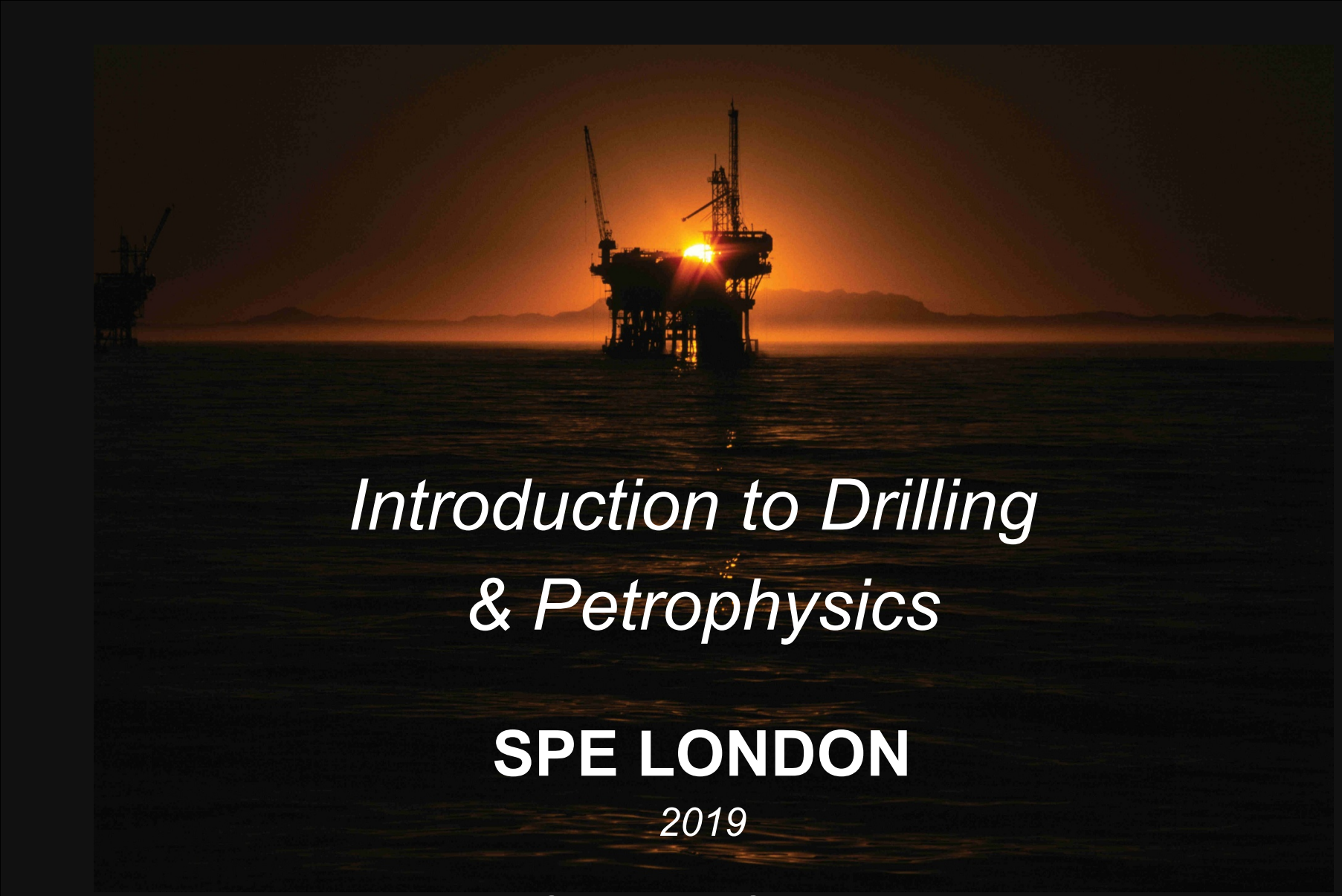

Introduction to Drilling & Petrophysics

SPE LONDON

2019

Stewart McGregor

Technical Development Manager, Merlin ERD Ltd

Content

MERLIN ERD
Extended Reach Drilling Engineers

- Well Types
- Costs & Values
- Rig Types
- Phases of a Well
- Formation Evaluation

It's ALL about Drilling!

Drilling Through Time

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- 1000 BC salt drilling China, 800 ft by 300 AD
- 1264 mining oil seeps Baku
- 1594 oil wells hand dug (115 ft)

- 1859 1st oil well in USA (70 ft)
- 1989 vertical well : 40,230 ft (Kola, Russia)
- 2018 directional well : 49,250 ft (Sakhalin, Russia)

Well Types

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- Exploration
  - Anything there (success rate 1:5)
- Appraisal
  - How much is there?
- Development
  - Production : makes the money
  - Injection : keeps it coming

Vertical & Directional Wells

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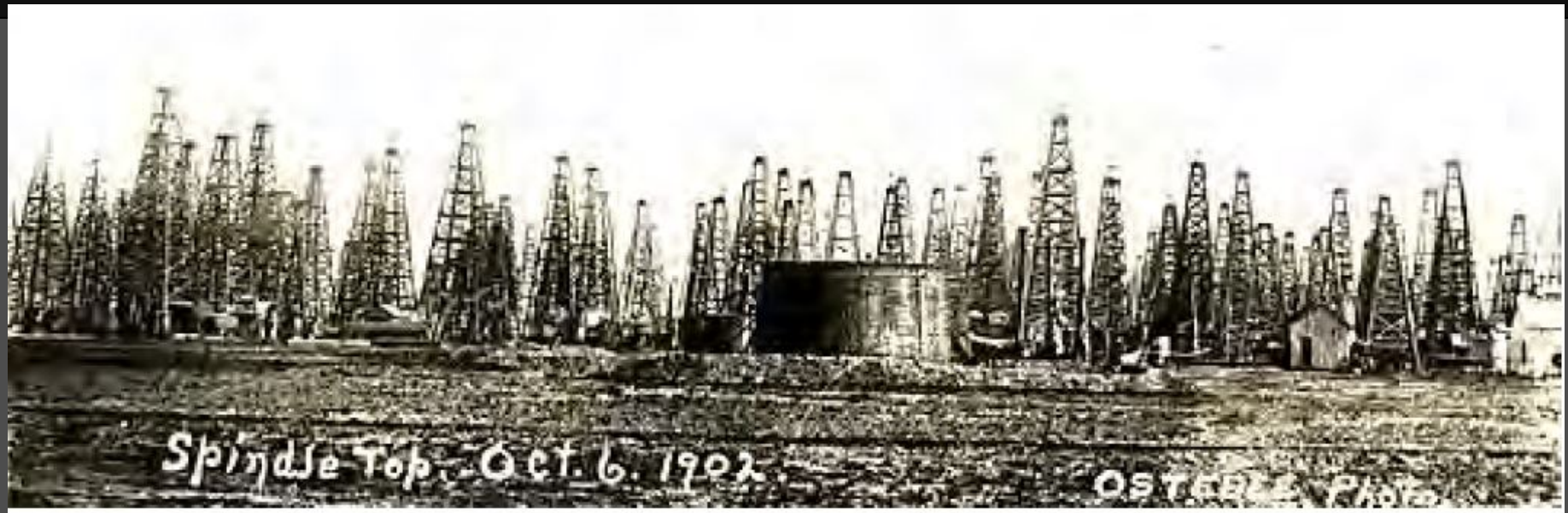

Directional Drilling

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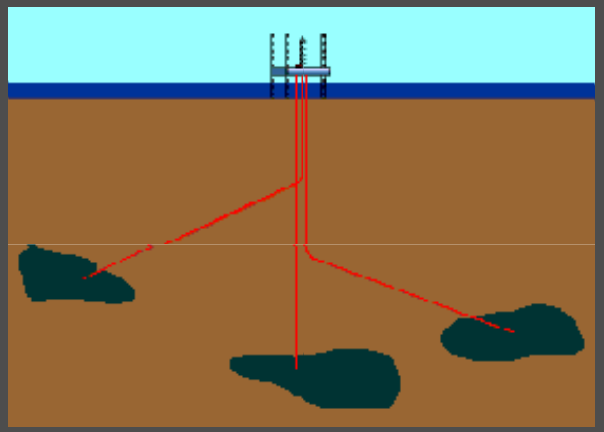
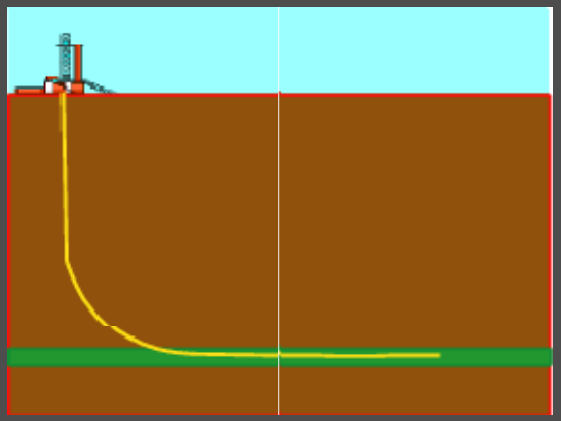
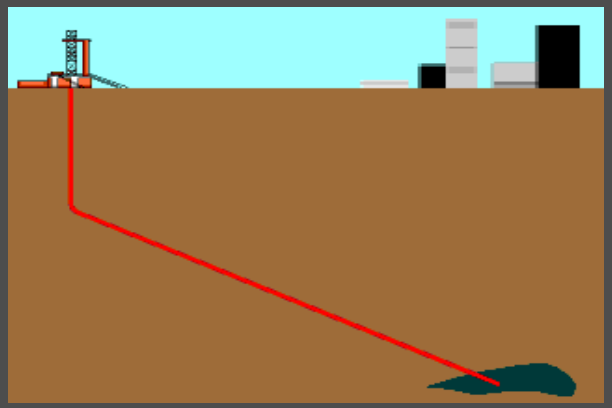


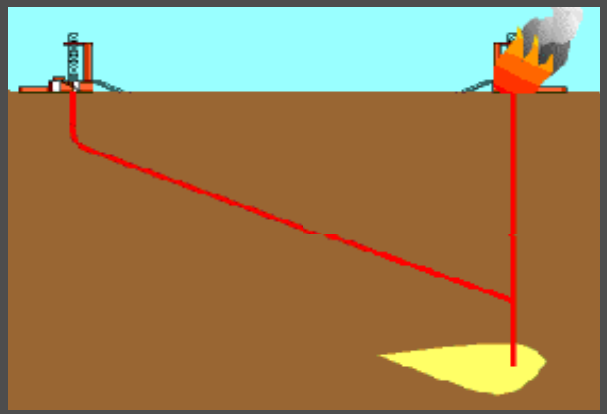
Platform or Pad



Drainage



Inaccessible Locations



Relief well

Well Time & Costs

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- Drilling times
  - 5 to 500 days
  - Typical 20 – 50 days
- Drilling costs
  - US$100k – US$1Mn per day
  - Well : US$2Mn to US$100's Mn
  - Typical onshore US$5Mn / offshore US$30Mn
  - ≈ 80% of costs are time dependent

Value of Drilling Quickly!

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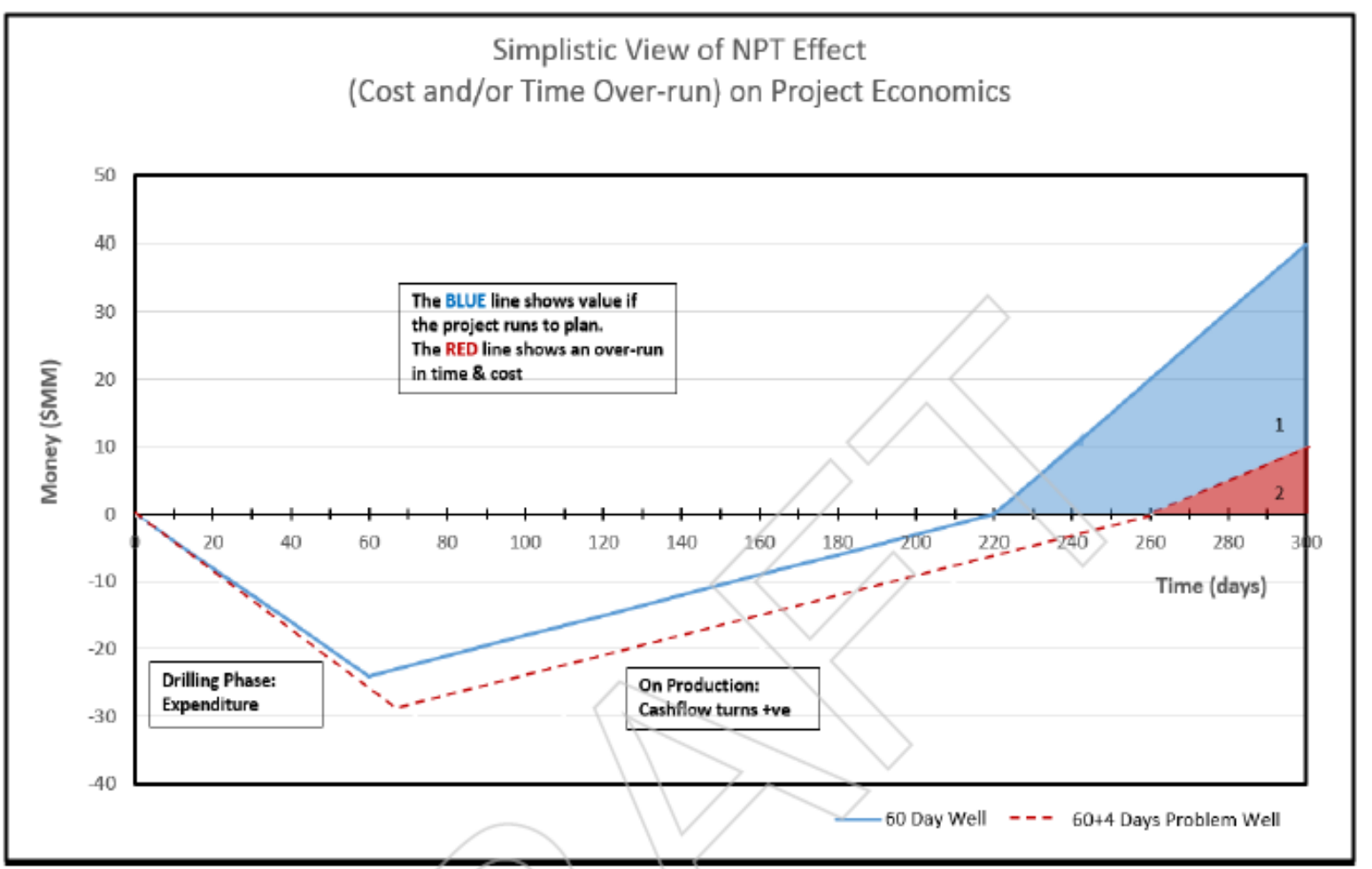
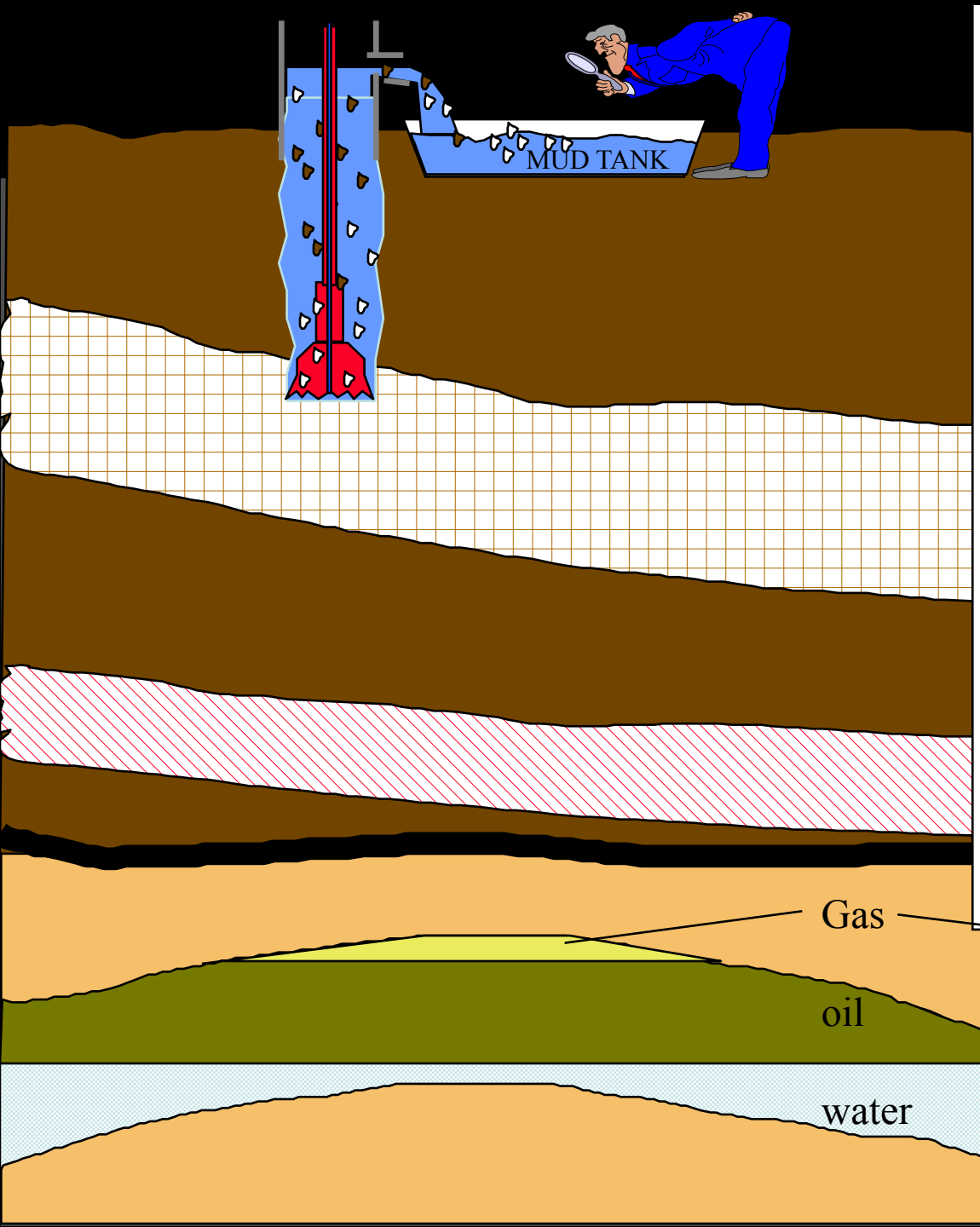
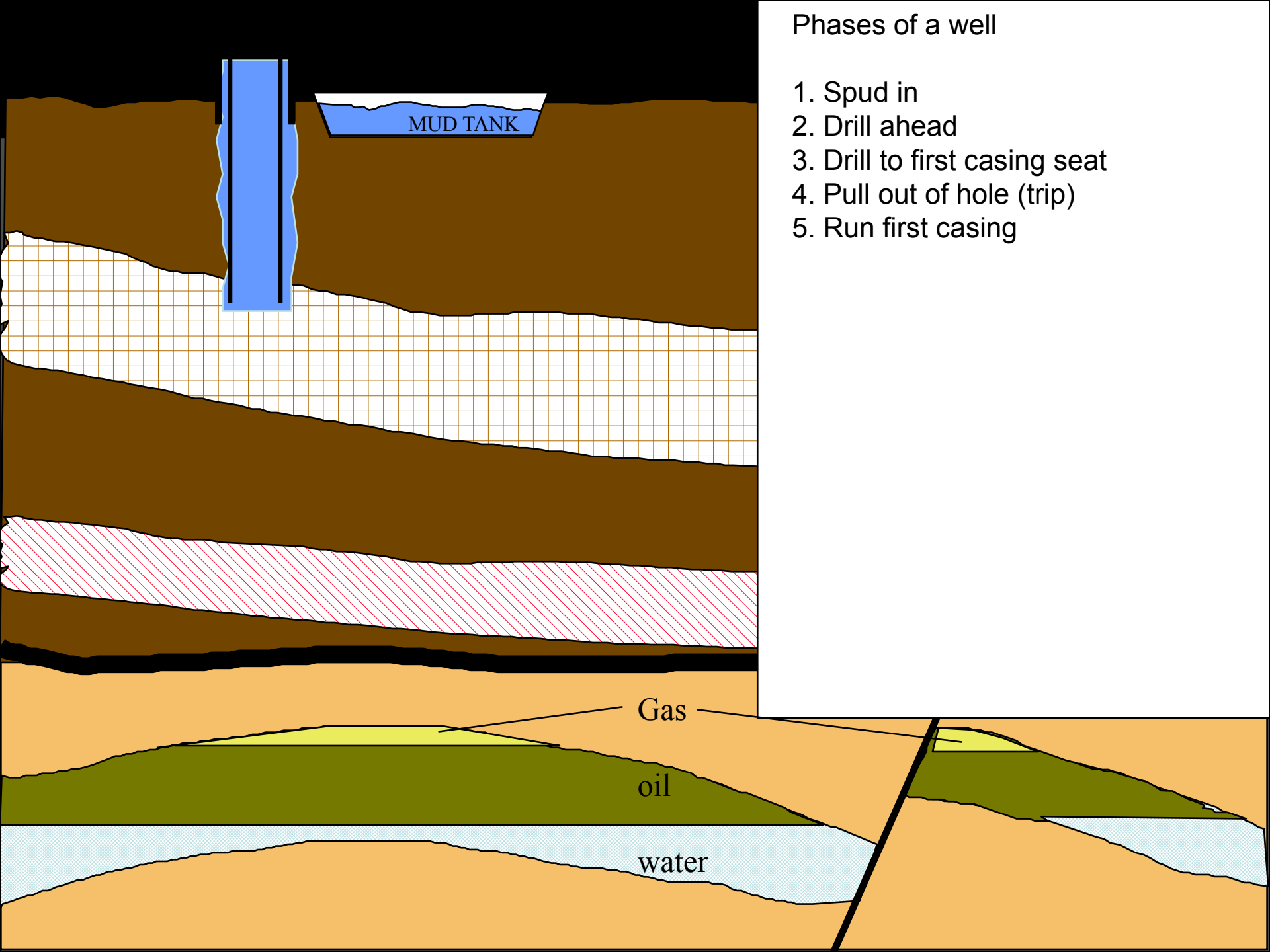


Figure 12 : Impact of Non Productive Time on Project Economics *(Merlin ERD Ltd)*



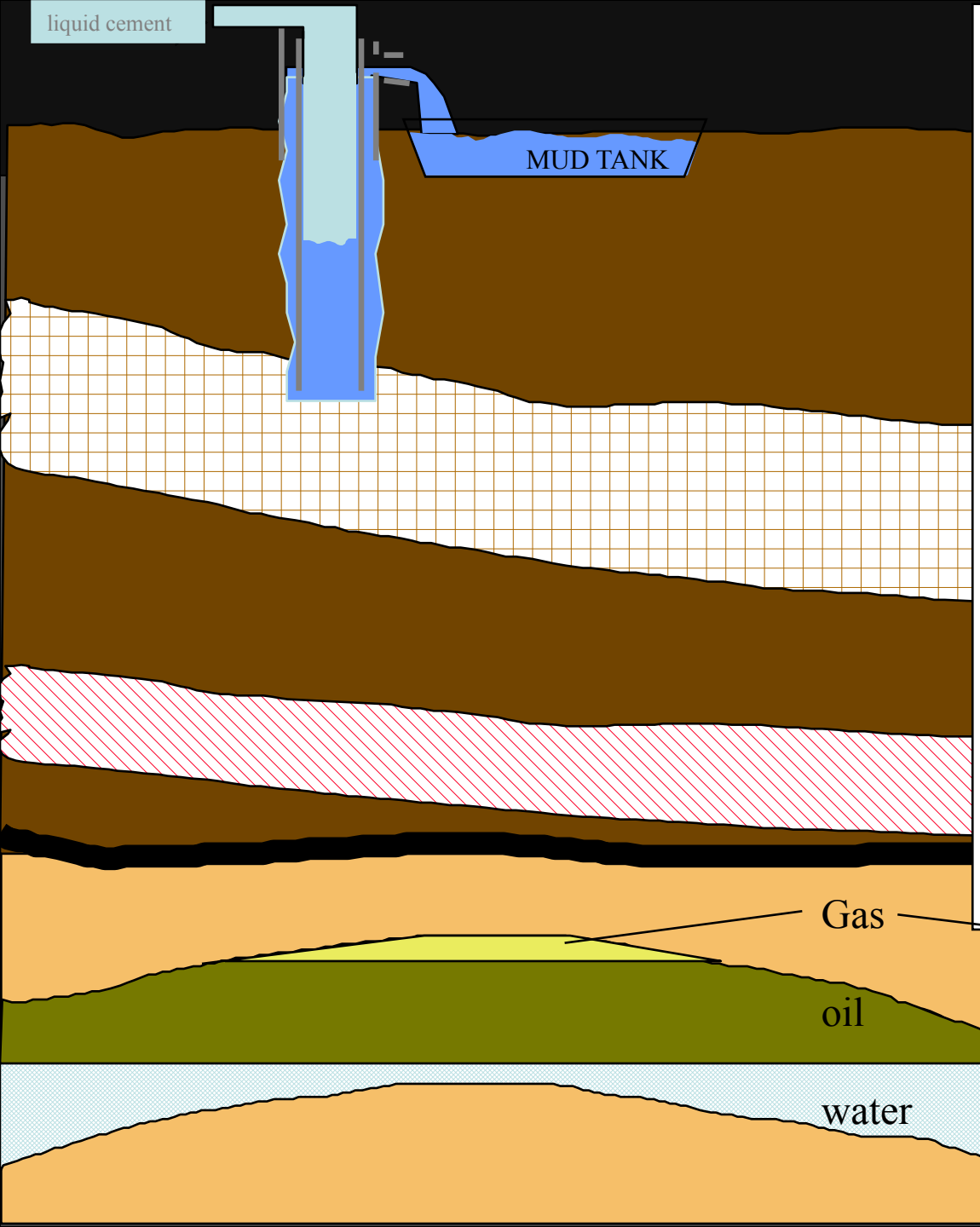
Phases of a well

1. Spud in
2. Drill ahead
3. Drill to first casing seat



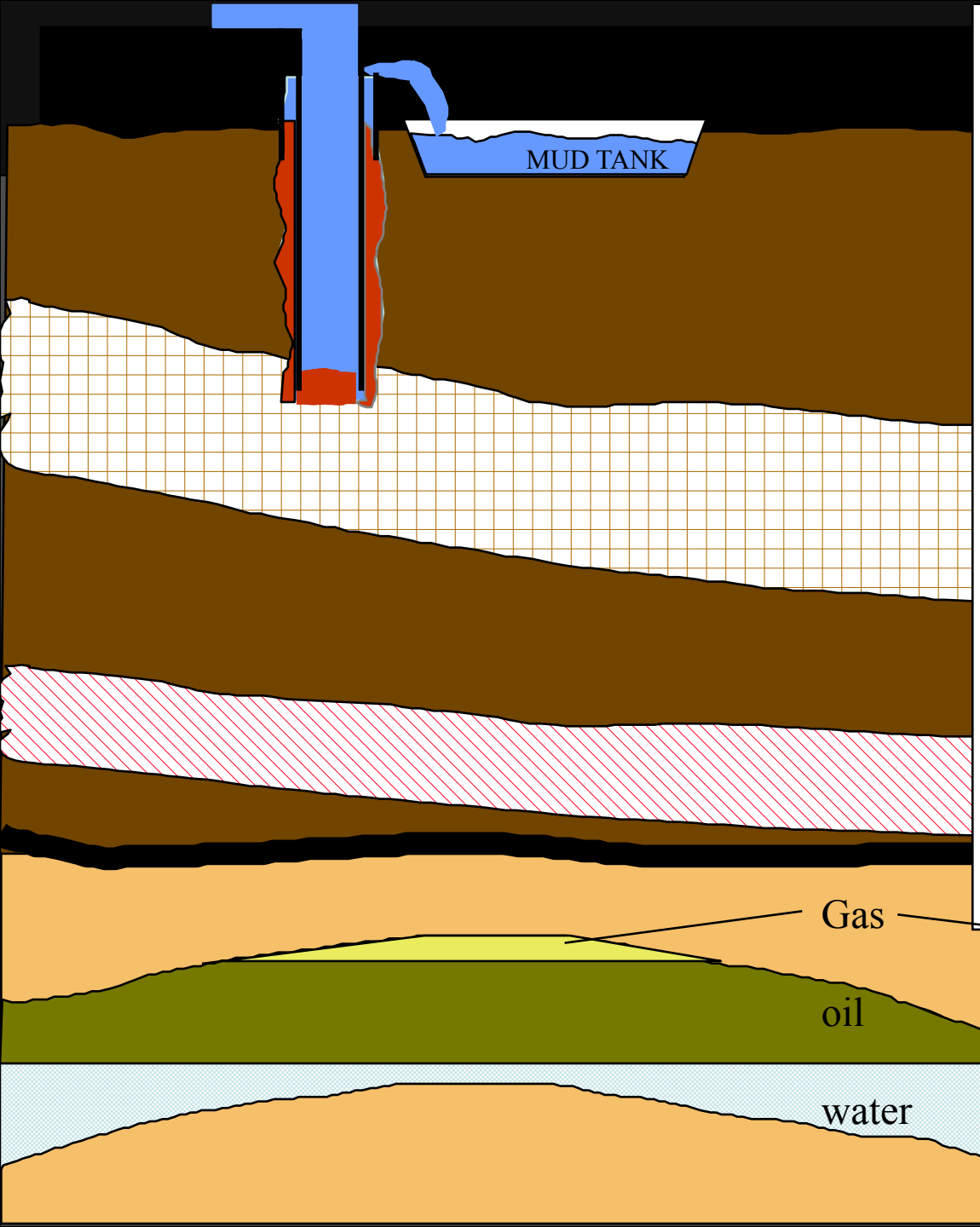
Phases of a well

1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing



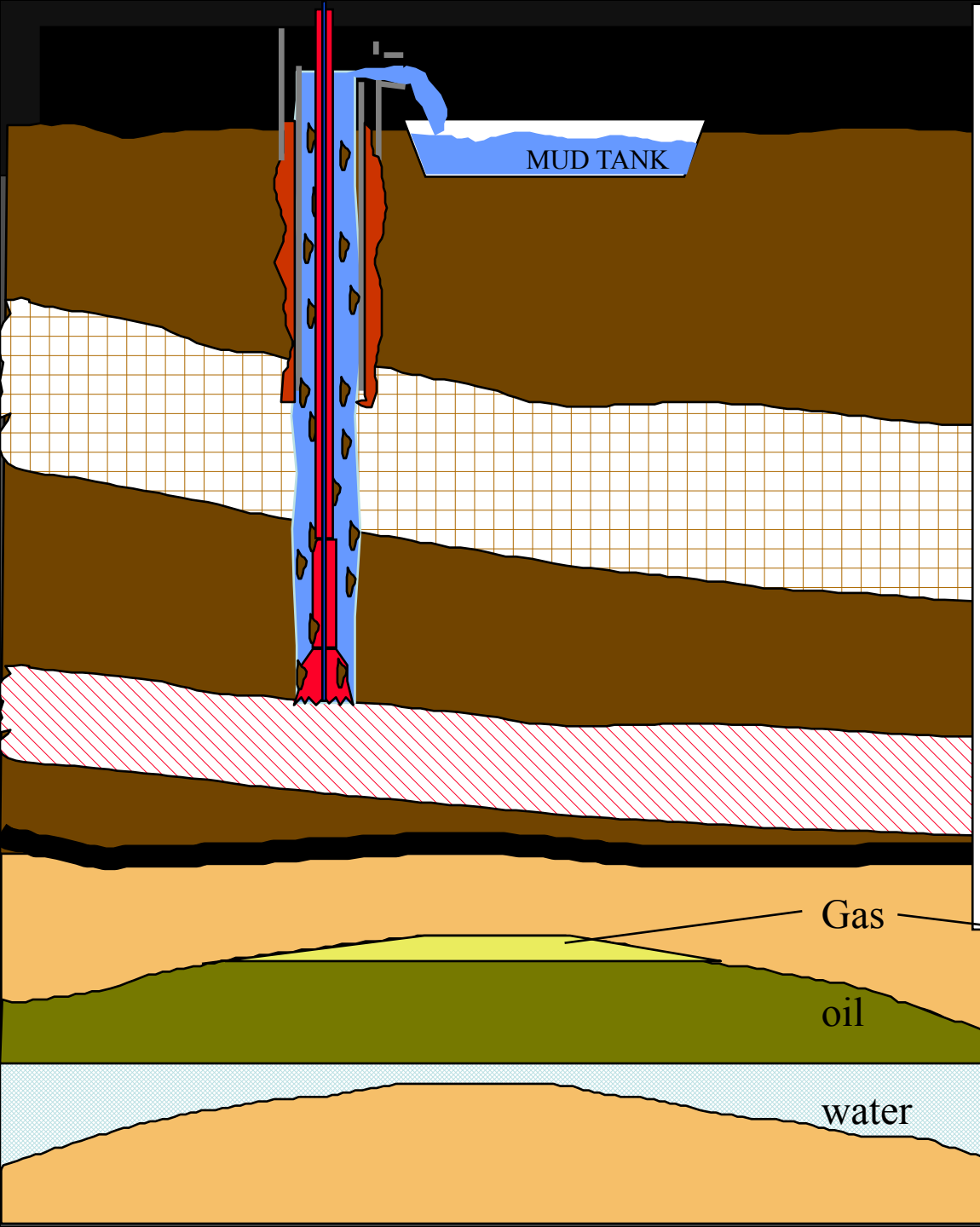
Phases of a well

1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing
6. Pump cement



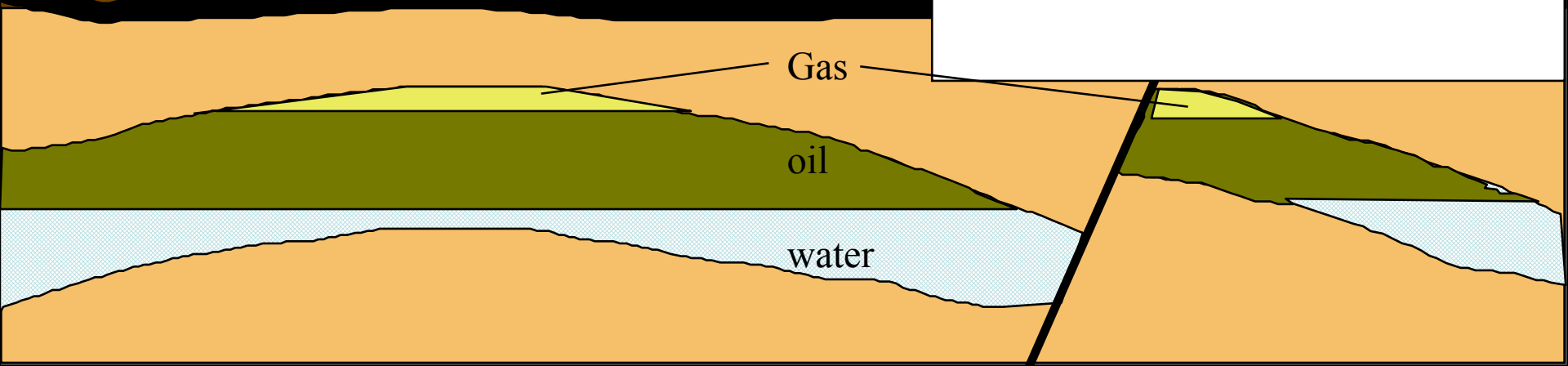
Phases of a well

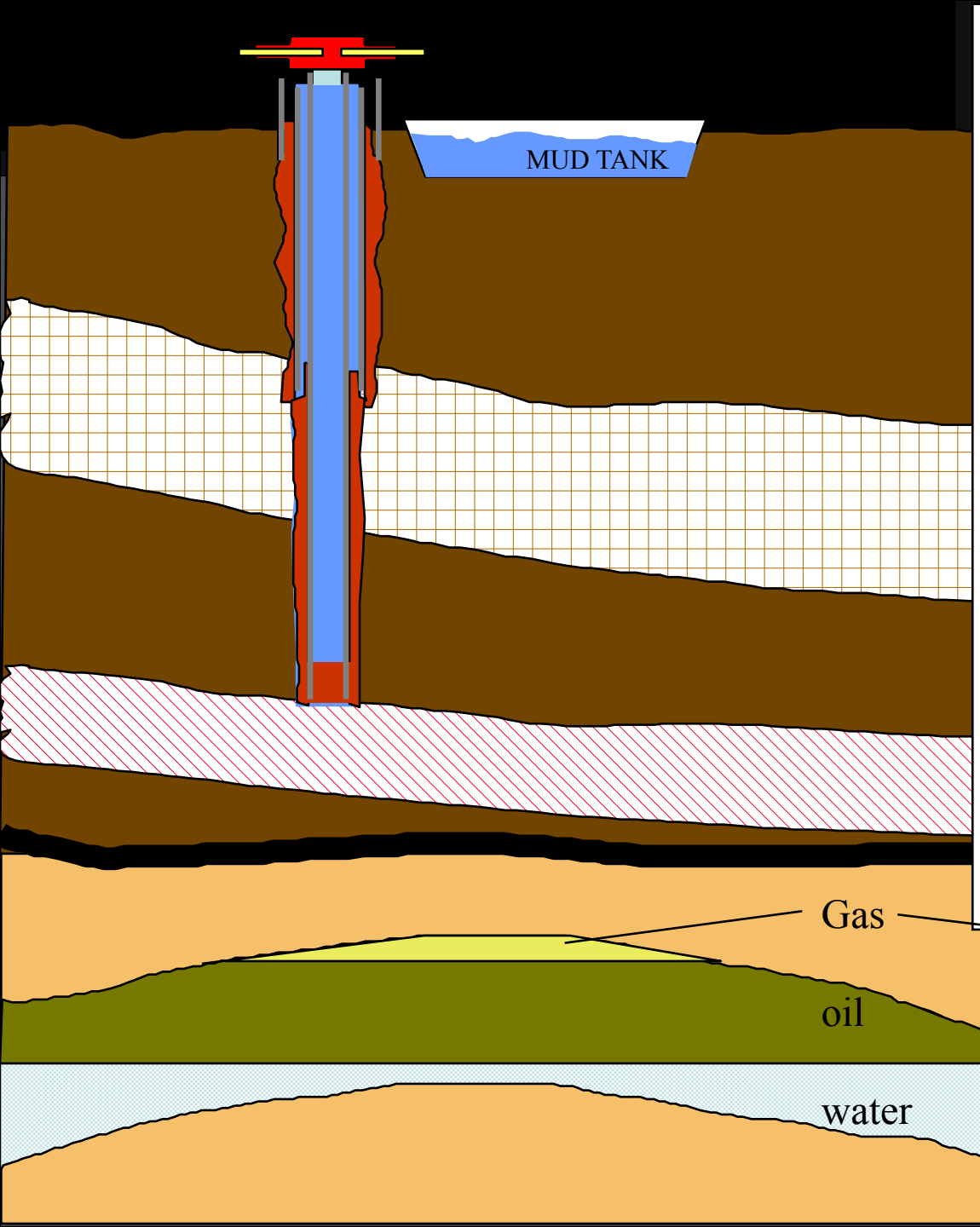
1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing
6. Pump cement
7. Displace cement “behind” casing



Phases of a well

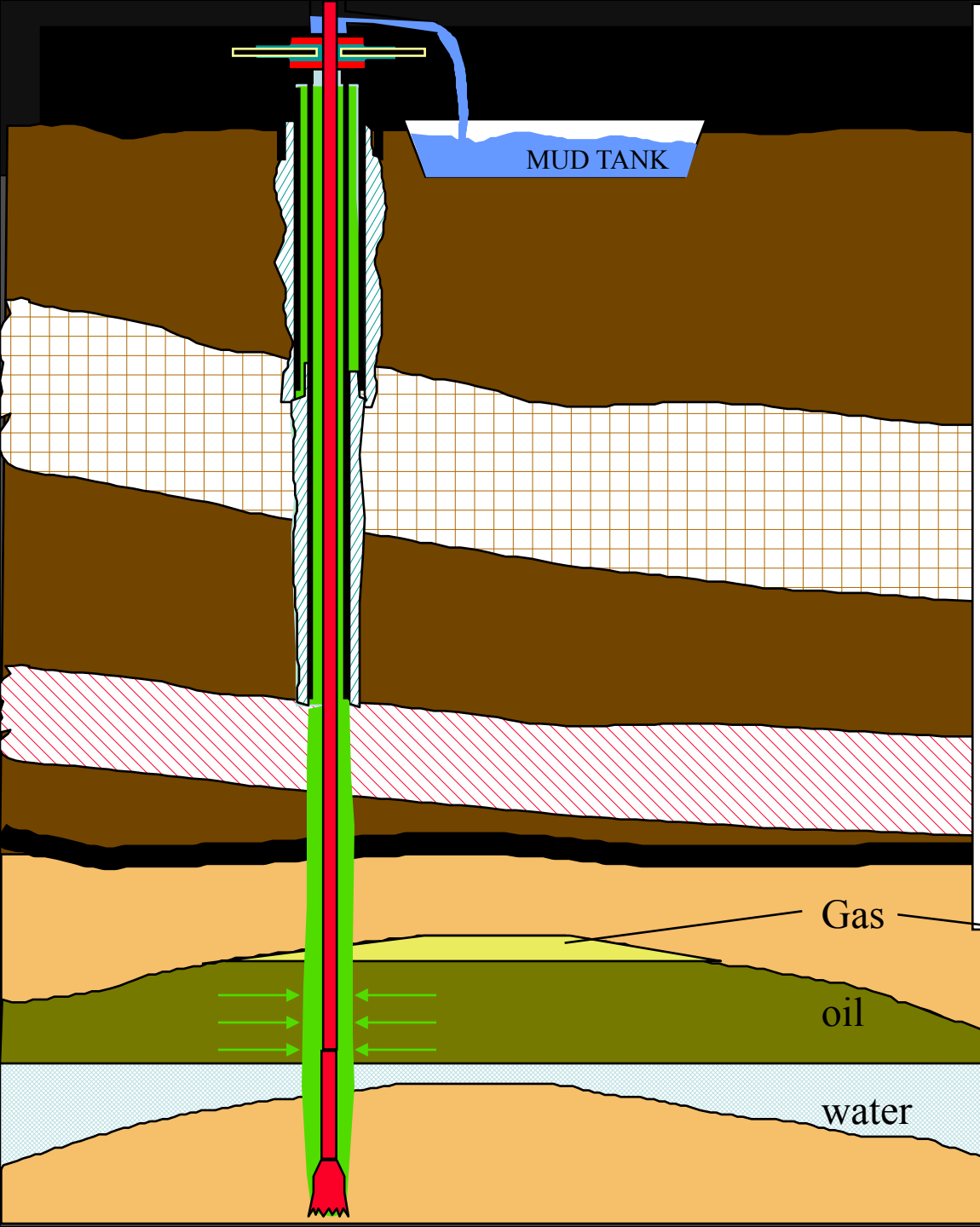
1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing
6. Pump cement
7. Displace cement “behind” casing
8. Drill ahead to 2nd casing seat





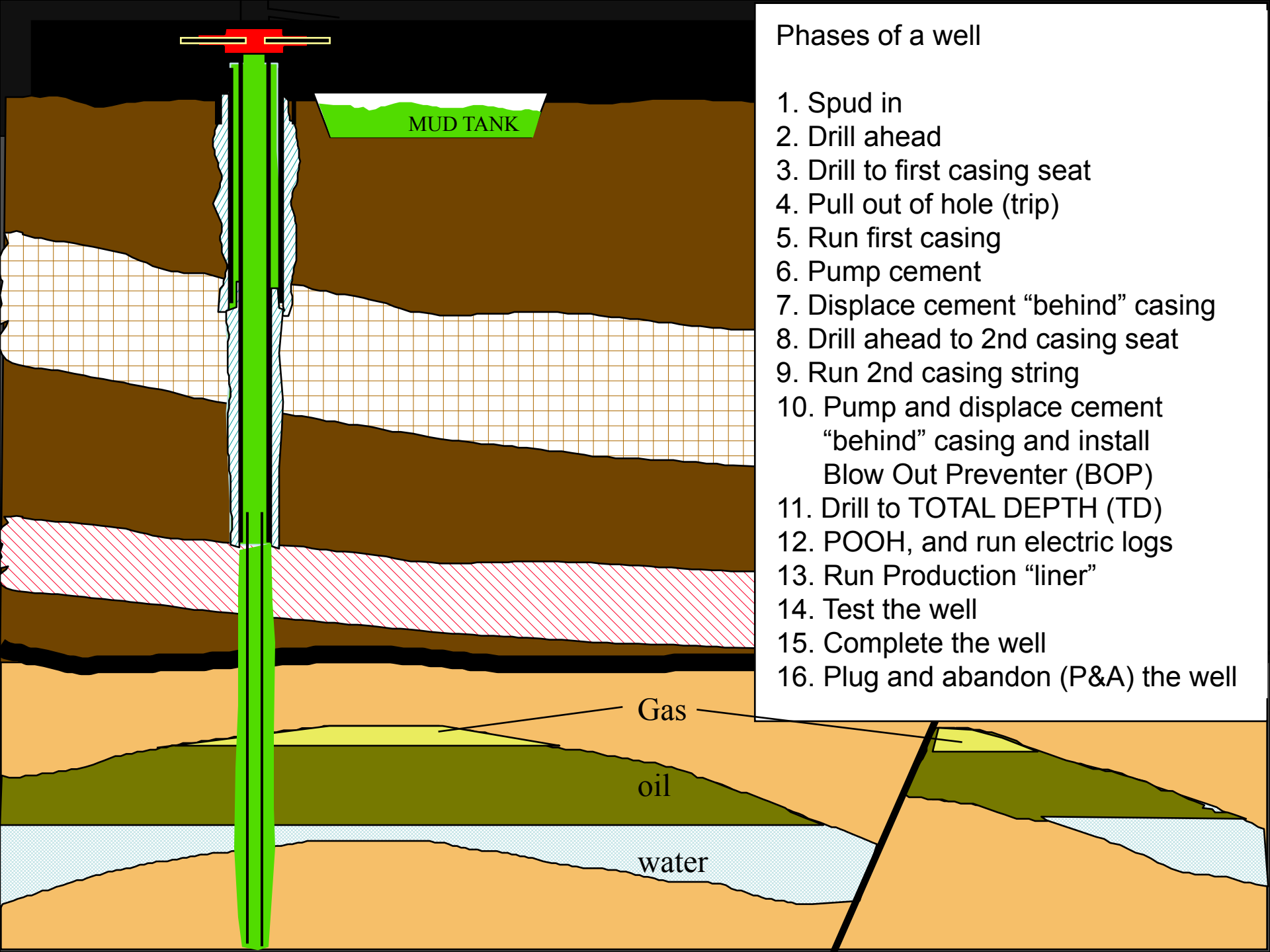
Phases of a well

1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing
6. Pump cement
7. Displace cement “behind” casing
8. Drill ahead to 2nd casing seat
9. Run 2nd casing string
10. Pump and displace cement “behind” casing and install Blow Out Preventer (BOP)



Phases of a well

1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing
6. Pump cement
7. Displace cement “behind” casing
8. Drill ahead to 2nd casing seat
9. Run 2nd casing string
10. Pump and displace cement “behind” casing and install Blow Out Preventer (BOP)
11. Drill through the reservoir to TOTAL DEPTH (TD)



Phases of a well

1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing
6. Pump cement
7. Displace cement “behind” casing
8. Drill ahead to 2nd casing seat
9. Run 2nd casing string
10. Pump and displace cement “behind” casing and install Blow Out Preventer (BOP)
11. Drill to TOTAL DEPTH (TD)
12. POOH, and run electric logs
13. Run Production “liner”
14. Test the well
15. Complete the well
16. Plug and abandon (P&A) the well

ERD Design

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Viable? How to tell / prove it?

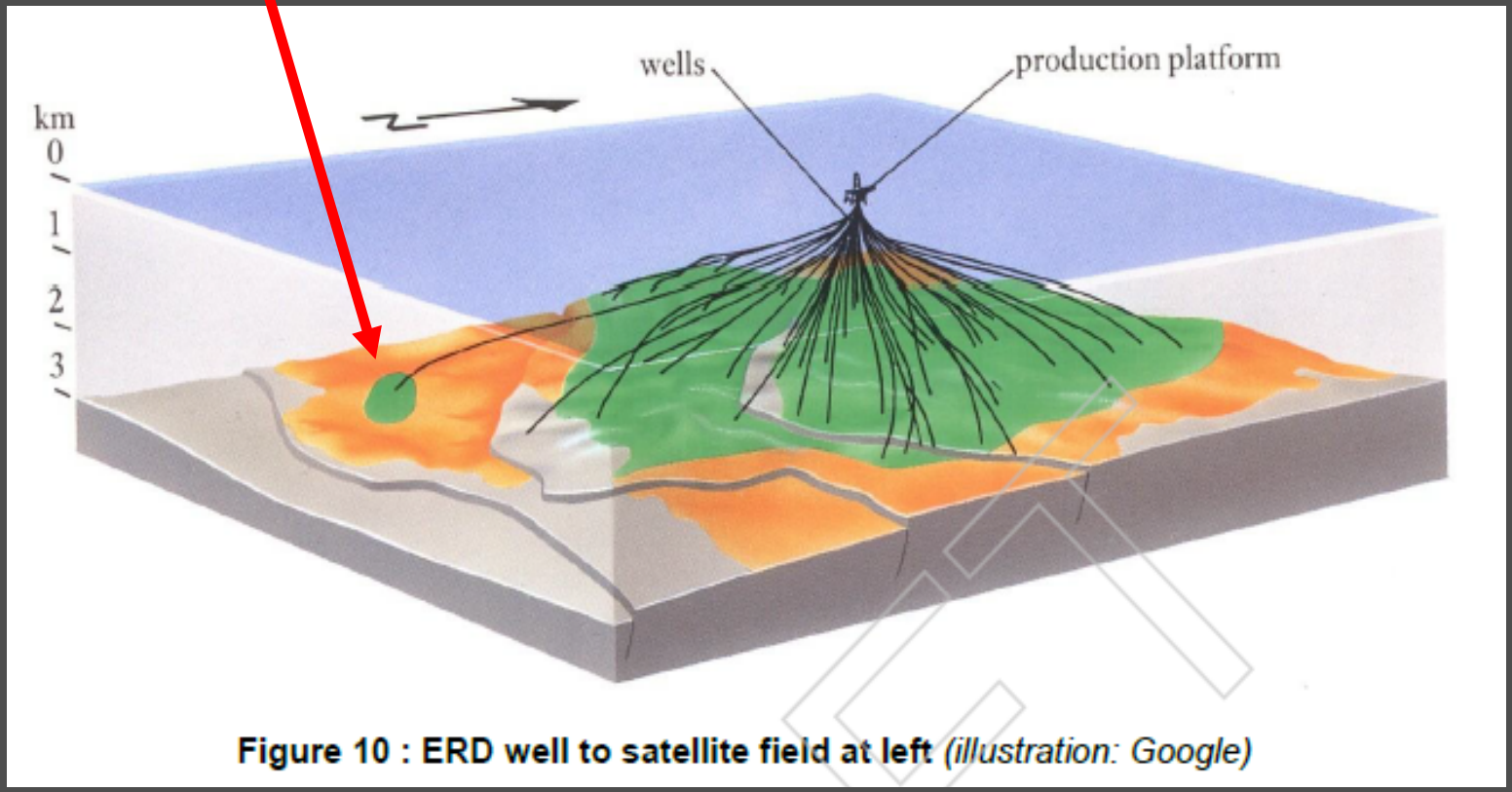

Figure 10 : ERD well to satellite field at left *(illustration: Google)*

Industry Drilling Envelope

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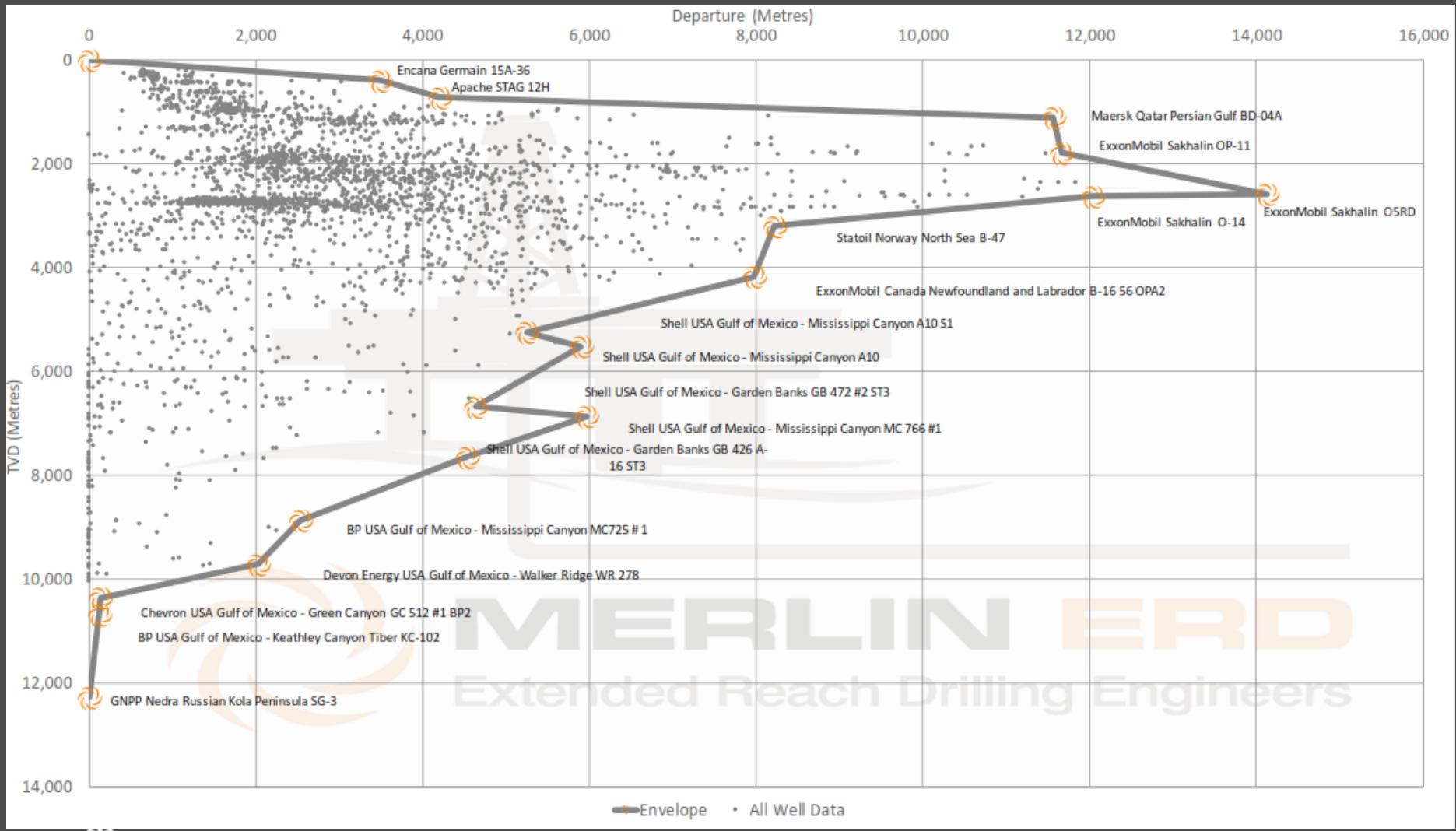

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Deepest Well - Departure

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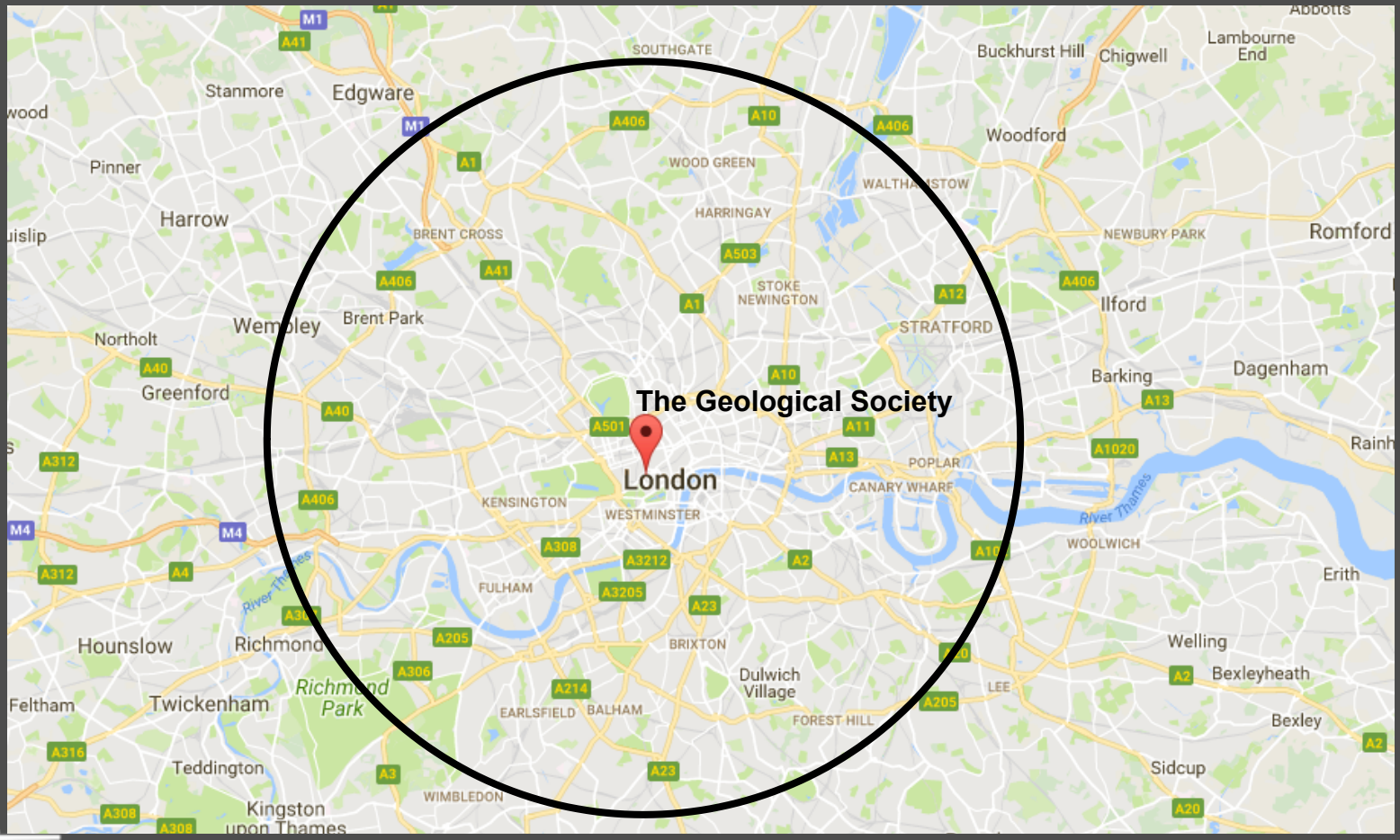
- Longest Step-Out – Chayvo O-5 - 41,338ft (12,600m)



Drilling Rigs - Land

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Drilling Rigs - Offshore

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Drilling Rigs - Offshore

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Drill String - Bits

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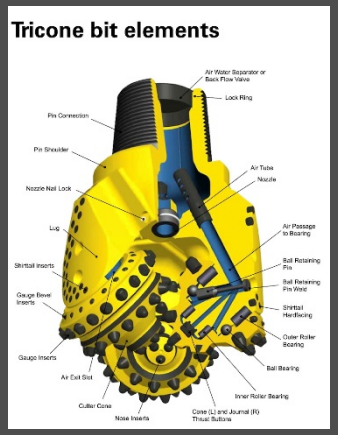
- $400 - $100,000+
- Durability matched with ROP

Gouges

Scrapes

Wears

- Best bit = cheapest bit in terms of overall cost = cost/foot



Crushes

Drilling – Core Sampling

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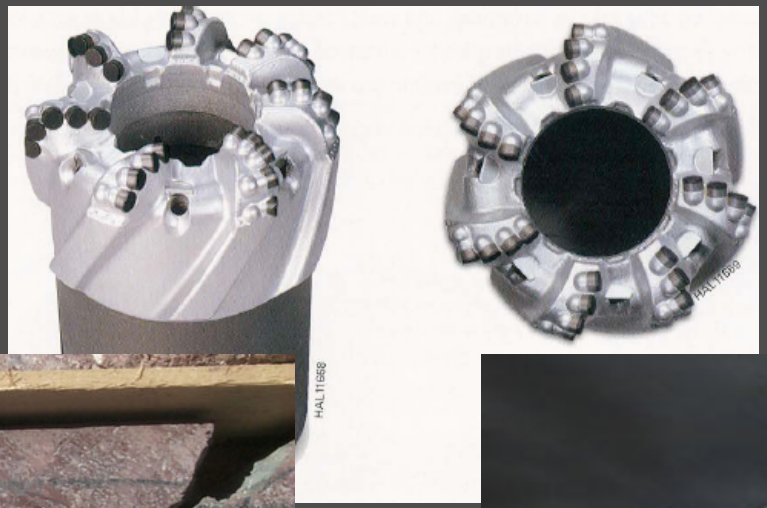
- Core – direct samples of the formation



Formation Evaluation

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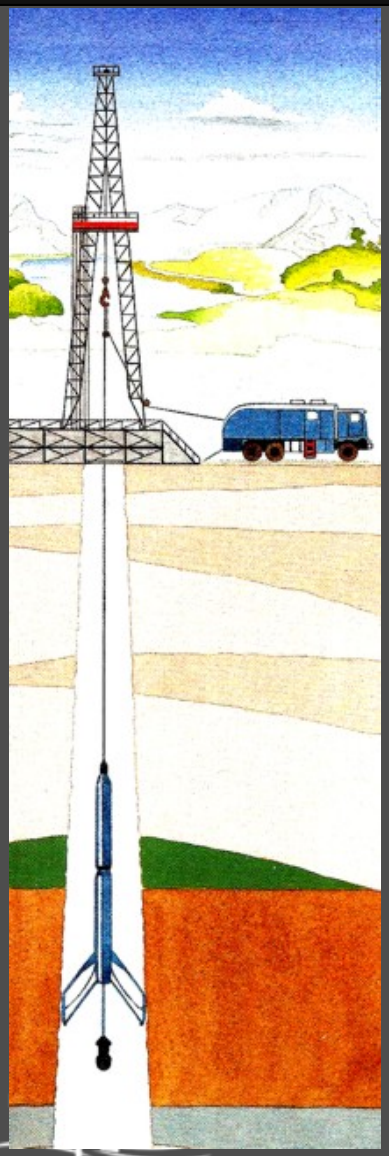
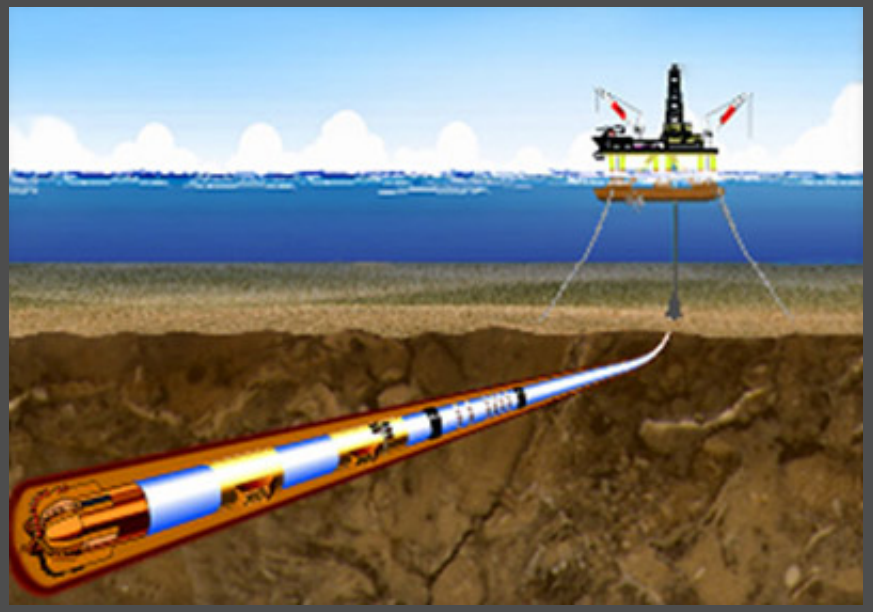


Wireline Logging (post drilling)



Logging While Drilling (LWD)

Need to knows

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- Porosity
  - Voids which hold fluids/gas
- Saturation
  - Volume of each fluid present in voids
- Permeability
  - How easy the fluid will move through the formation
- Fluid Properties
  - What is it?

“Basic” Logging Measurements

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- Resistivity Logs
  - Salty Water vs Hydrocarbon filled pores
- Porosity Logs
  - % of pore volume in the rock - porosity
- Density Logs
  - Bulk density of the formation, guide to porosity
- Sonic Logs
  - % of pore volume in the rock – porosity
- Gamma Ray
  - Natural Gamma Radiation – Sand/Limestone or Shale

Log Example

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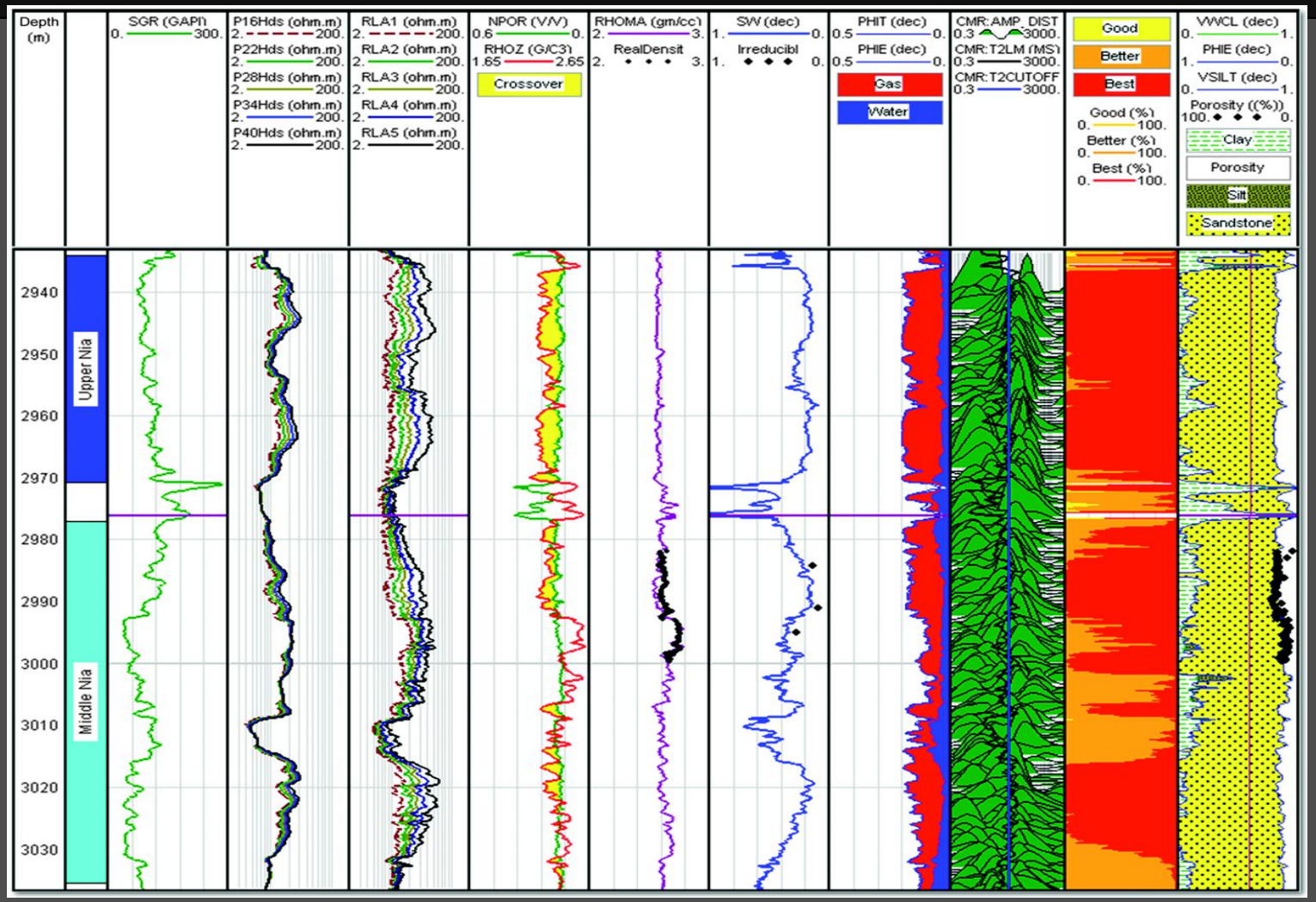

In Summary

MERLIN ERD
Extended Reach Drilling Engineers

Merlin ERD Ltd

MERLIN ERD
Extended Reach Drilling Engineers

Increasing value through Drilling :

- Further, faster, cheaper
- Trouble-free
- More Wells Sooner!

Call us to unlock your potential

Tel +44 1738 627922
Email: Miles.Long@MerlinERD.com

If we always do what we've always done, we'll only get what we've always had!