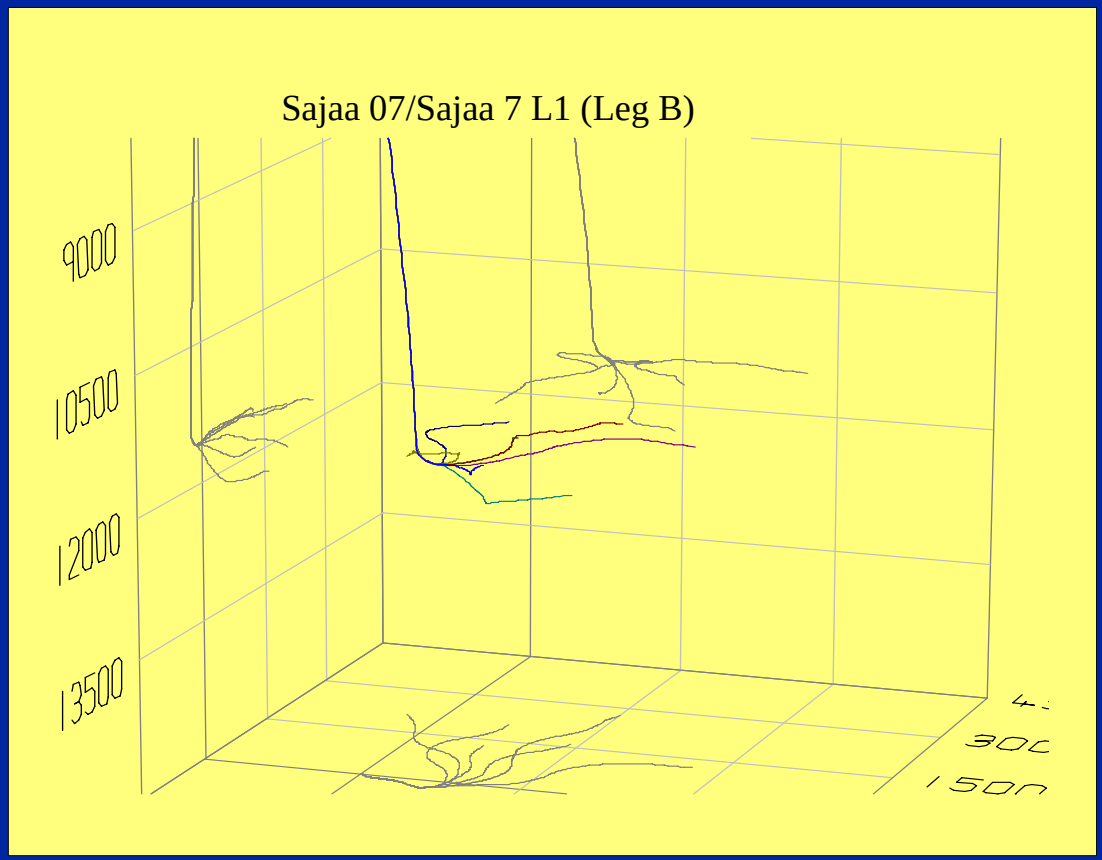
Pros and Cons of Underbalanced Drilling for Tight Gas



RPSEA Conference
Anchorage, AK
April 7, 2008

MOJ
BP Exploration

Presentation Overview

- May need unconventional drilling for unconventional gas.
- UBD definition and overview
- 3 field examples with pros and cons
  - 3 ways to do it
- Summary/conclusions

UBD Definition & Overview

- Drilling with the well flowing
- Typically at ~200 psi below reservoir pressure.
- Potential benefits
  - reduced formation damage
  - test while drilling, change direction if needed
  - ROP increase
- Potential drawbacks
  - higher dayrate & equipment spread
  - formation instability
  - initial field personnel concerns
  - significant FEL to ensure safety

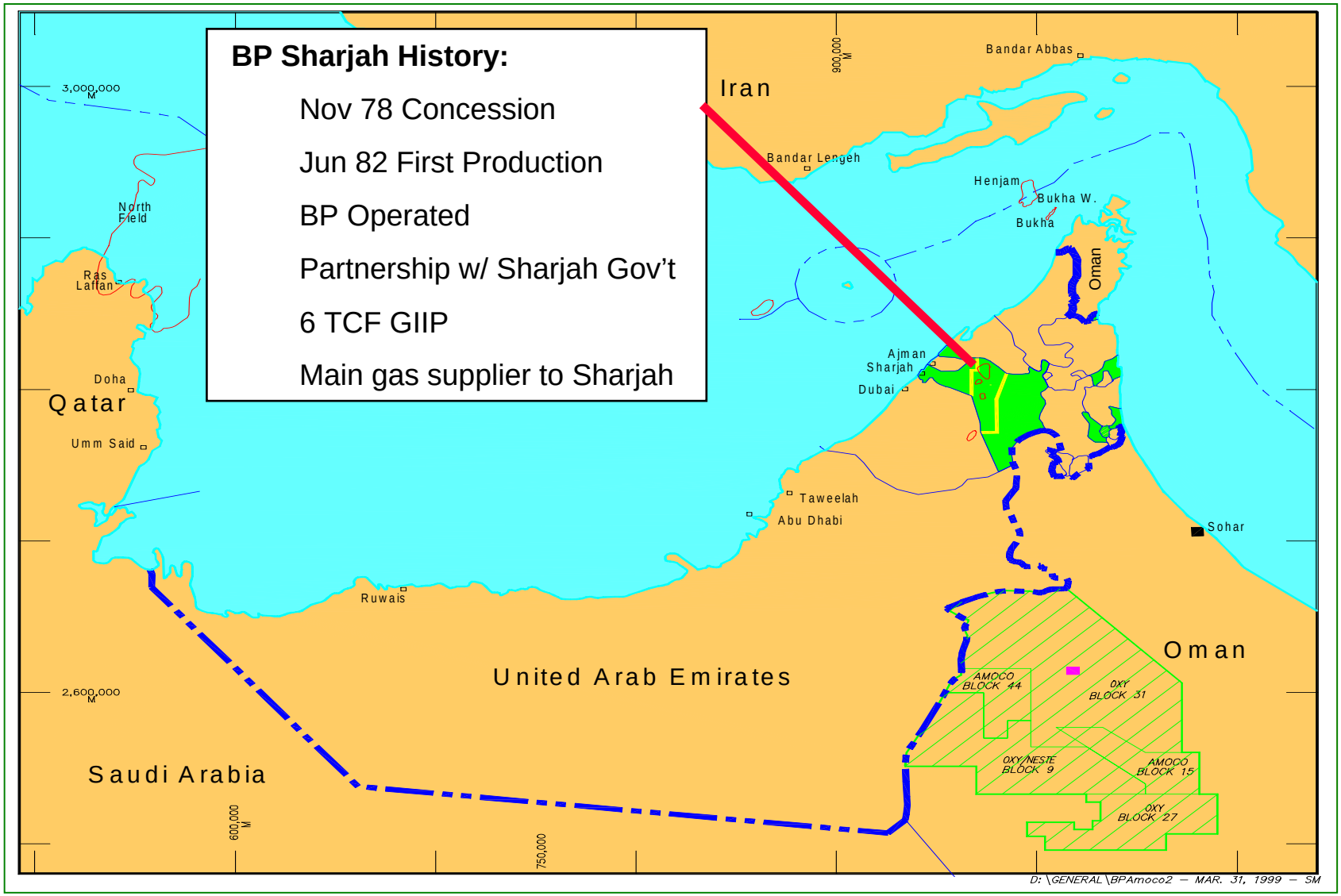
For unconventional gas – things to think about…..

-Would the formation flow if drilled without damage?

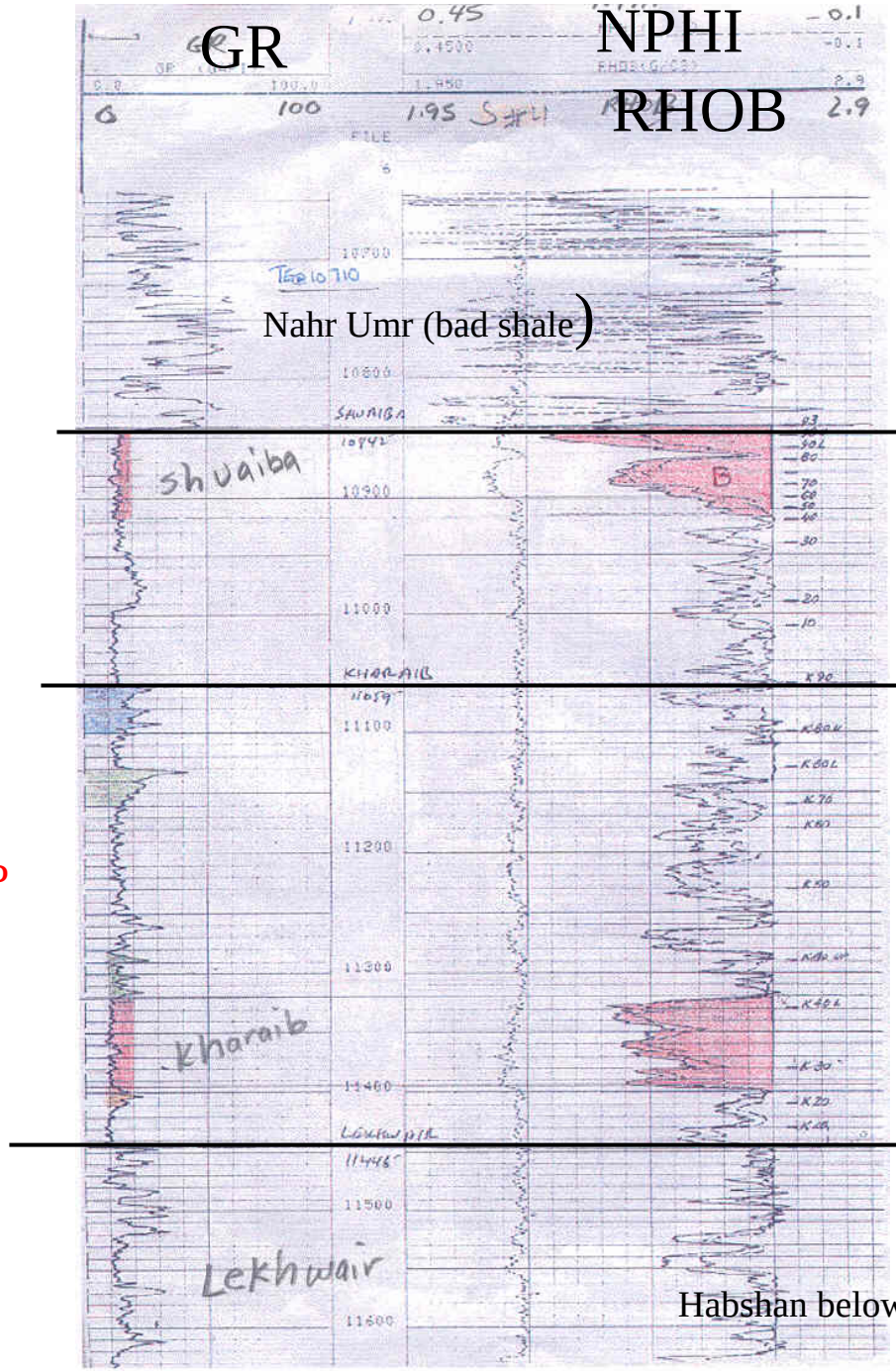
-Is the formation stable enough for UBD?

- Will the higher cost be economic?

Middle East
Sharjah Location and Brief

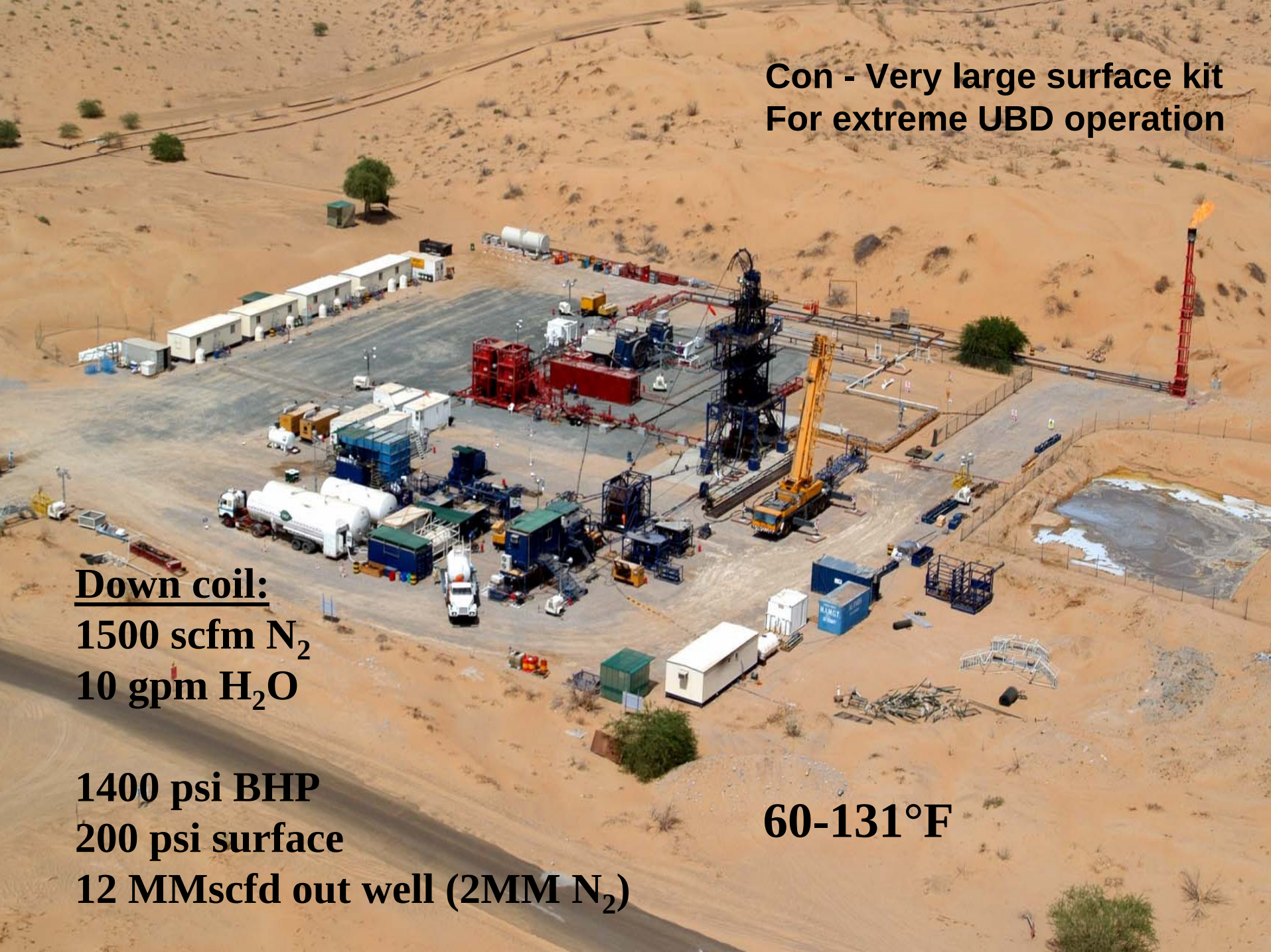


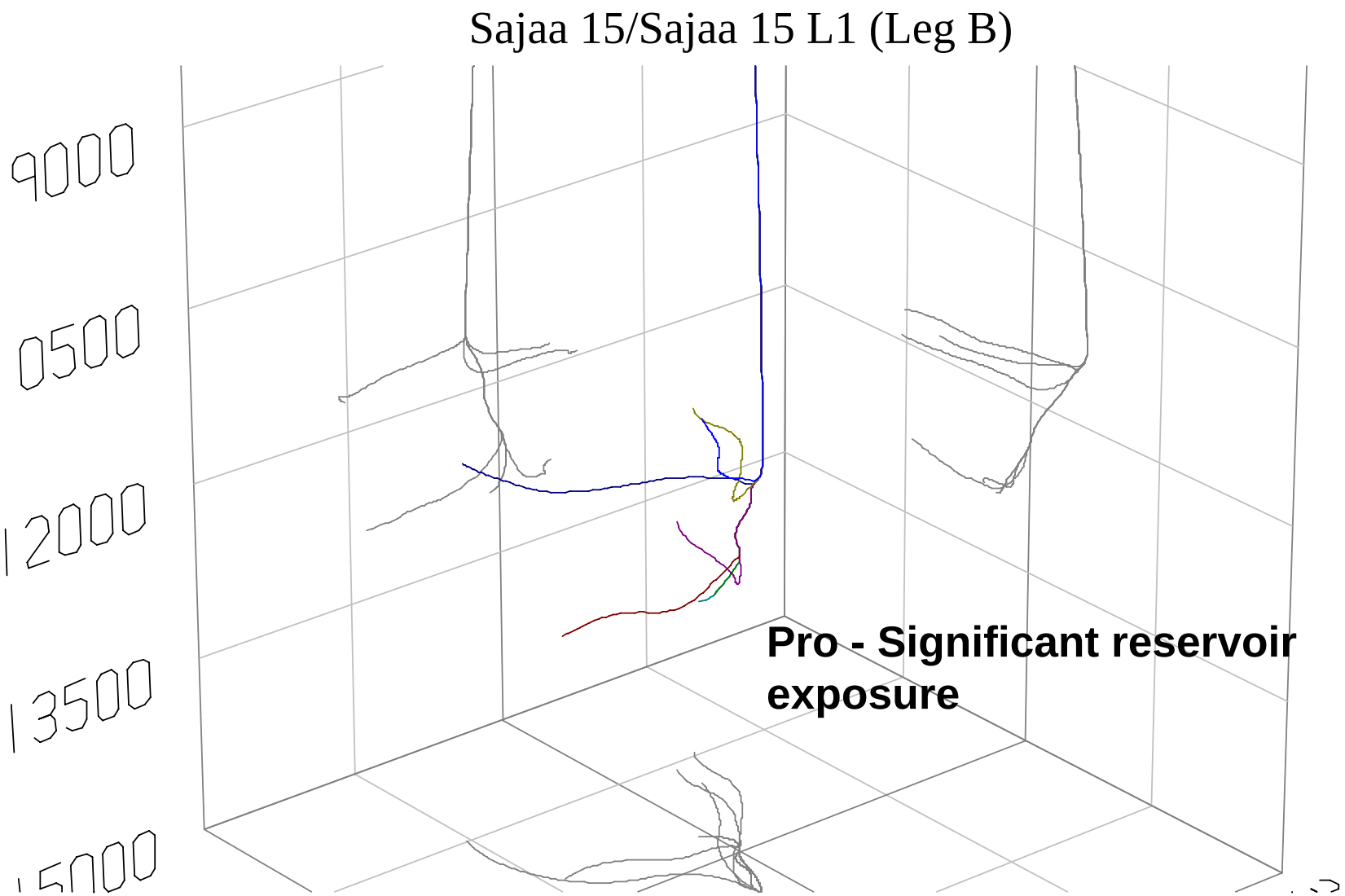
- 11,000-13,000’ TVD
- 650’ pay
- Limestone fractured
- 300° F
- Depleted <3 ppg BHP (was 14 ppg)

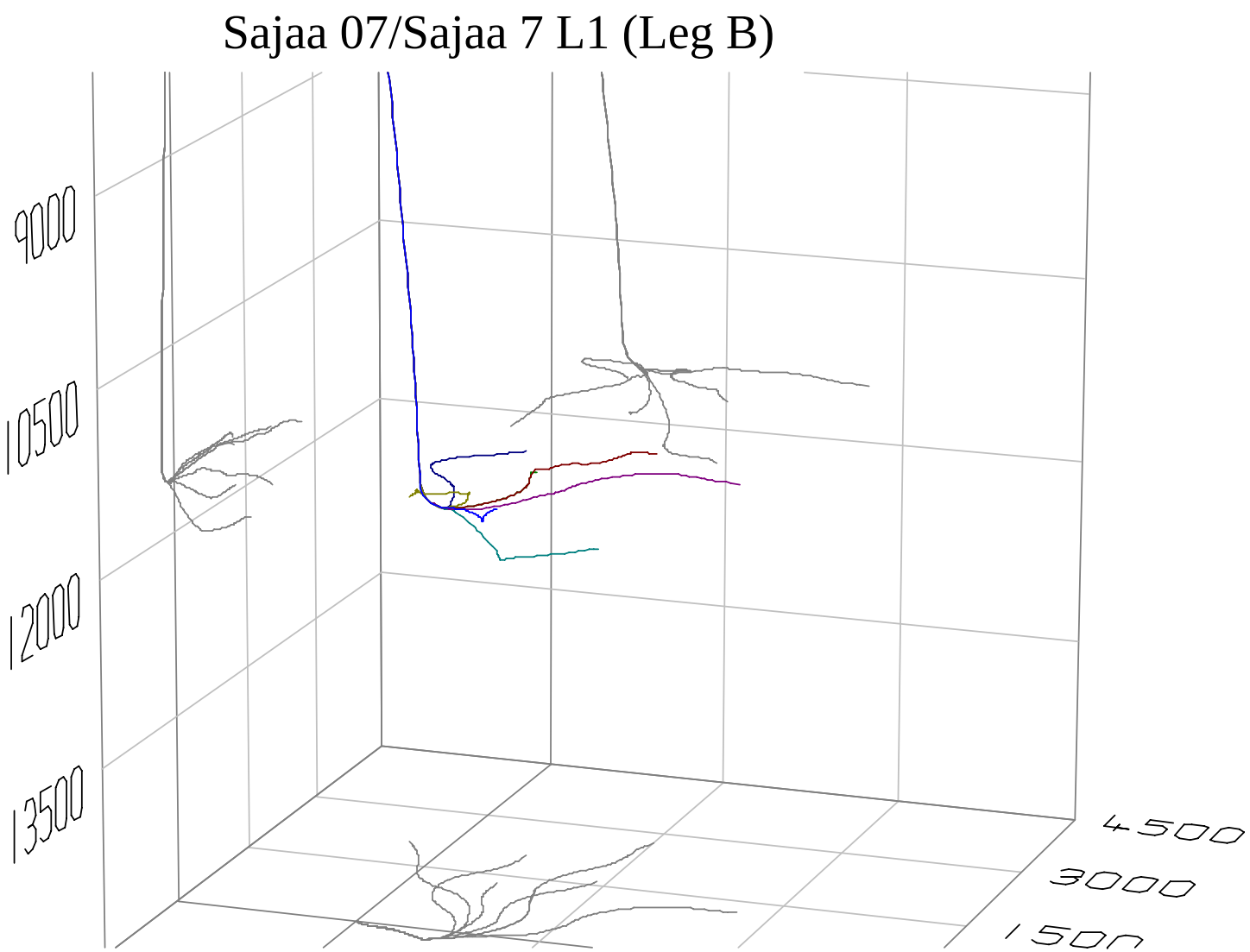


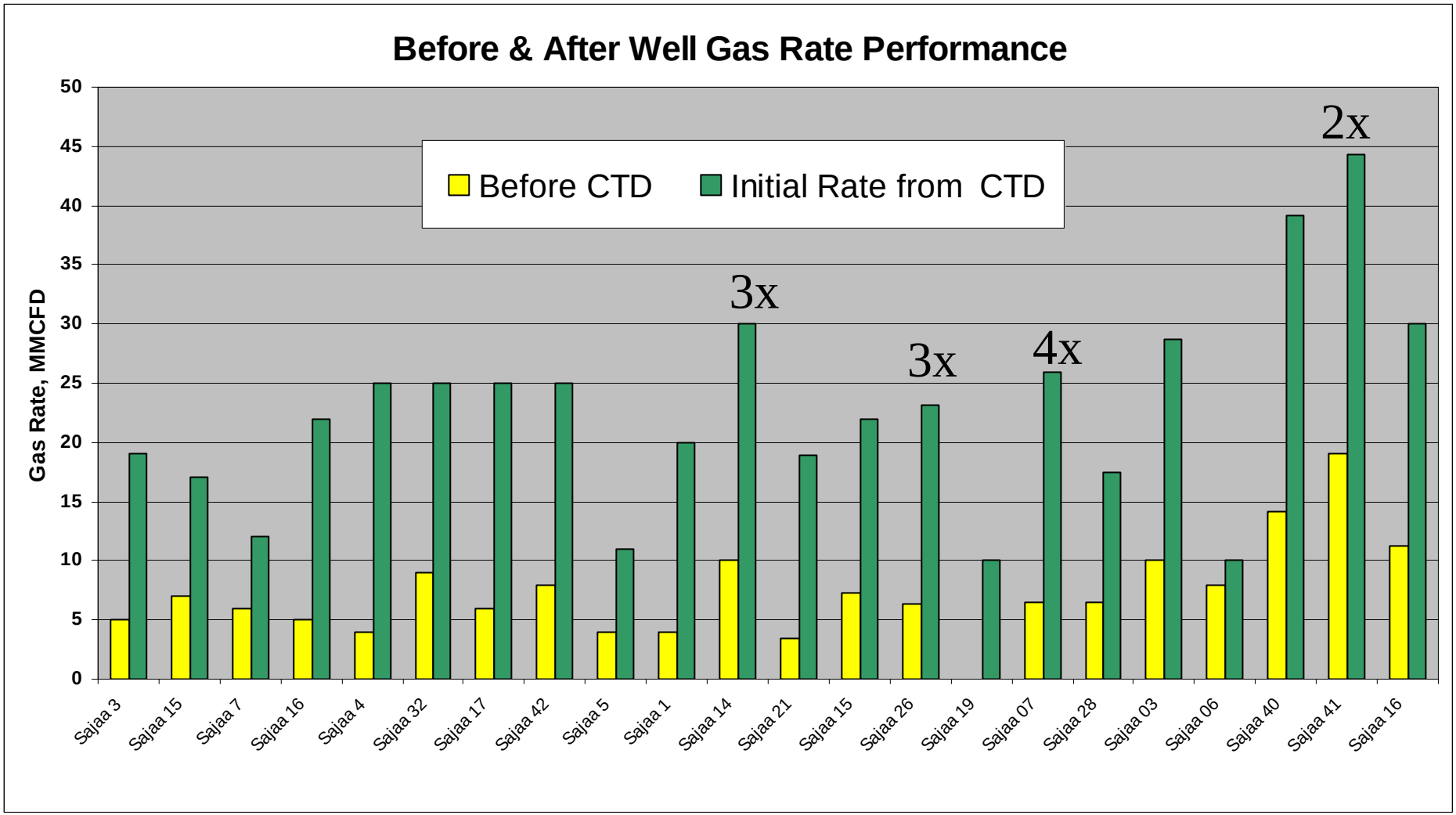
Con - Hit this shale and will get stuck.

No problem shales in payzone


Con - Very large surface kit
For extreme UBD operation
Down coil:
1500 scfm N_2
10 gpm H_2O
1400 psi BHP
200 psi surface
12 MMscfd out well (2MM N_2)
60-131°F

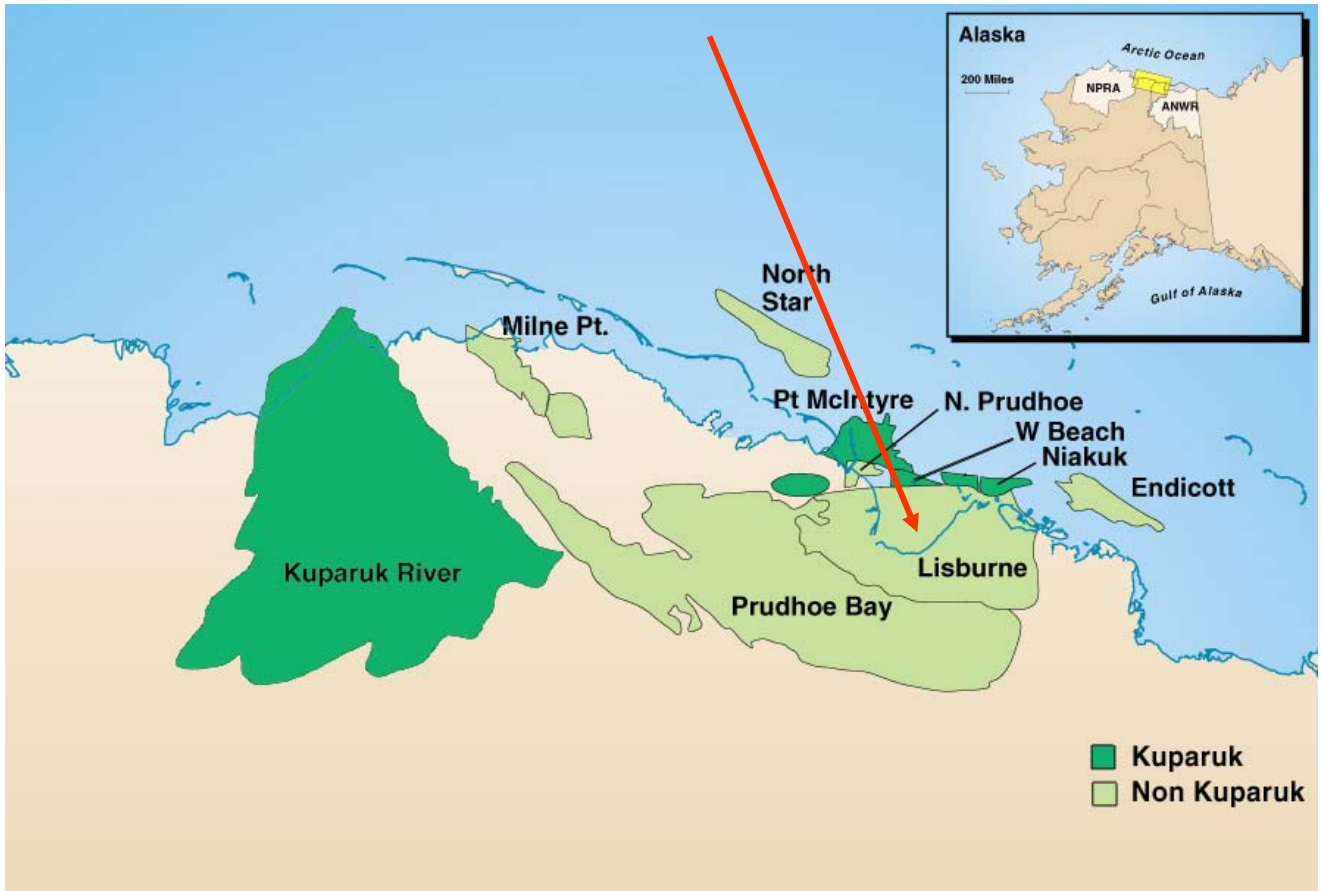

Sajaa 15/Sajaa 15 L1 (Leg B)
9000
0500
12000
13500
15000
Pro - Significant reservoir exposure


Sajaa 07/Sajaa 7 L1 (Leg B)
9000
10500
12000
13500
4500
3000
1500



Pro - Why it was done! Big production rate increases.

North Slope Fields LISBURNE



- Lisburne carbonate – 2B Bbl OOIP, poor recovery to date <10%.
- Tight carbonate, need fractures to flow.
- In 2006, pilot similar concept as Sharjah
- Target reservoir exposure with ROP, prod info, less damage.

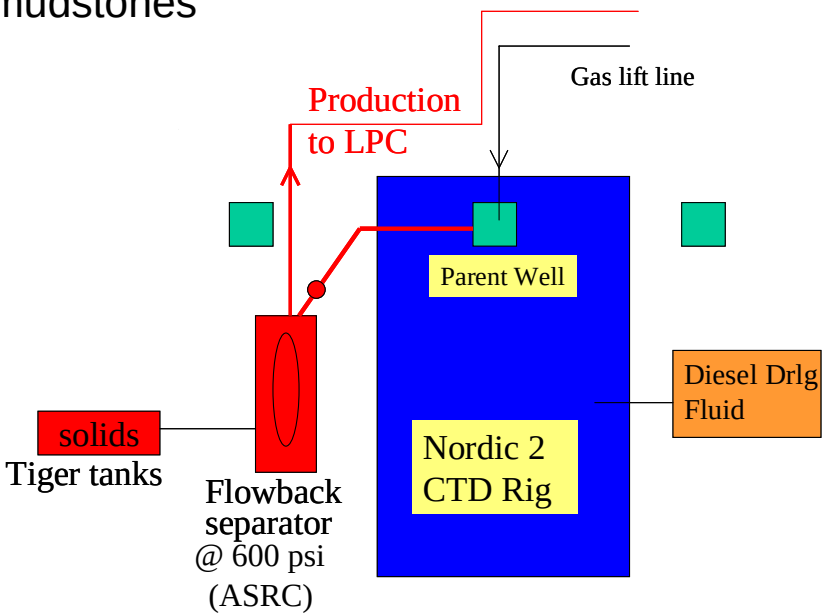
Coiled Tubing Drilling capability on the North Slope

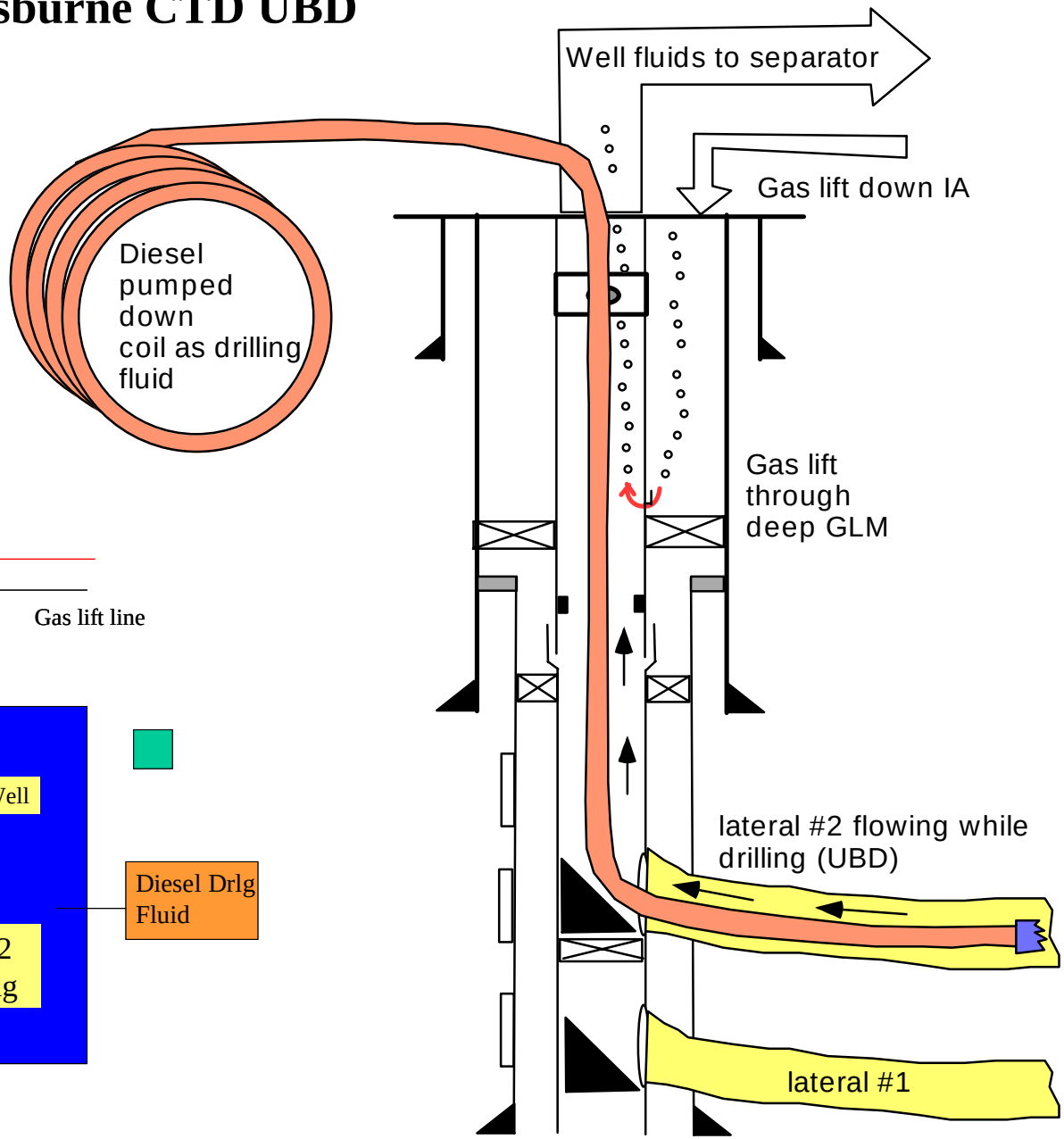
Pro – easy to trip with well flowing with continuous coil tubing.

Lisburne CTD UBD

<u>Surface drilling kit</u>
Gas lift for underbalance
Drill with diesel
Send returns to LPC (600 psi)
Remove solids at rigsite
No pumping, compression, or flare
7 months of FEL

Pro – diesel does not disperse mudstones



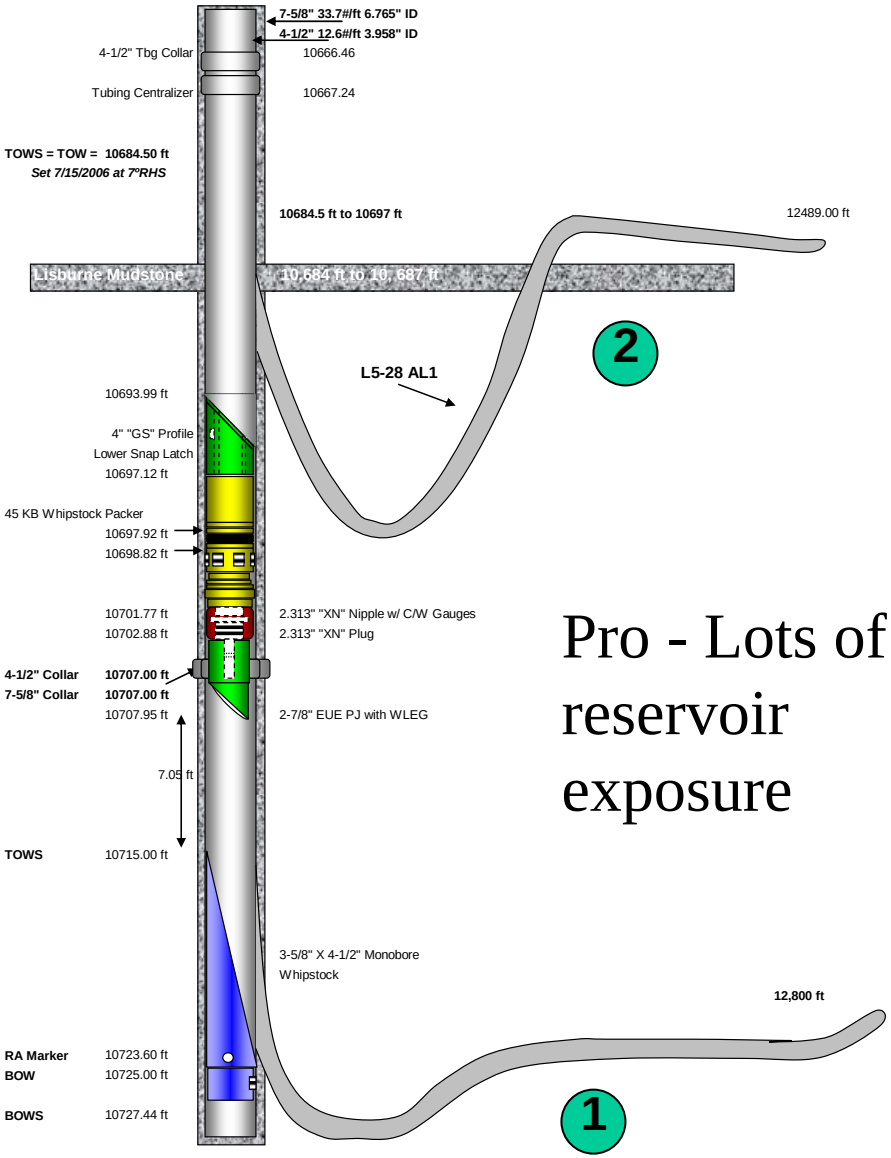


Con – still a large surface kit

Fully Assembled Surface Kit

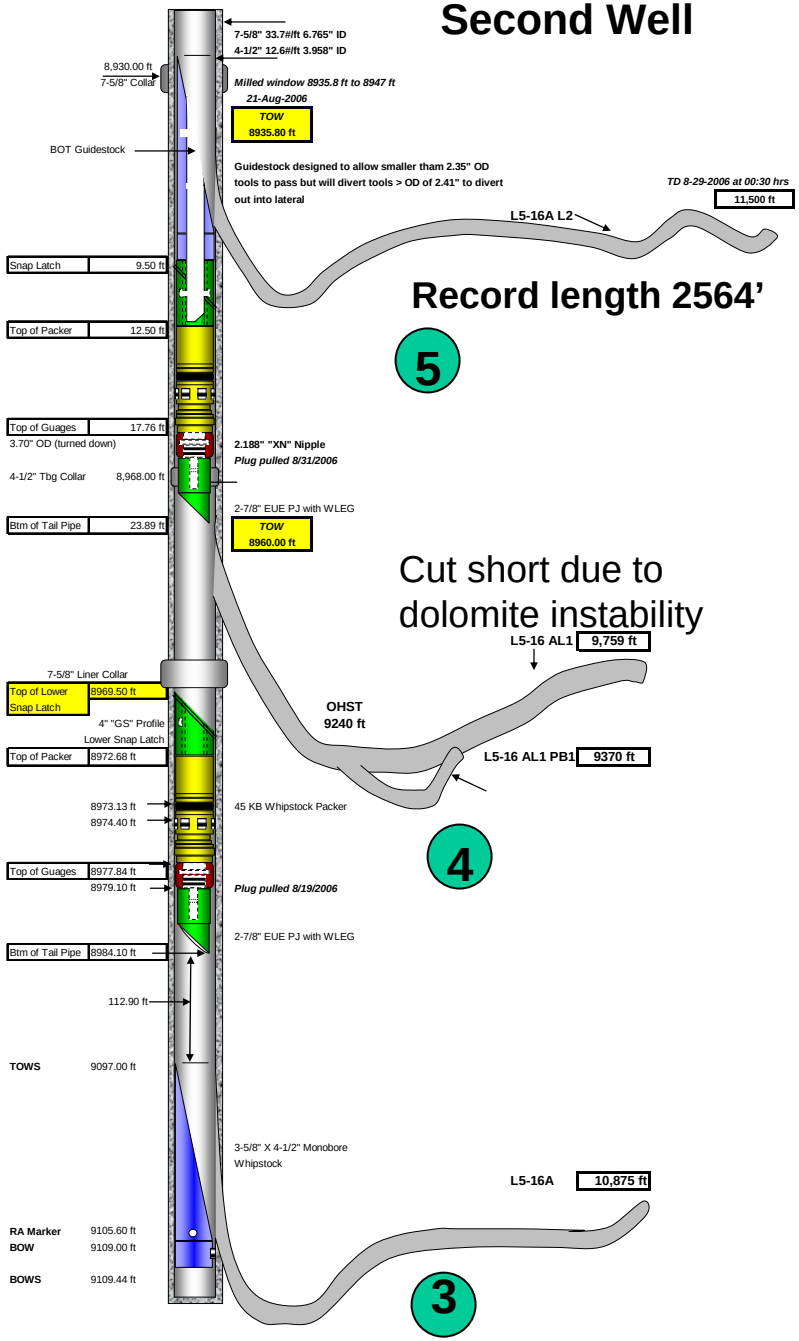
Diesel Tanks, Heater, Separator

First Well



Pro - Lots of reservoir exposure

Second Well



Lisburne UBD Summary

Outstanding HSE performance

Drilling

- Remarkable bit runs of 832', 729', 780', and 977' md (all records).
- Drilled 666' in one day (record).
- 2564' lateral (record, 984' longer than any OB well).
- Total of 9,130 feet drilled.
- ROP averaged over 250 ft/day (doubled).
- 40+ BHA pressure deployments into ~1000 psi flowing WHP.
- Pilot 40% over on cost but essential lessons learned.

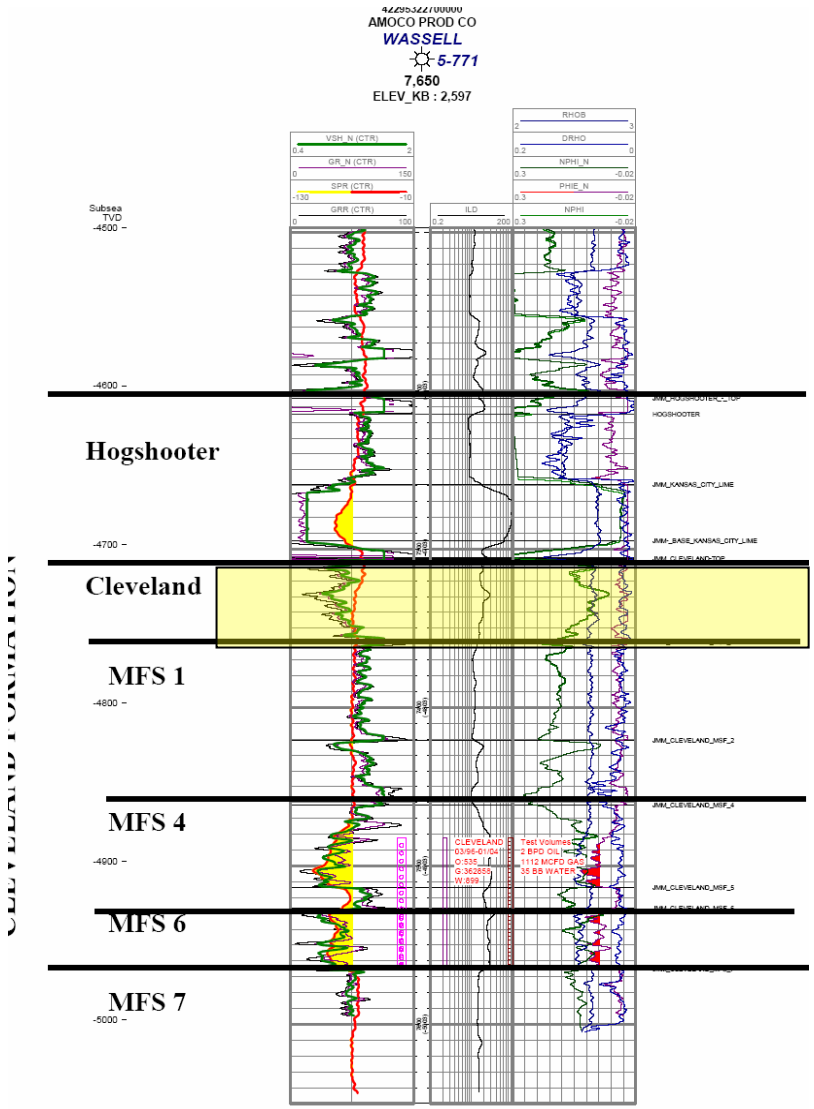
Production

- Produced 14,000 bbls of oil while drilling.
- Con - Higher GOR production than desired. Faults may connect upwards.
- High gas rates make UBD rate benefit analysis difficult – still assessing.
- Continue post-drill evaluation & data gathering.
- Planning for 2009 program.

Cleveland Tight Gas Sand

Anadarko Basin
Cleveland Reservoir
- Texas & Oklahoma

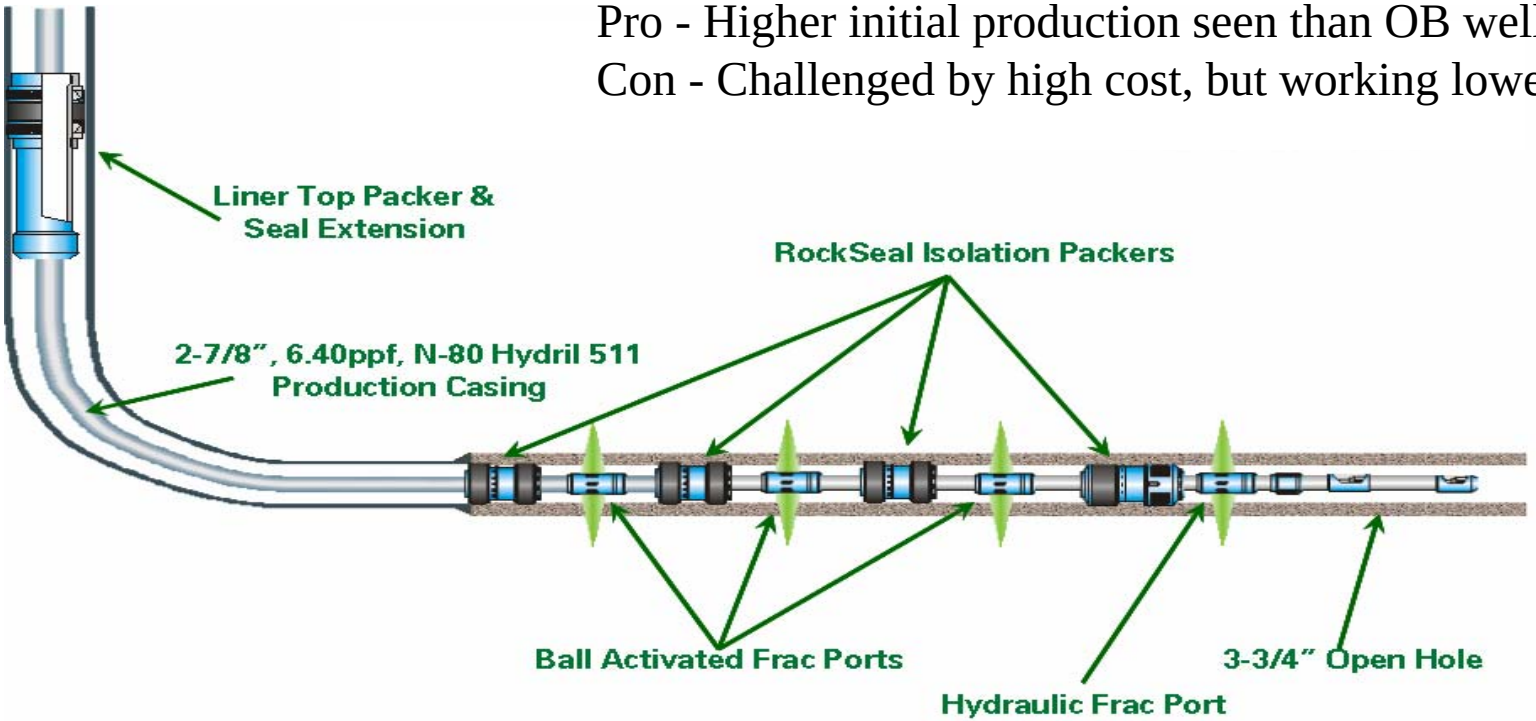
- **Very fine-grained sandstones, rock fragments**
- **Top Reservoir: 6500 - 8200 ft TVD**
- **Net Pay: 25 - 80 ft**
- **Porosity: 8 - 14 %,**
- **Permeability: < 50 microdarcies, avg. ~10 microdarcies**
- **Down to 4 ppg reservoir pressure**
- **Pro – allows drilling without severe lost circ.**



Completion System

- *Utilize 2-7/8” system with external OH packers to isolate stimulations throughout the horizontal wellbore. System utilizes ball-activated sliding sleeves to both isolate the zone below and stimulate the next zone. Packers straddle the sleeve to provide the isolation on the backside.*

Pro - Higher initial production seen than OB wells
Con - Challenged by high cost, but working lower.



Summary & Conclusions

- Discussed Pros & Cons of UBD & showed 3 field examples

- Potential benefits
  - reduced formation damage
  - test while drilling, change direction if needed
  - ROP increase

- Potential drawbacks
  - higher dayrate & equipment spread
  - formation instability

- Questions to consider for unconventional gas
  - Would the formation flow if drilled without damage?
  - Is the formation stable enough for UBD?
  - Will the higher cost be economic?

Thamama
6 x 6 miles