Schlumberger

Combining Static and Continuous surveys

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Outline

- Background/History
- Why combine continuous and static surveys?
- A case study
- Proving the concept
- Value
- Conclusion

Background/History

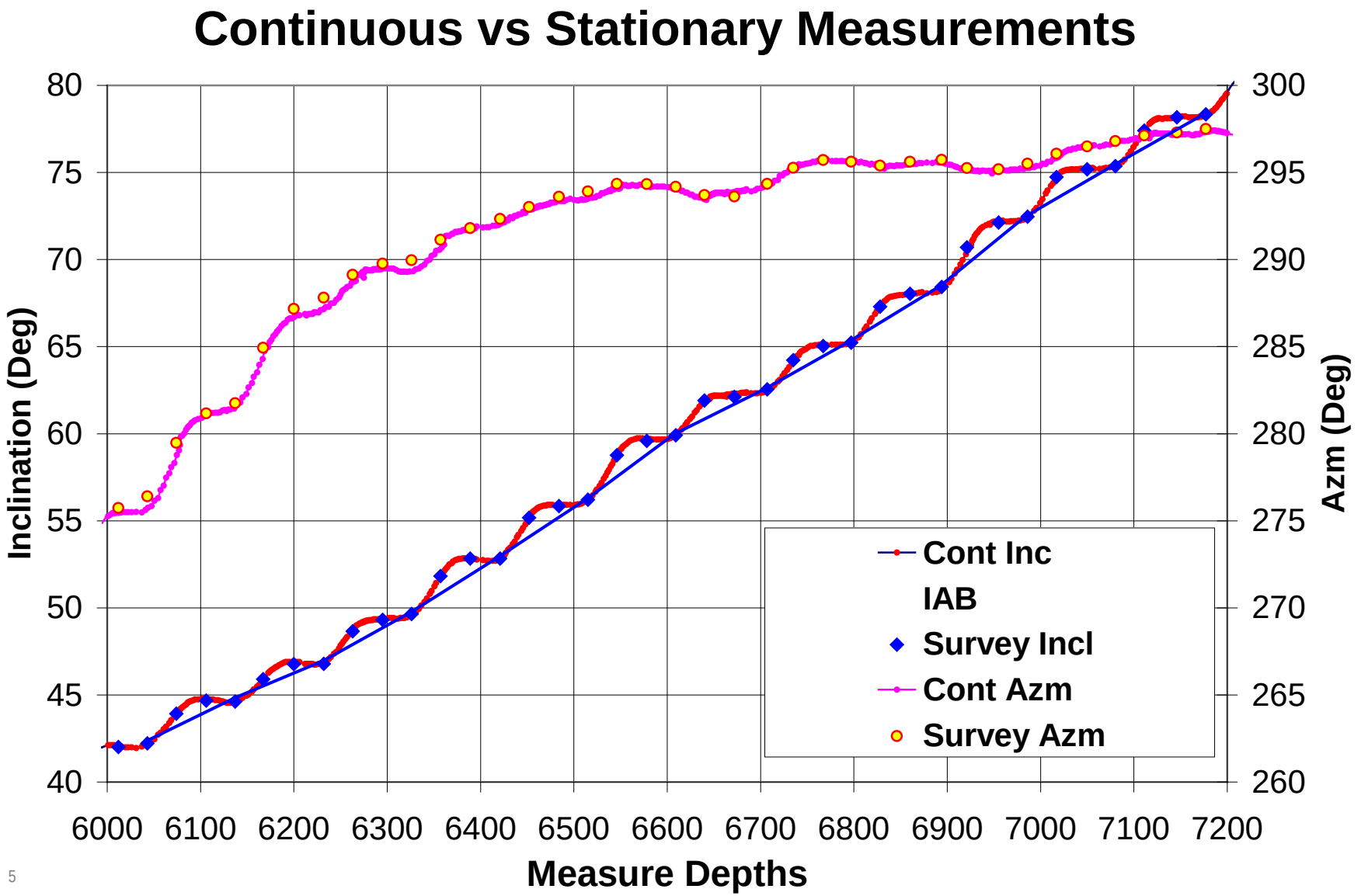
- Continuous surveys have been available for a long time
- Lesso et al., 2001, IADC/SPE 67752 - paper on tendency analysis
- Stockhausen and Lesso 2003, IADC/SPE 67752 – paper on TVD Errors associated with survey frequency
- Waiting on a Solution – collecting additional data examples – beta testing software solutions

Background/History

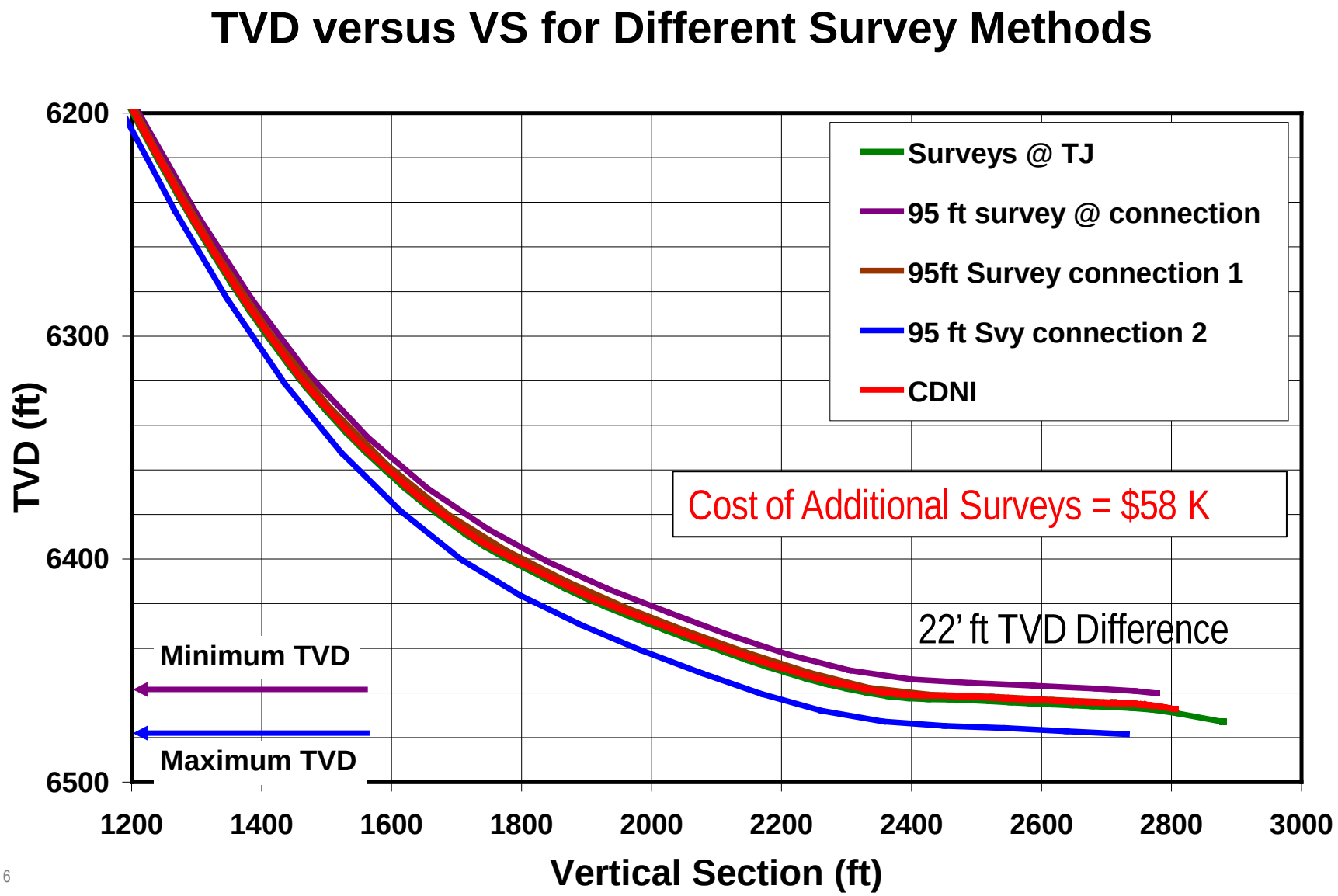
- Assumption of minimum curvature

- Identified sources of TVD/positional errors associated with long survey intervals
  - Pattern Slide/Rotate drilling practices in build/drop/turn sections
  - Short slides during tangent sections
  - Changing modes between survey stations with Rotary Steerable Systems
  - Bha reaction to tight streaks, boulders, or nodules
  - Geologist interventions
    - Steering decisions
    - Control ROP to acquire logging data
  - BHA auto control with some RSS

Pattern Slide/Rotate Drilling Practices

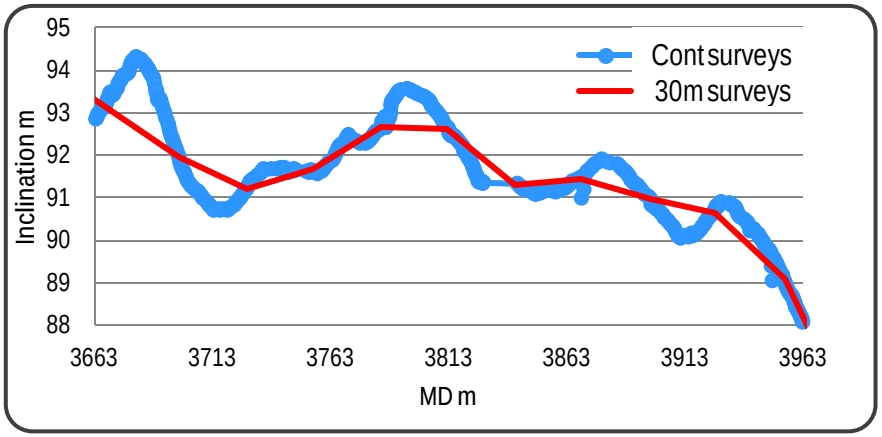


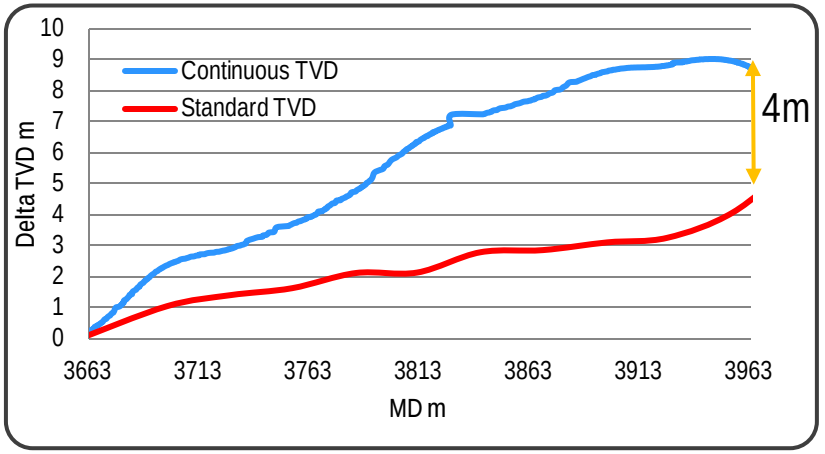
Pattern Slide/Rotate Drilling Practices



Why combine continuous and static surveys?

- The survey frequency issue

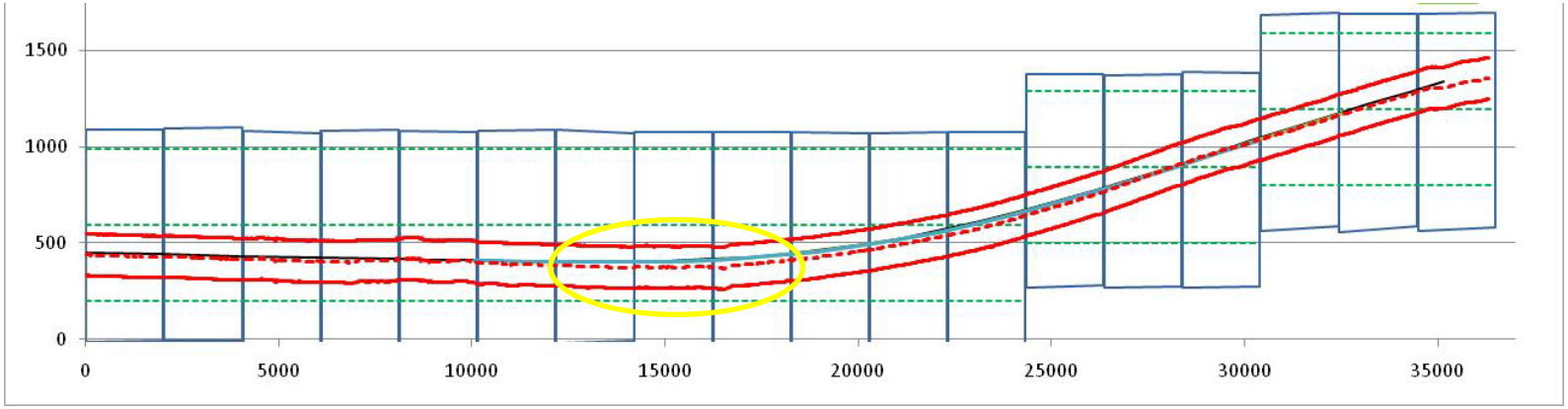




- Combining static and continuous surveys
  - This data is available
  - 3m spacing
  - Issues with North/South azimuth
  - Not possible in a near vertical well

The Results

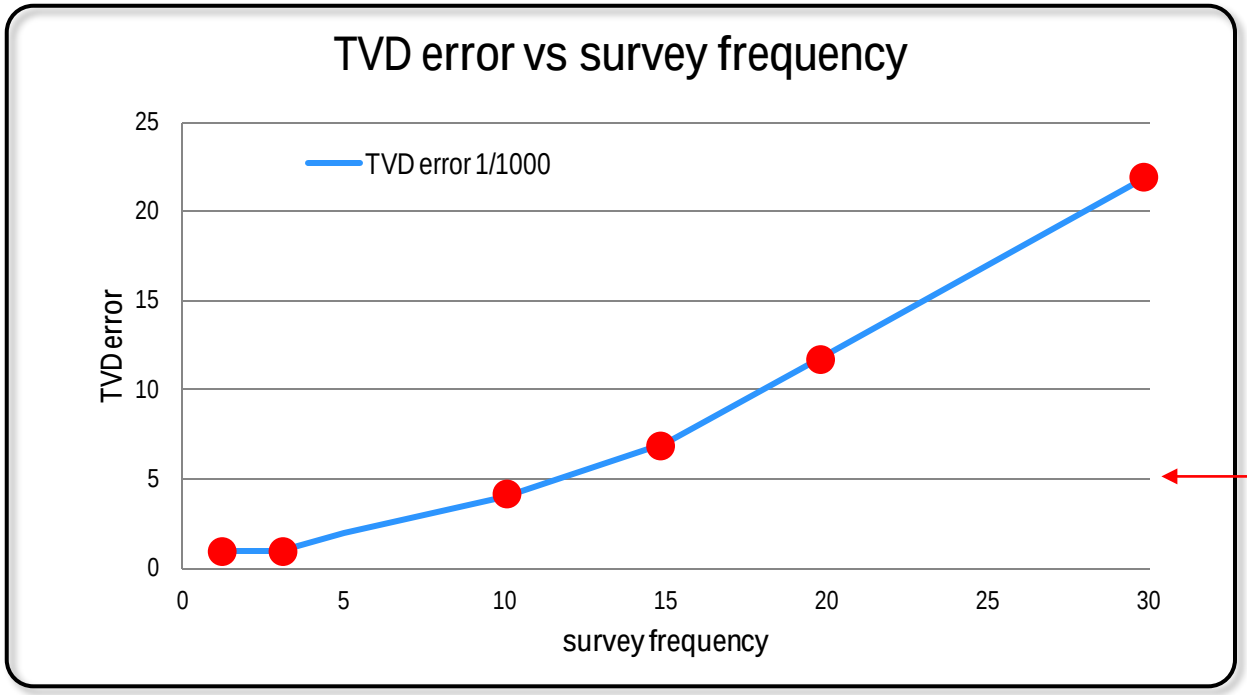
- Trajectory Measurements



- MWD increase Incl before Slide point
  - Static and continuous survey agree
  - All 3 SP trajectories 15mm TVD alignment
  - Static and continuous within 20mm of baseline
  - ISCWSA error model 130mm

The Test Implications

- TVD control
  - Implications on1000m reservoir section
  - MWD TVD EOU 5m
  - TVD errors cancel out?



Modeled error

Value of Increase Surveys Frequency

- Reserve Recovery from Horizontal Wells
  - Strong Bottom Water Drive Oil Reservoirs
    - 10,000 to 100,000 Barrels of recoverable oil per foot TVD
    - ~$ 900,000 to $9,000,000/ft TVD
  - Placing wells relative to Gas/Oil, Gas/Water, and Oil/Water
    - Accidental? placing in/near gas cap – loose the well
    - Accidental? Placement near or in the water – loose recovery
  - Incorrect Dip interpretation
    - Poor steering decisions
    - Lost footage in the reservoirs
- Improve Reservoir Models and Forecasting/History Matching

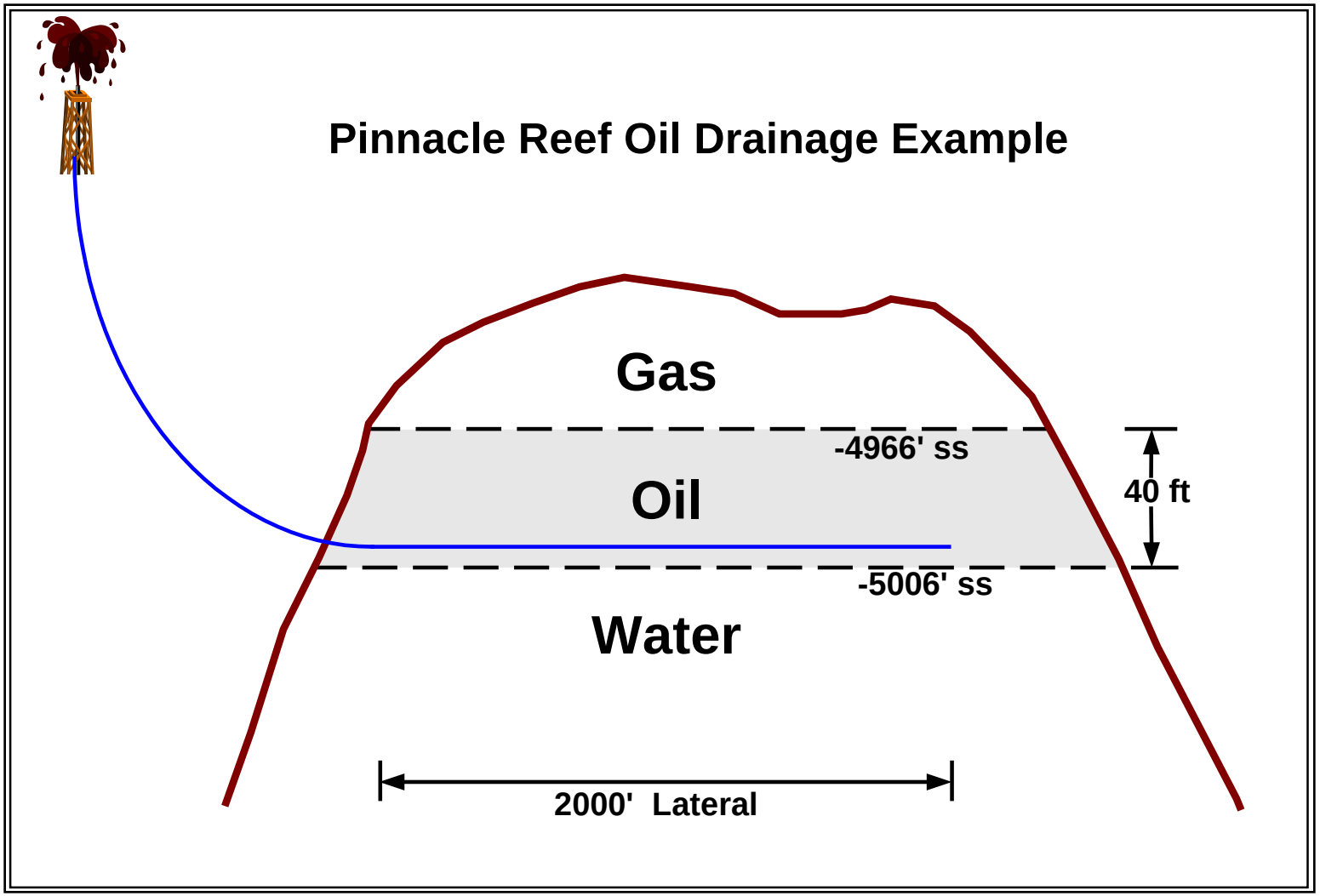
Value of Increase Surveys Frequency

- Improved Torque and Drag Analysis
- Avoid completion problems – Understand production logs
  - Stuck casing , liners, screens
  - Electrical submersible Pump Failures
- Lower Collision risk – Higher probability of well intercept
- Improved positional accuracy?
- Improved directional drilling performance monitoring
  - When combined with additional data -- GTF, ROP, Steering Force and Geology

Conclusions

- Continuous surveys are repeatable and accurate
- Combining continuous with static surveys = ISCWSA error model
- Survey intervals matter – 3m
- Continuous surveys are essential for TVD accuracy
- There is value in continuous surveys

Can Directional Uncertainty Affect Oil Drainage?



TVD Uncertainty Can Affect Oil Drainage