

A photograph of an offshore oil rig at sunset. The sun is low on the horizon, creating a warm orange glow that silhouettes the rig's structure. The water is dark with some ripples. The sky is a gradient of orange and yellow.

*An introduction to drilling
and petrophysics*

SPE LONDON

2017

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Content

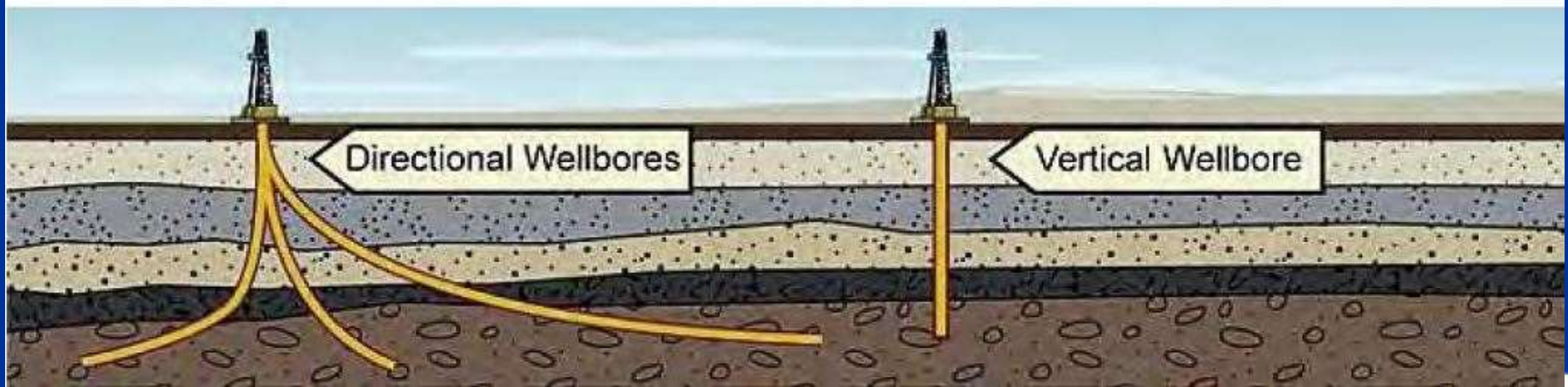
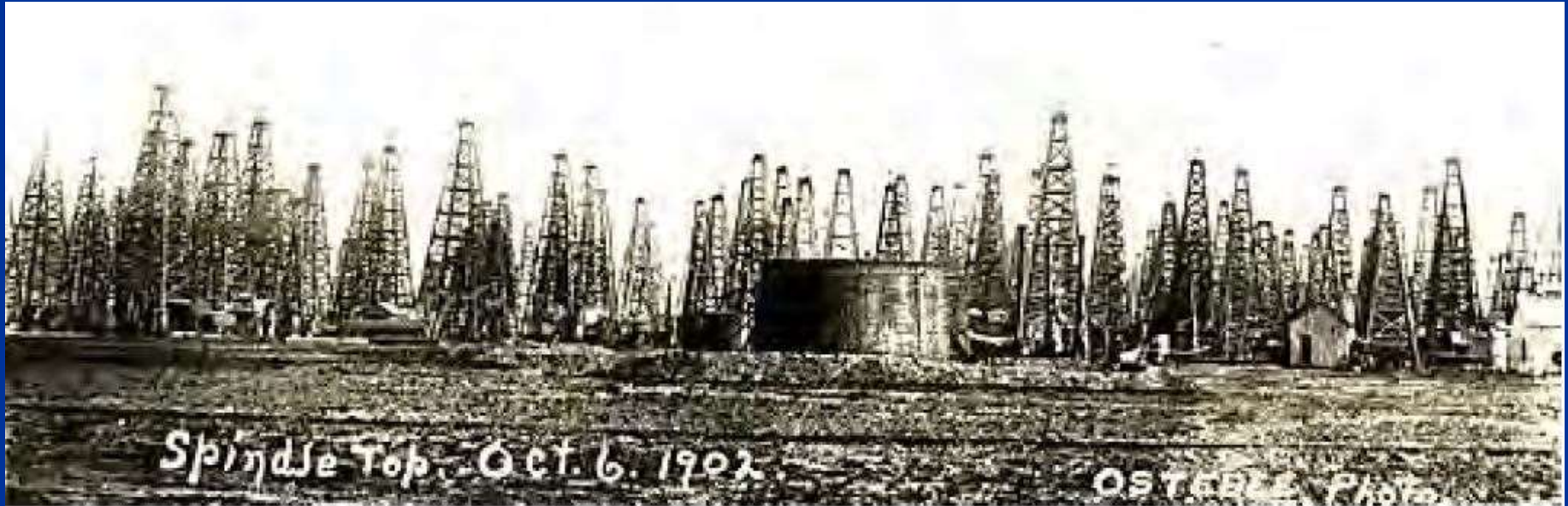
- Well Types
- Costs & Value
- Rig Types
- Phases of a Well
- Formation Evaluation

It's ALL about Drilling!

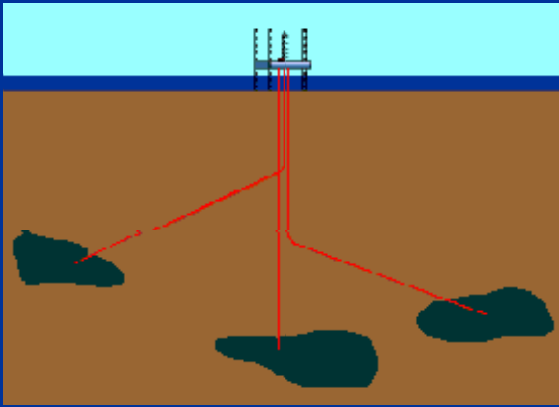
Well Types

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

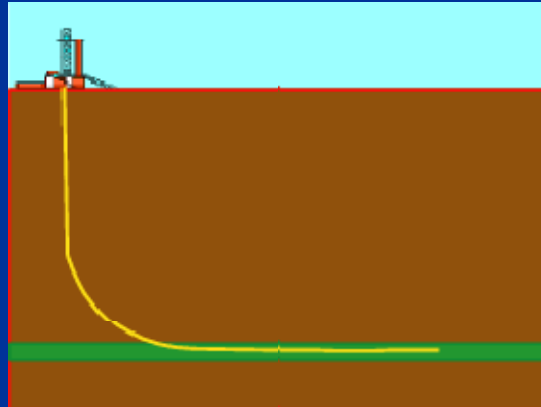
Vertical & Directional Wells



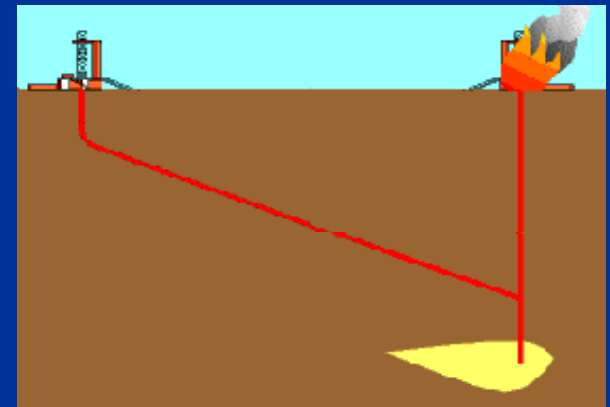
Directional Drilling



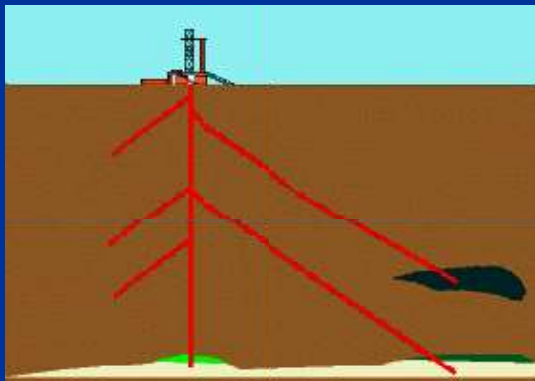
Platform or Pad



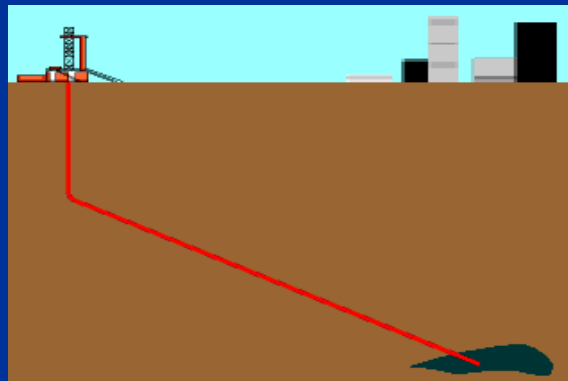
Drainage



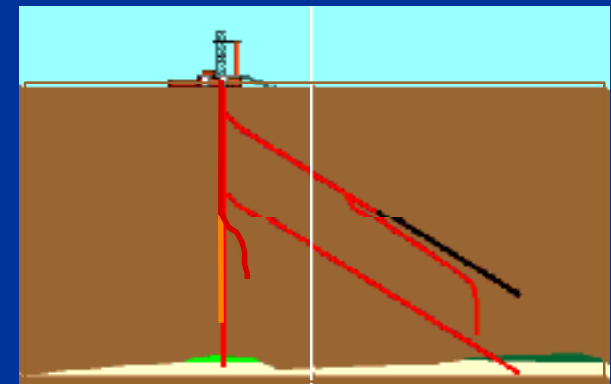
Relief well



Multilaterals



Inaccessible Locations



Sidetracking

Well Time & Costs

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

Value of Drilling Quickly!

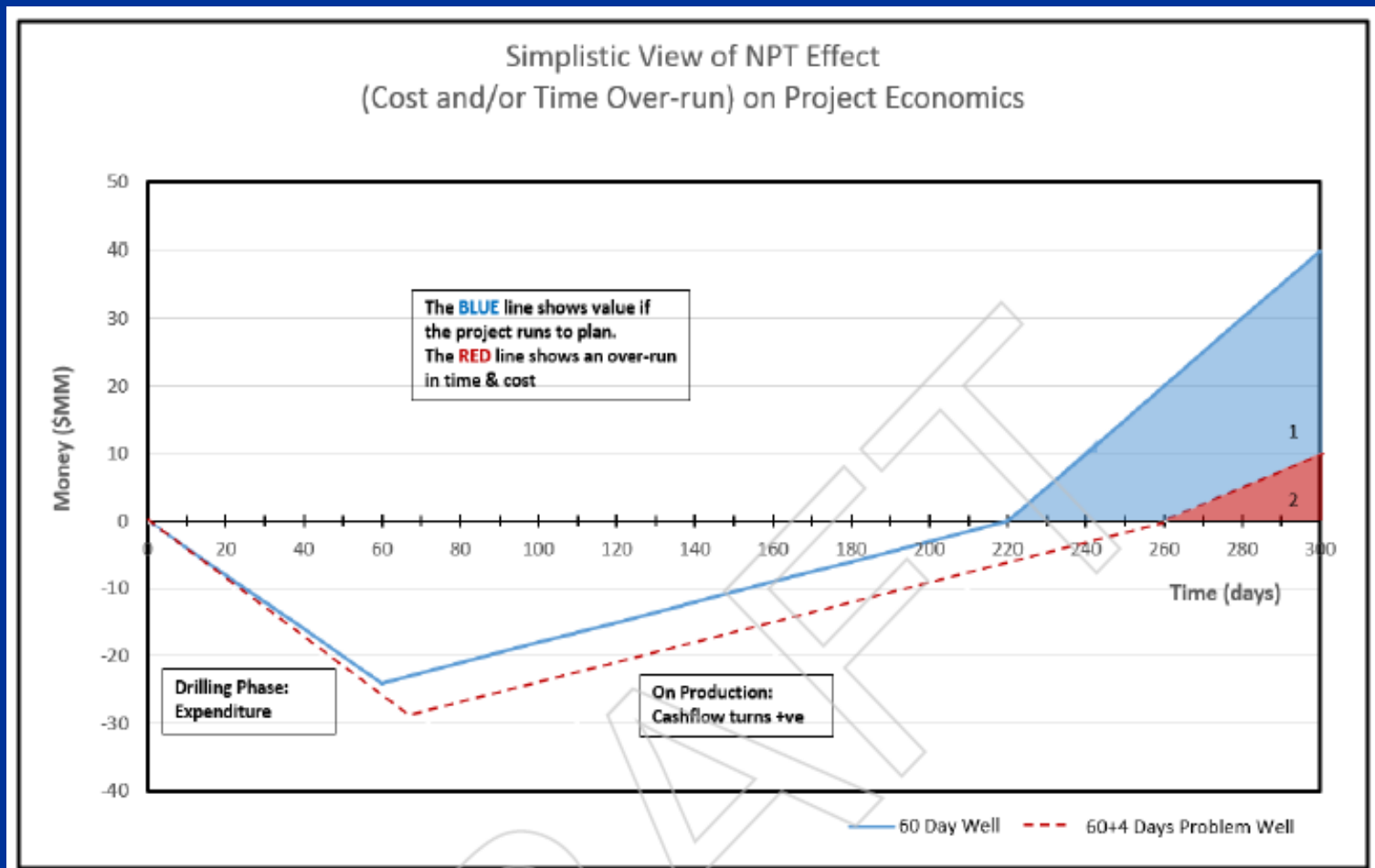
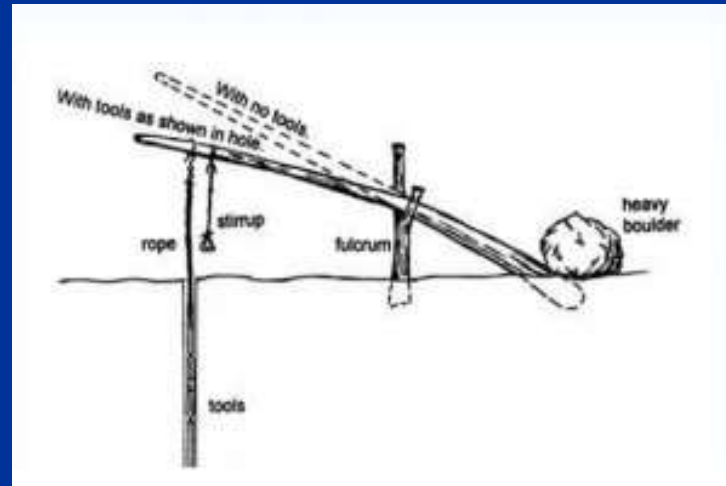
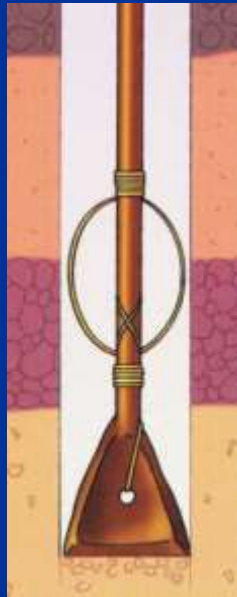


Figure 12 : Impact of Non Productive Time on Project Economics (Merlin ERD Ltd)

“ Brief History in Time”

- First recorded drilling in Sichuan Province, China – c. 2,000 years ago, salt drilling



“ Brief History in Time”

- 1264 – mining of seep oil witnessed by Marco Polo in Baku, Azerbaijan
- 1594 – Oil wells are hand dug to 115ft (35m) in Baku, Azerbaijan



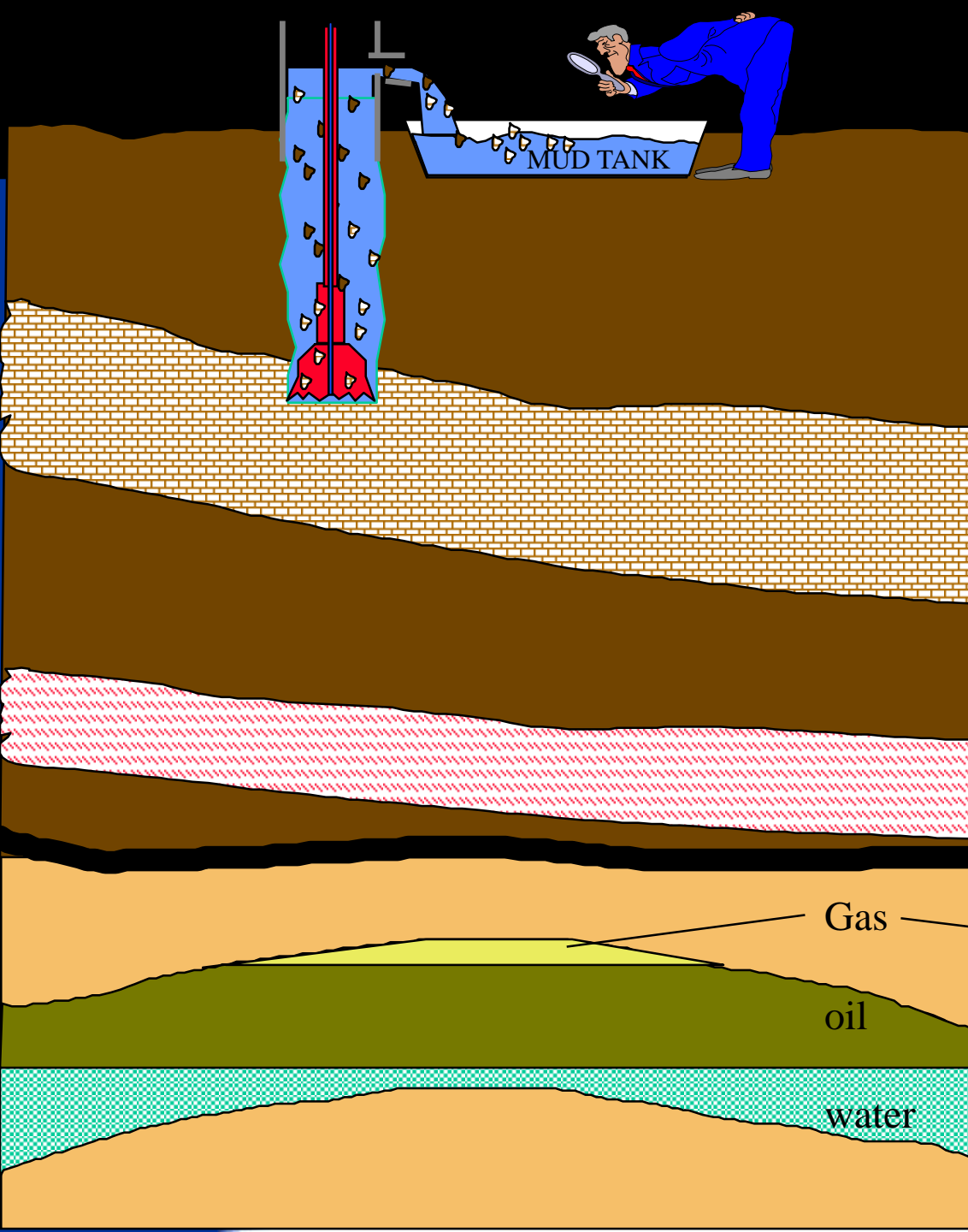
“ Brief History in Time”

- 1859 – first oil well drilled in the United States (21m)



Phases of a well

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



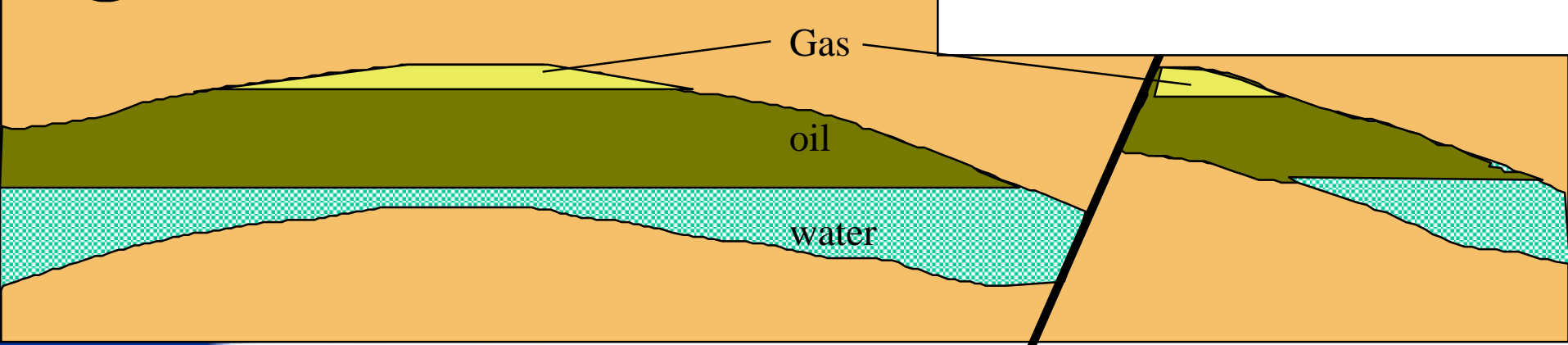
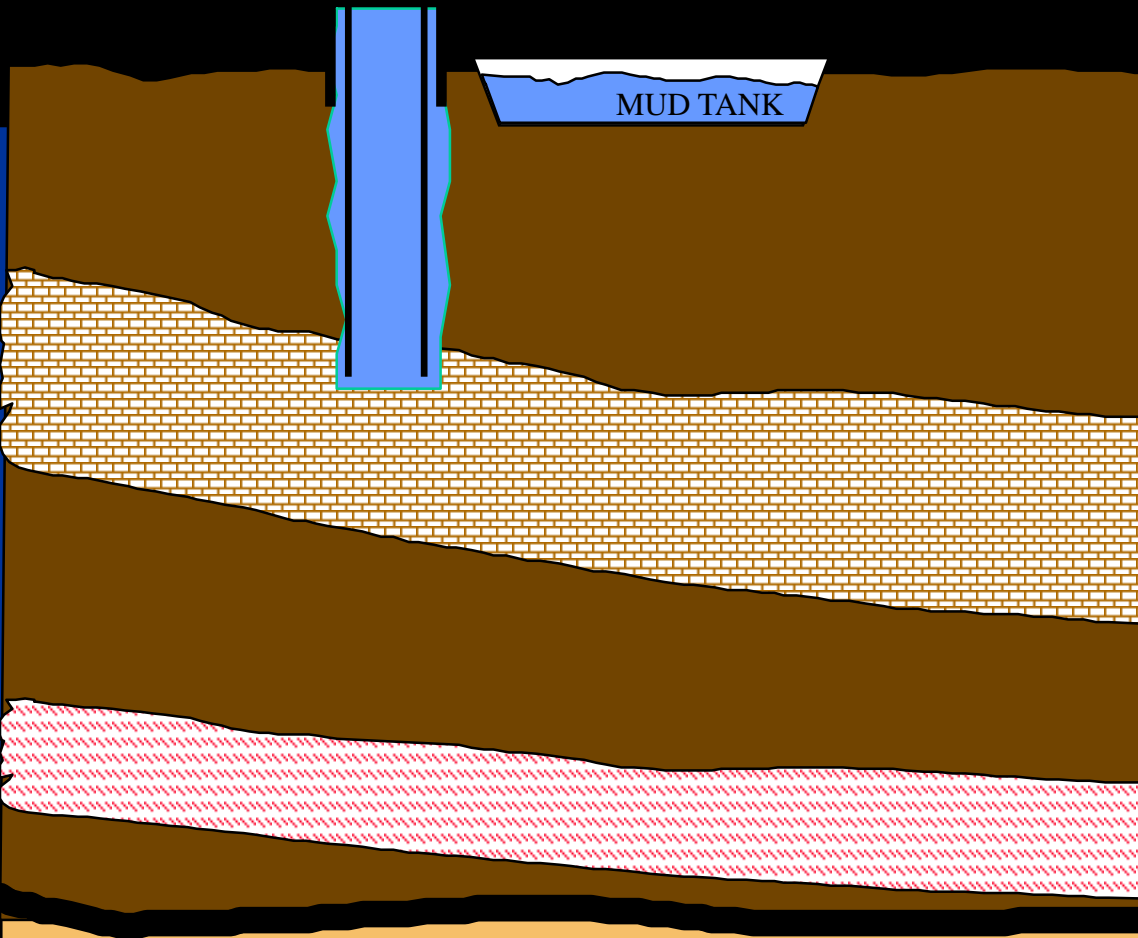
Gas

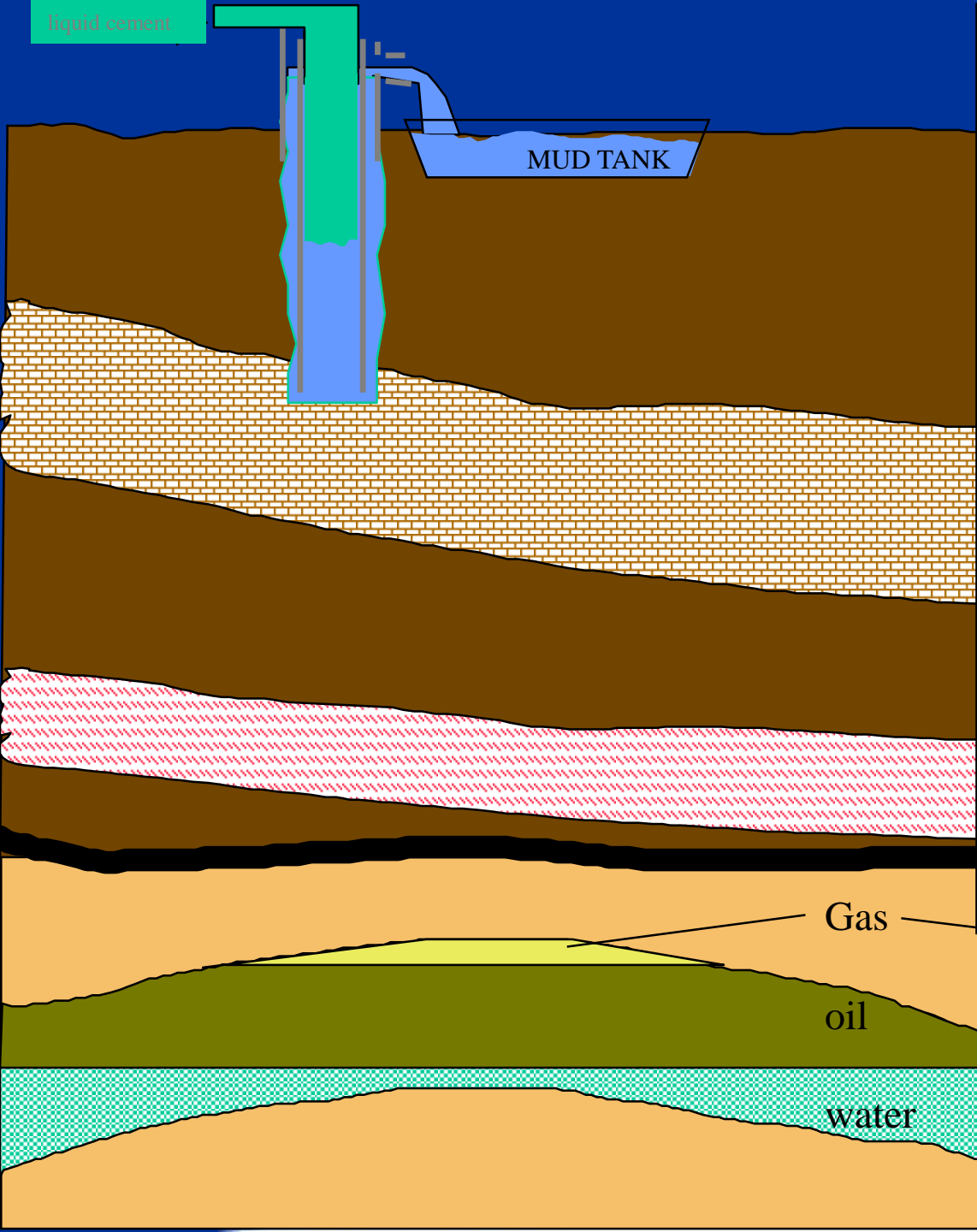
oil

water

Phases of a well

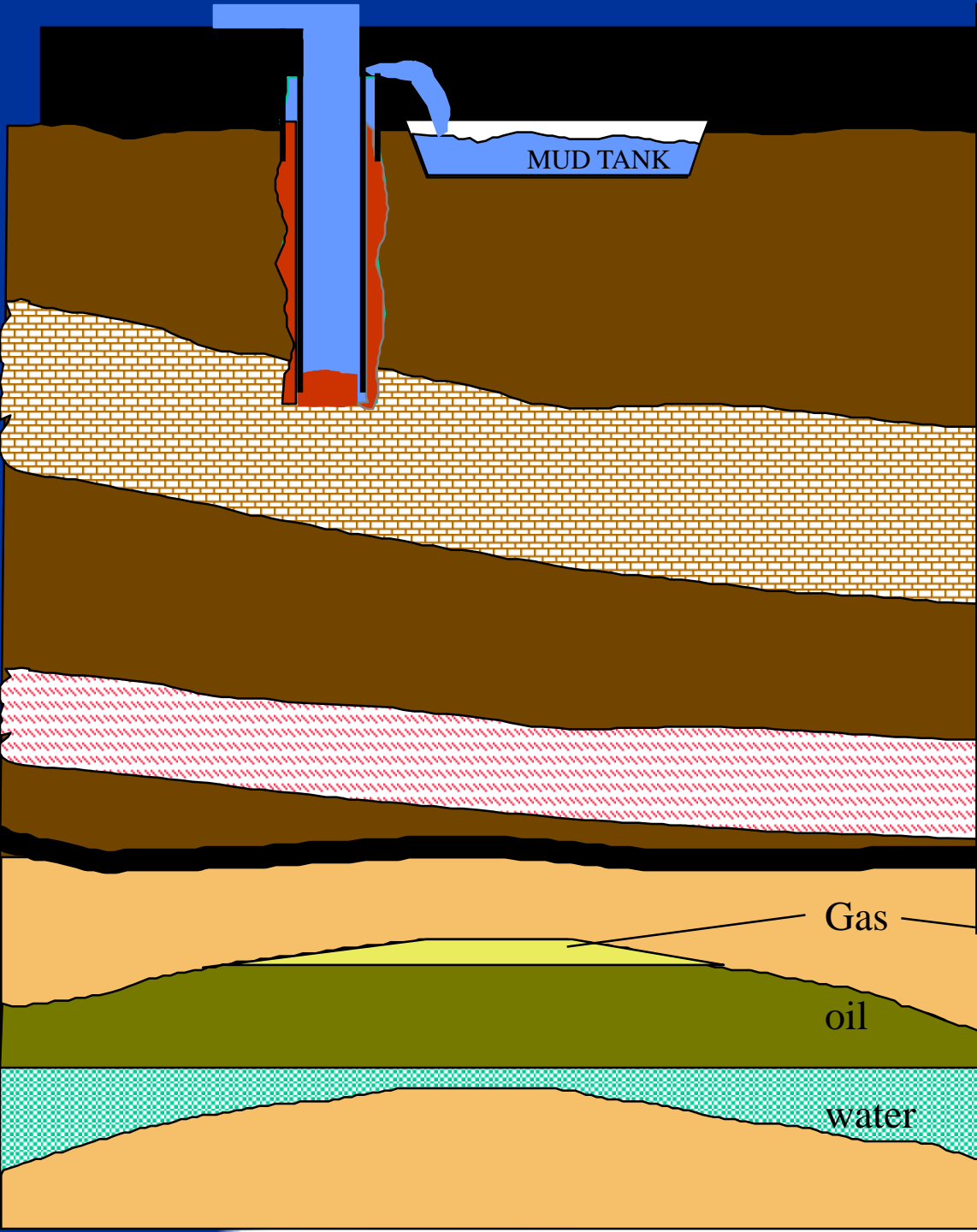
1. Spud in
2. Drill ahead
3. Drill to first casing seat
4. Pull out of hole (trip)
5. Run first casing





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



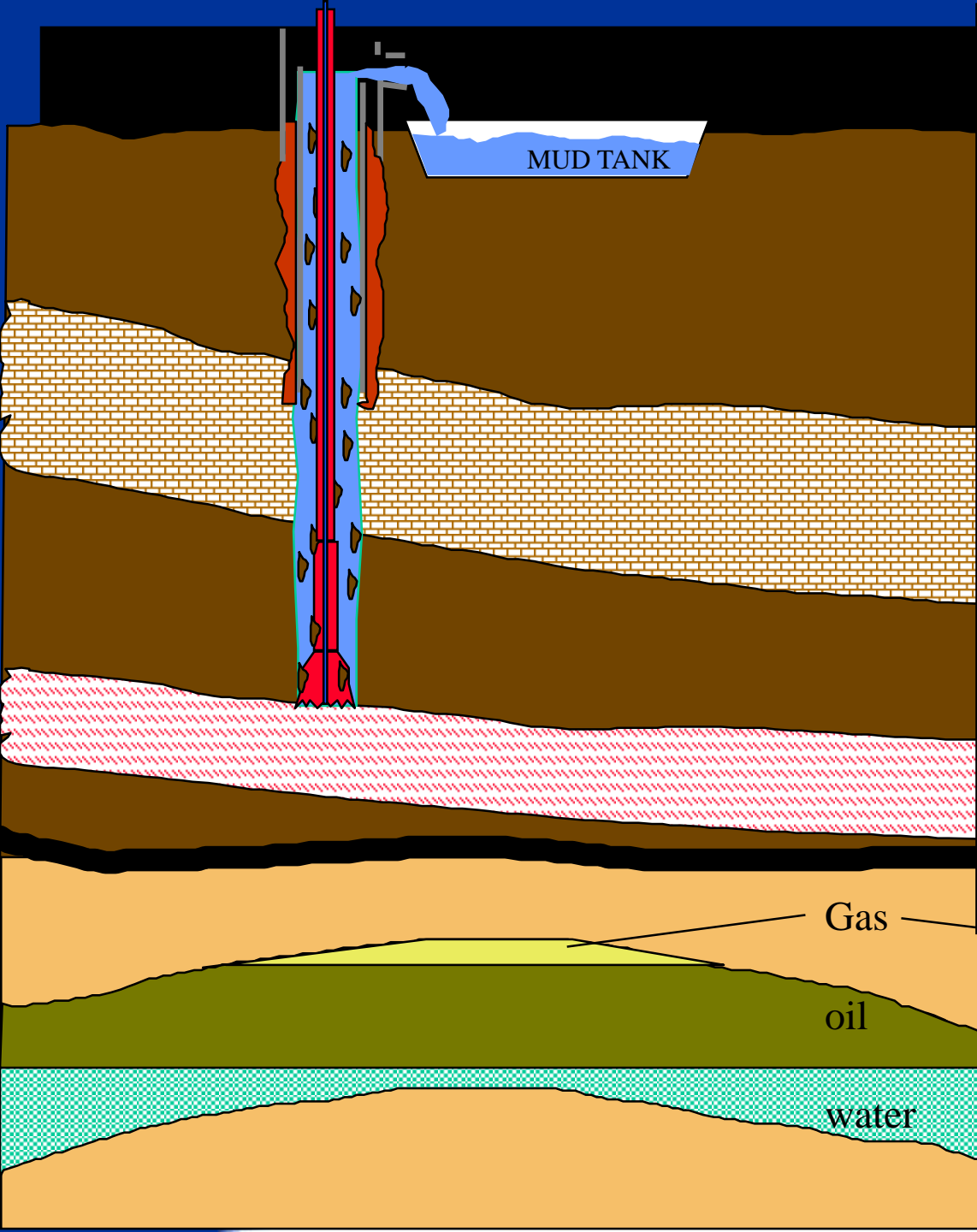
Phases of a well

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

Gas

oil

water

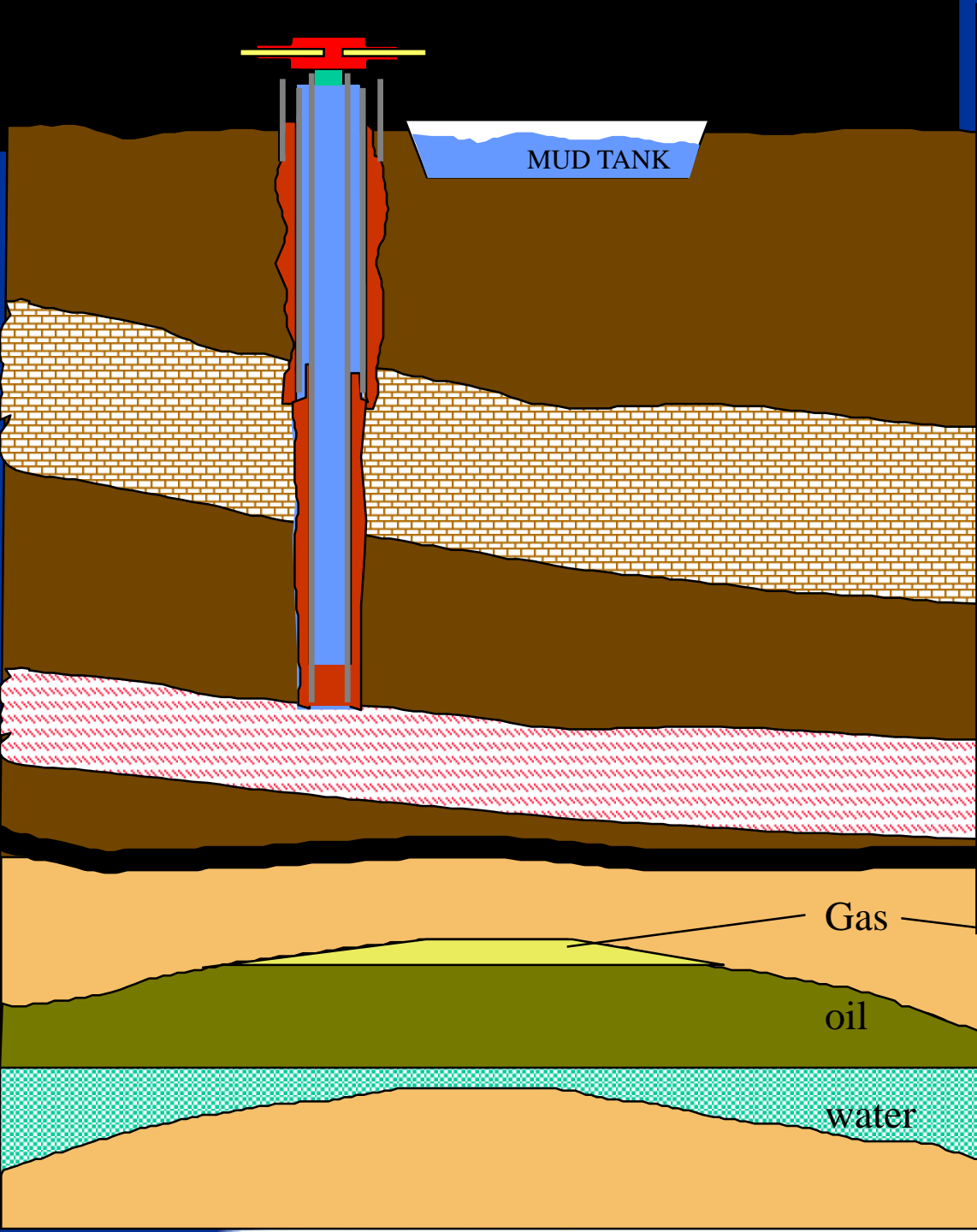


- ### Phases of a well
1. Spud in
 2. Drill ahead
 3. Drill to first casing seat
 4. Pull out of hole (trip)
 5. Run first casing
 6. Pump cement
 7. Displace cement "behind" casing
 8. Drill ahead to 2nd casing seat

Gas

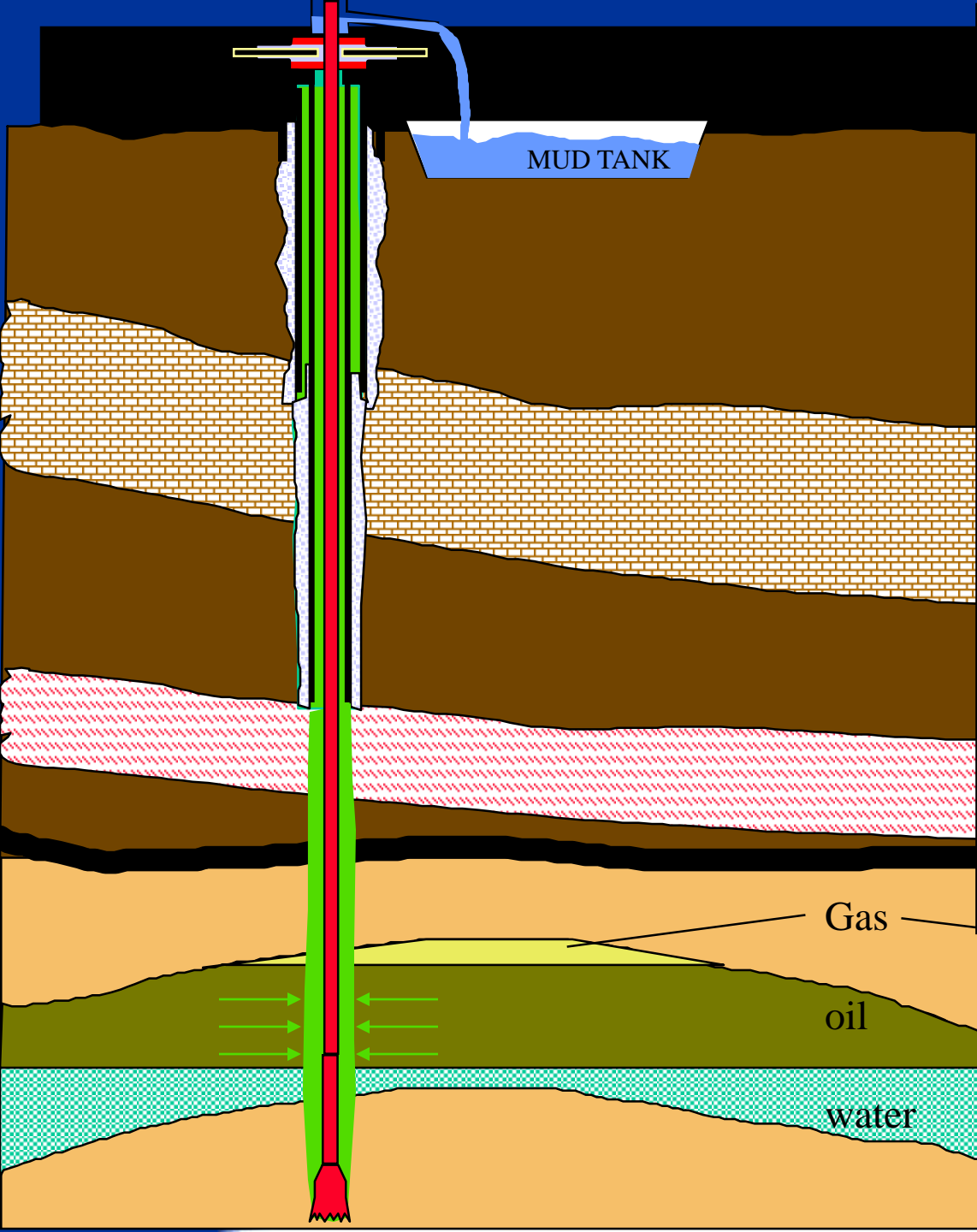
oil

water



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)

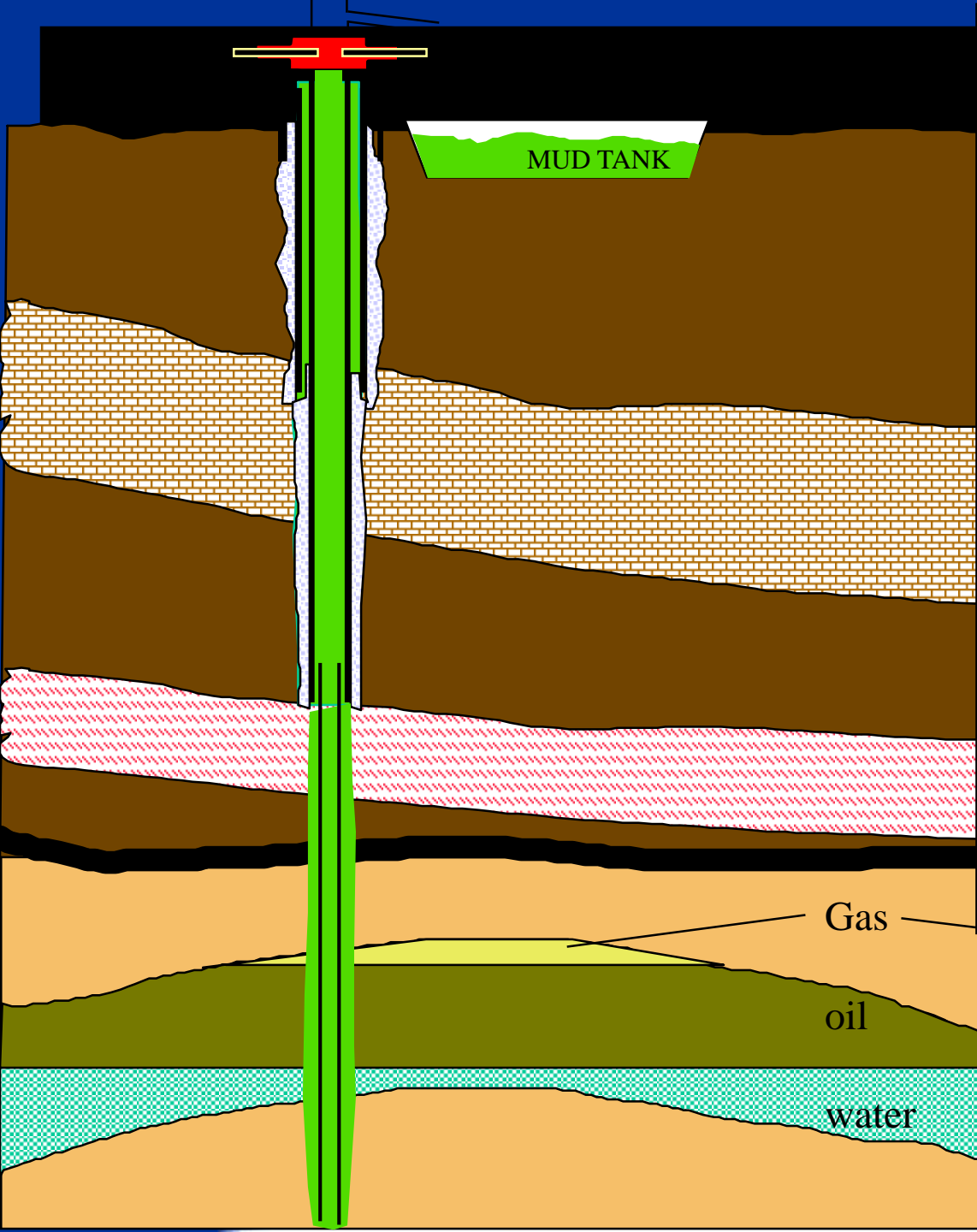


- ### Phases of a well
1. Spud in
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 6. Pump cement
 7. Displace cement "behind" casing
 8. Drill ahead to 2nd casing seat
 9. Run 2nd casing string
 10. Pump and displace cement "behind" casing and install Blow Out Preventer (BOP)
 11. Drill through the reservoir to TOTAL DEPTH (TD)

Gas

oil

water



Phases of a well

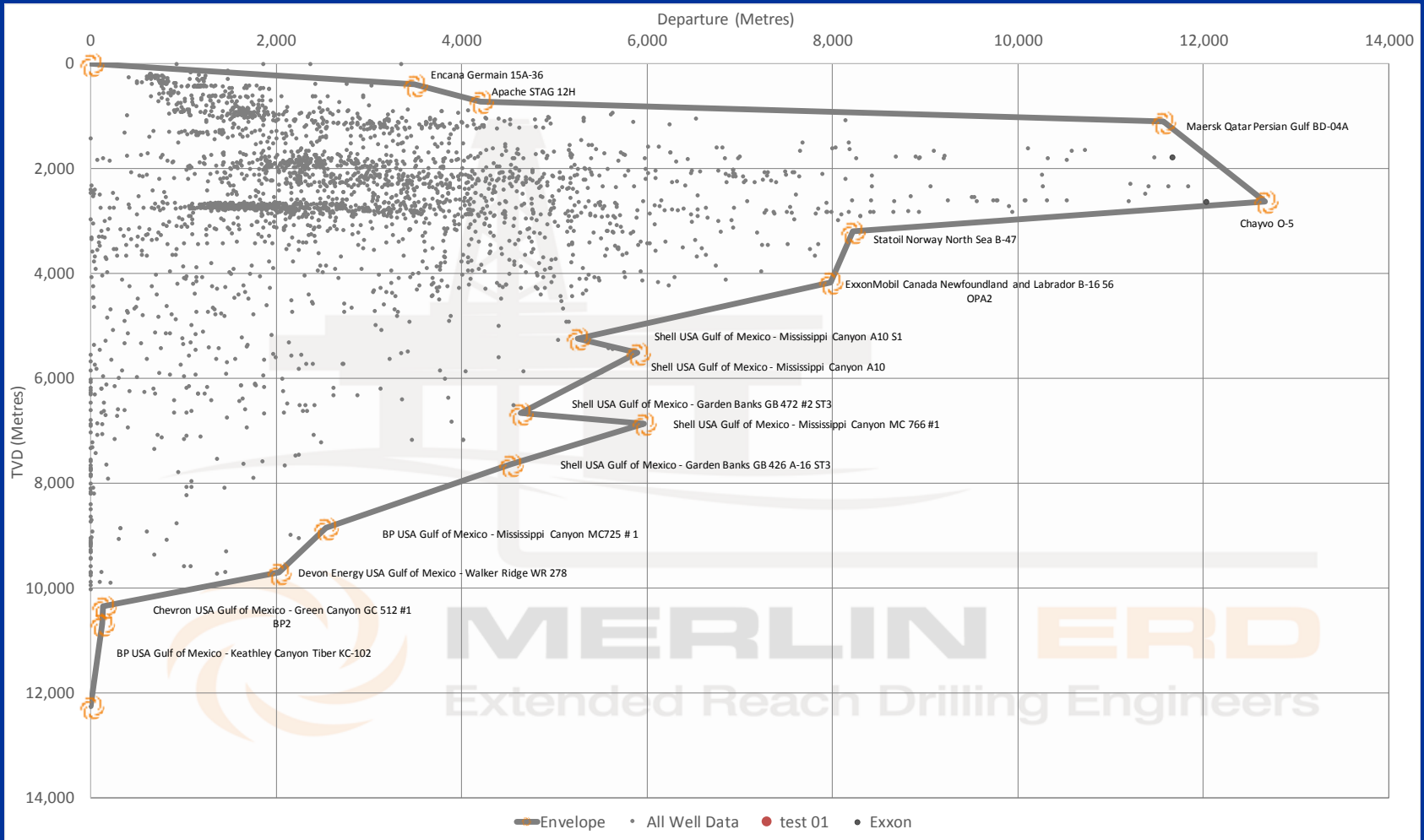
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6. Pump cement
7. Displace cement "behind" casing
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9. Run 2nd casing string
10. Pump and displace cement "behind" casing and install Blow Out Preventer (BOP)
11. Drill to TOTAL DEPTH (TD)
12. POOH, and run electric logs
13. Run Production "liner"
14. Test the well
15. Complete the well
16. Plug and abandon (P&A) the well

Gas

oil

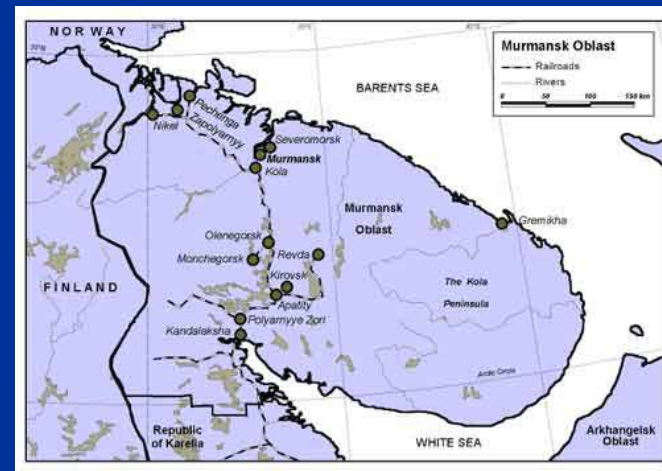
water

Drilling Envelope



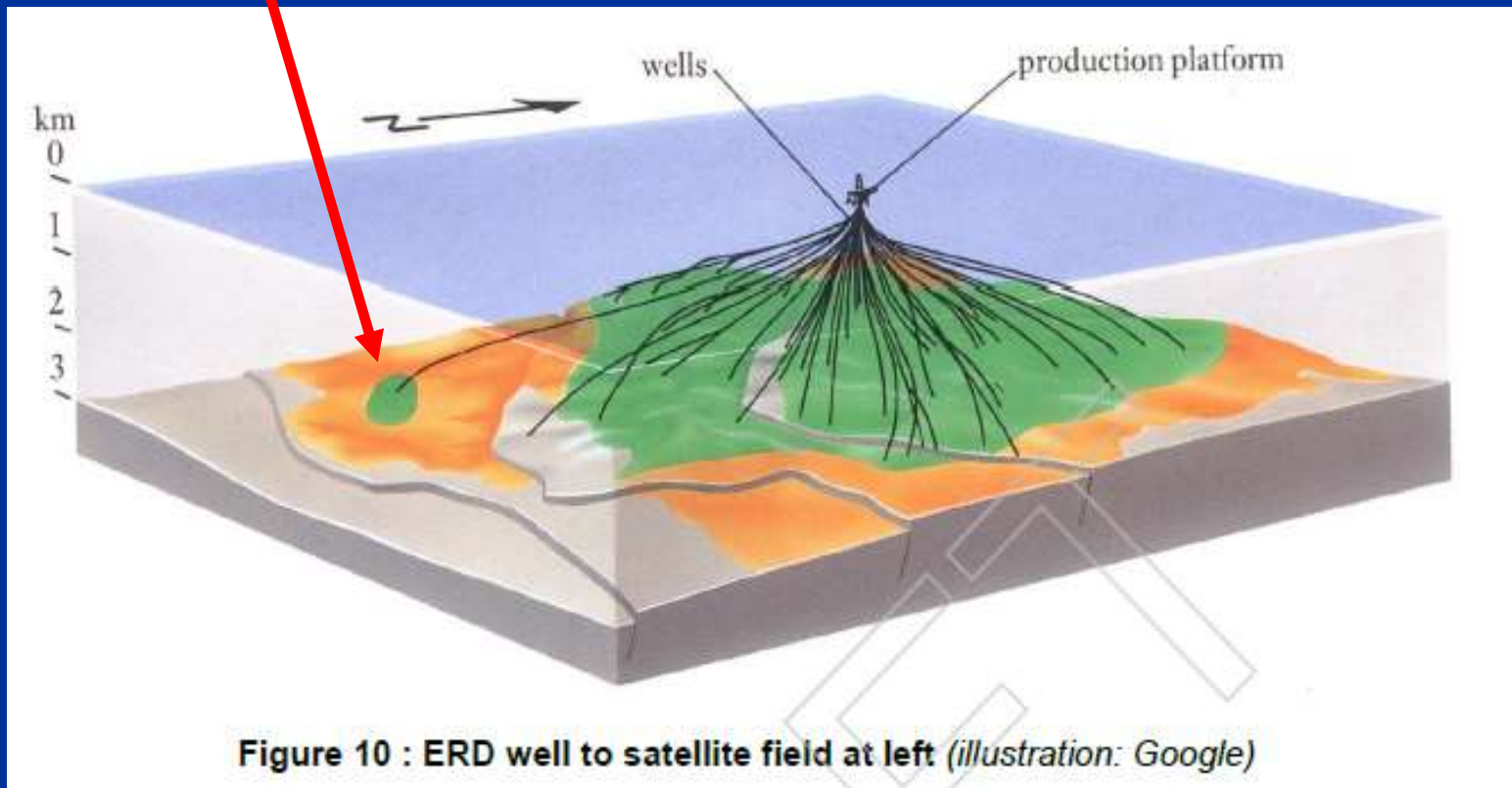
Drilling Today

- Thousands of wells per year
- Well costs \$2 million to \$100's million / well
- Deepest Vertical Well:
 - GNPP Nedra Russia Kola Peninsula SG-3
 - 40,230 ft (12,262m)



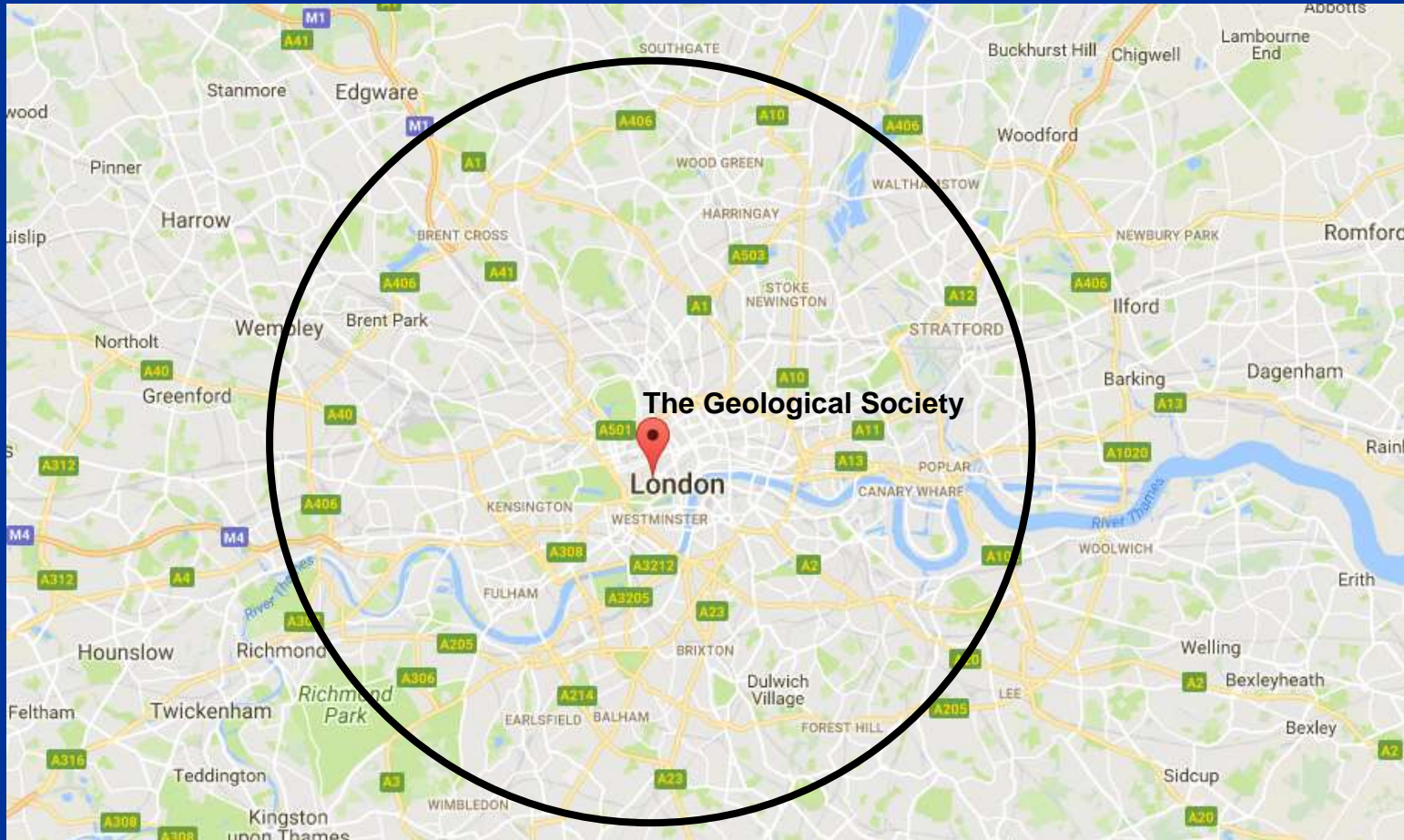
ERD Design

Viable? How to tell / prove it?

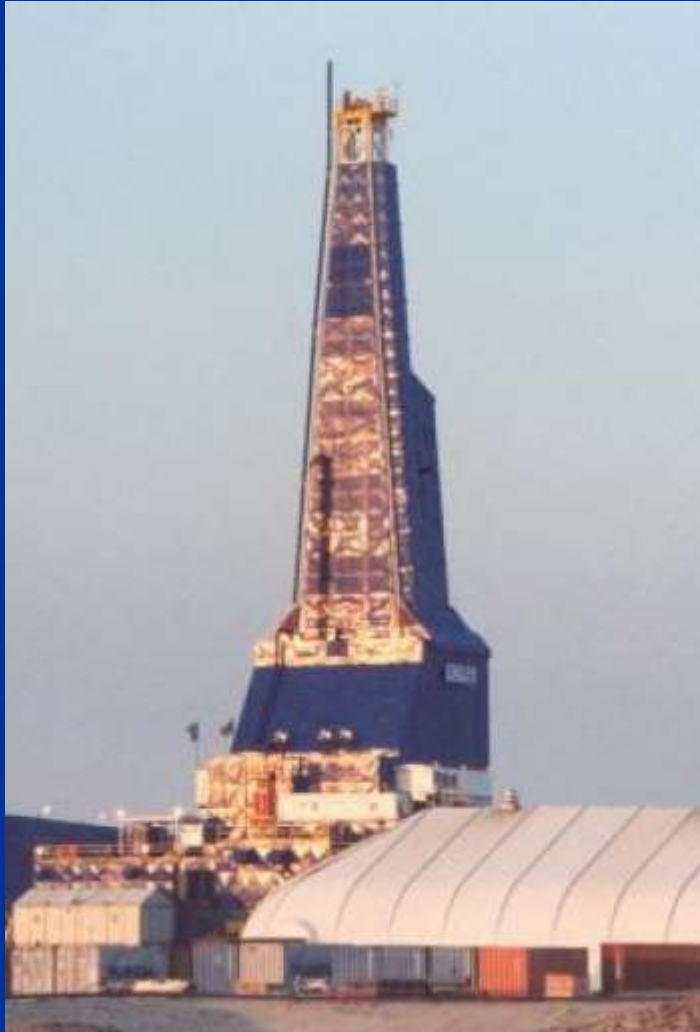


Deepest Well - Departure

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



Drilling Rigs - Land



Drilling Rigs - Offshore



Drilling Rigs - Offshore



Drill String - Bits

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



Gouges



Scrapes



Wears

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



Crushes

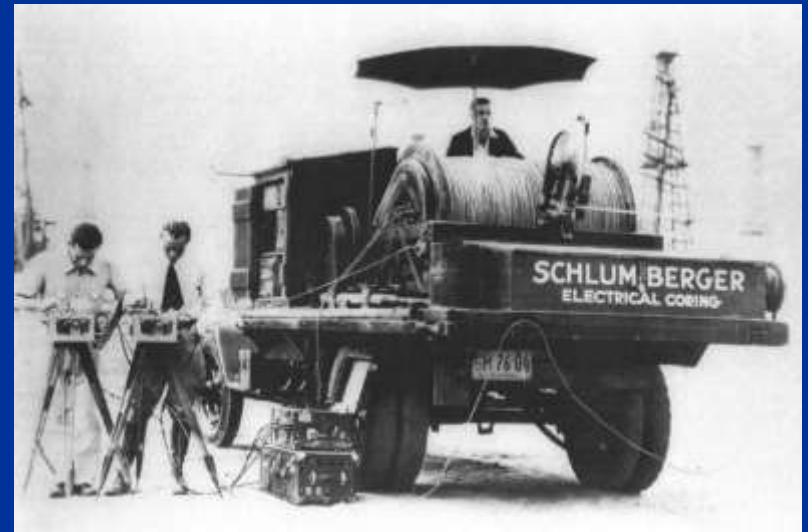
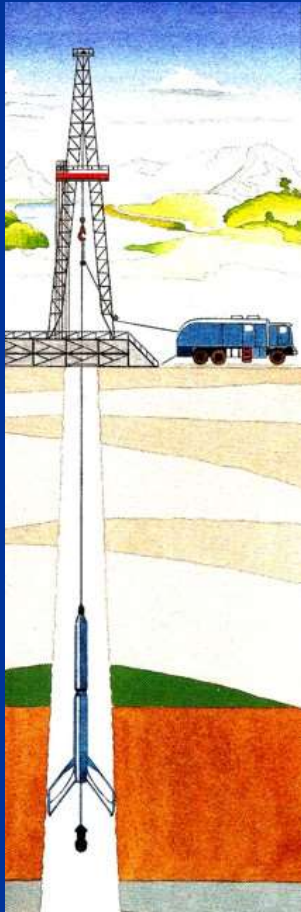
How Do We Know What We're Drilling Through?

- Core – direct samples of the formation

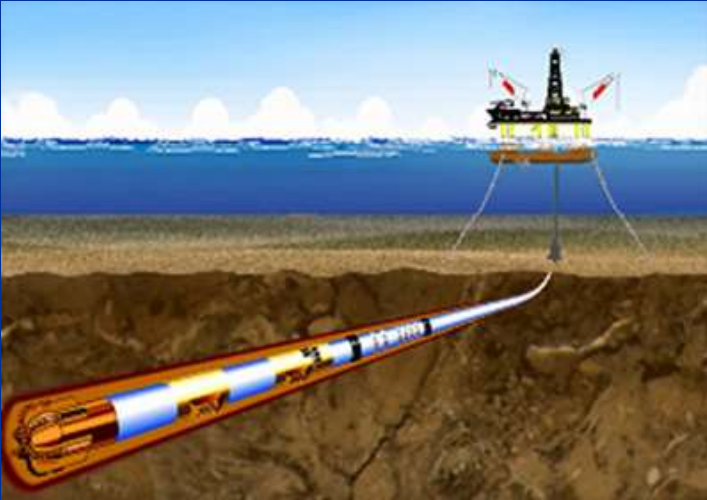


Wireline Logging

- Post drilling operation



Logging While Drilling



- Whilst Drilling Measurements

- Can accurately position well whilst drilling - Geosteering



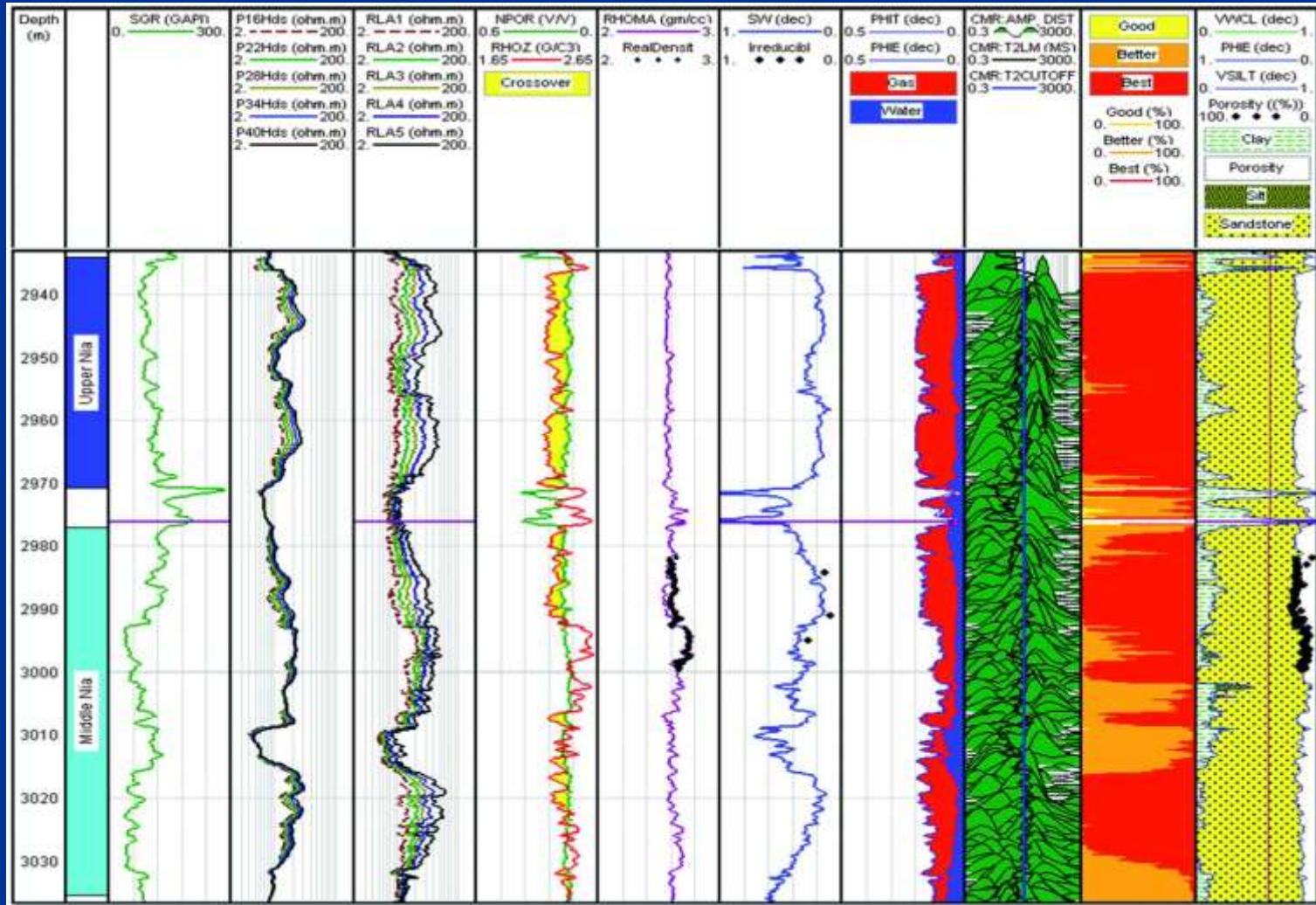
Need to knows

- 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?
 - How will it flow?

“Basic” Logging Measurements

- 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



Questions?





- Feasibility studies, Peer reviews, Problem investigation
- ERD Operational preparedness & Training
- Hole Condition Monitoring - Rig
- Drilling Manuals

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