



Covenant University Town & Gown Seminar Series

Topic:

Directional Drilling & Advanced Formation Evaluation: Keys to Accurate Reserves Booking

Okechukwu E. Ogbazi

Geoscientist Advisor – West Africa
Geoscience & Petroleum Engineering
Baker Hughes, a GE company
T +234 1 2718 454 | M + 234 803 525 1435
<http://www.bhge.com>

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Agenda

- **Introduction – An Overview of Baker Hughes, A GE Company**
- **Directional drilling:**
- **Formation Evaluation Services:**
- **How D & E Services Impact Reserves Booking & Ultimate Recovery:**
- **Summary**

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GE Oil & Gas

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a GE company

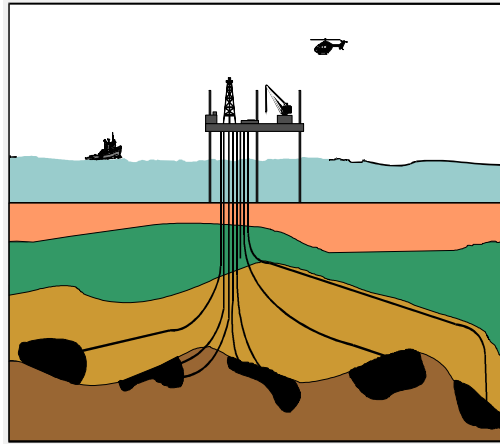


~70,000+ employees

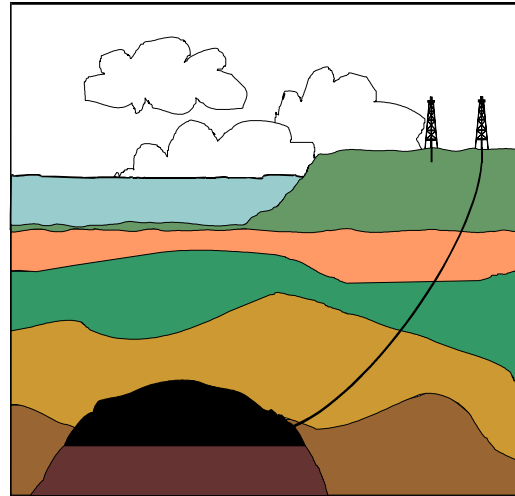
120 countries

The first and only **fullstream** company

Directional Drilling: Major Applications

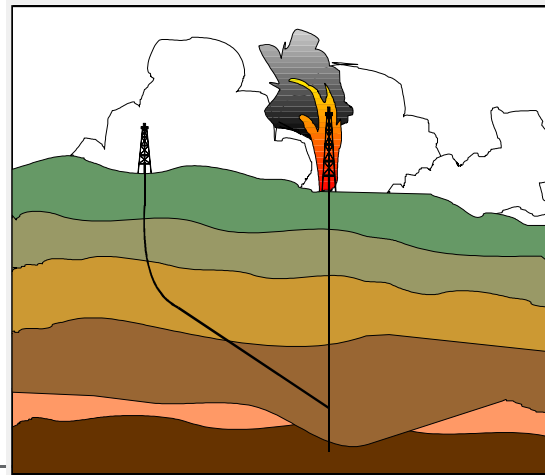


Multiple wells from offshore structures

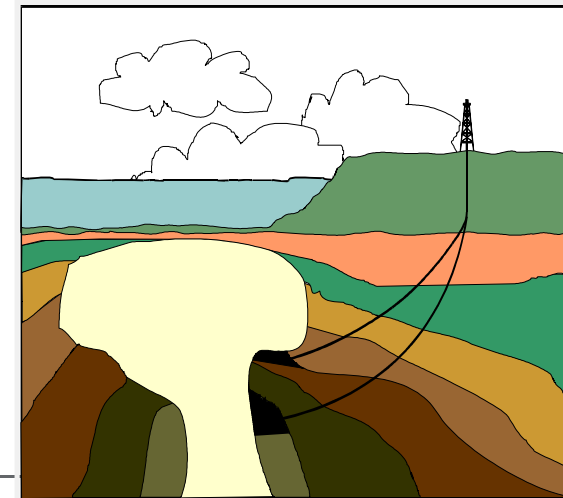


Shoreline reservoir

Salt dome trap reservoir



Relief wells to control blow out wells



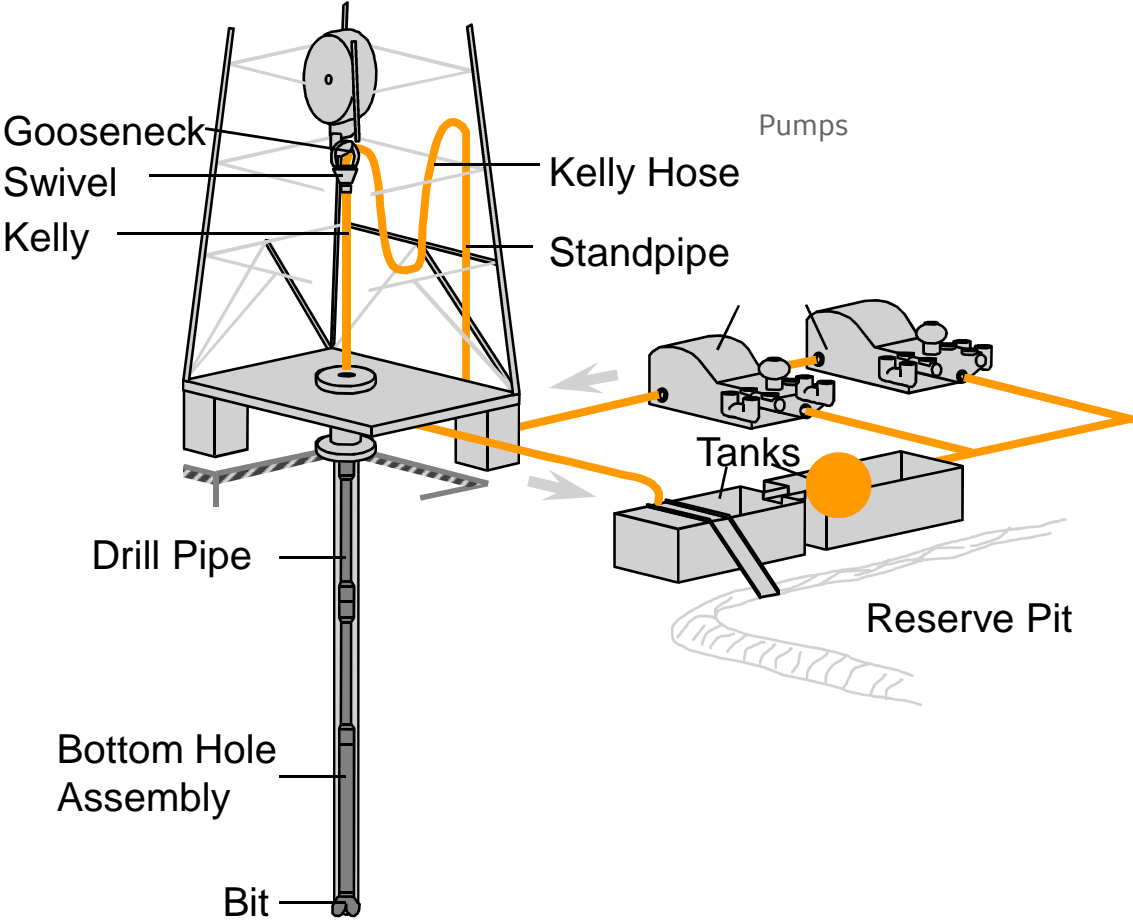
How We Do It – **Directional Drilling**

- The Mud Circulating System

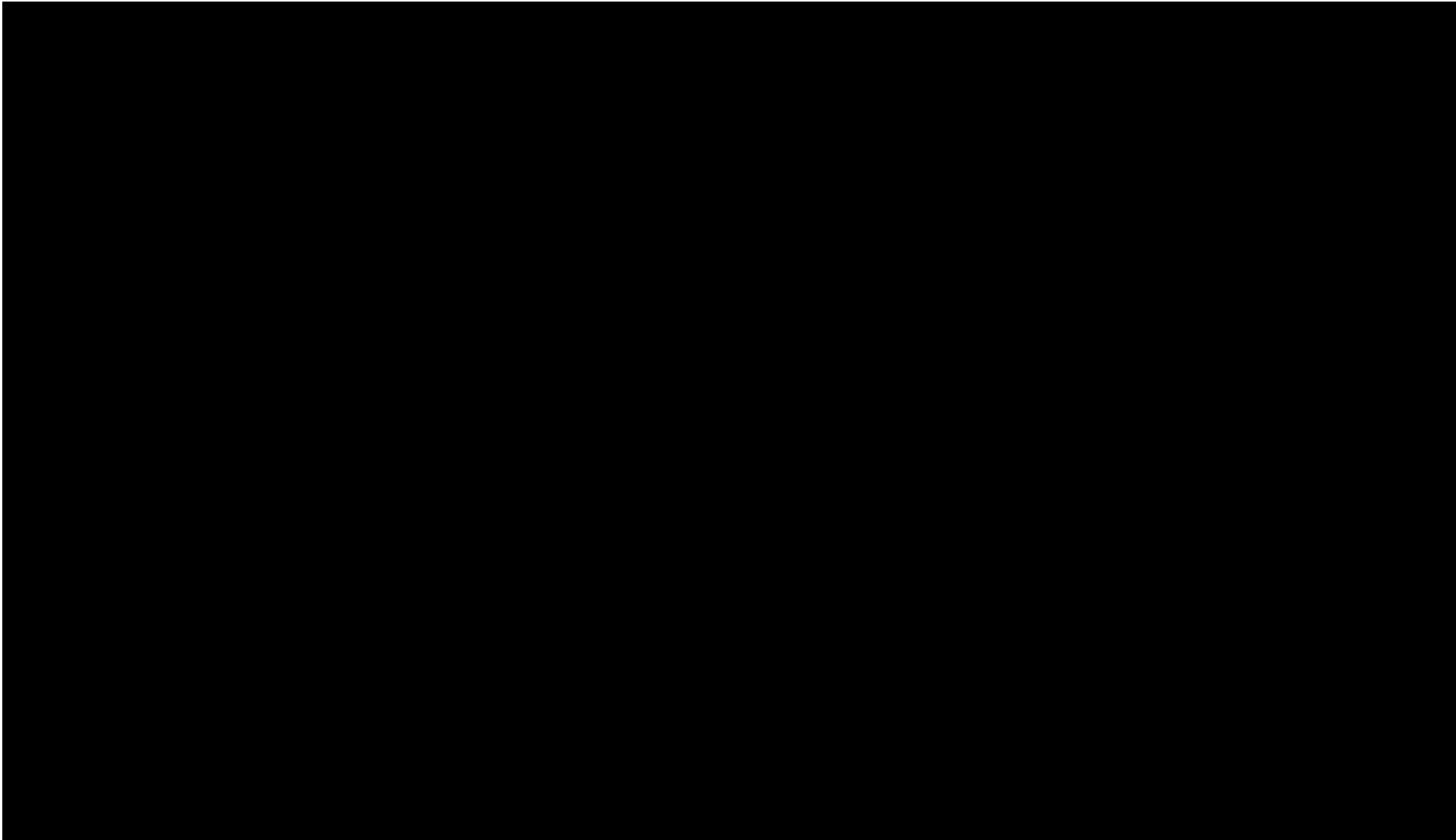
- Directional Drilling Systems
 - Positive Displacement Motors
 - VertiTrak[®] & TruTrak[™]
 - **Rotary Steerable Systems (AutoTrak[®])**
 - AutoTrak[®] X-treme

- Wellbore Surveying
 - Survey Measurements
 - Measurement While Drilling - OnTrak[®]
 - Telemetry Services – aXcelerateSM

Drilling: The Mud Circulation System

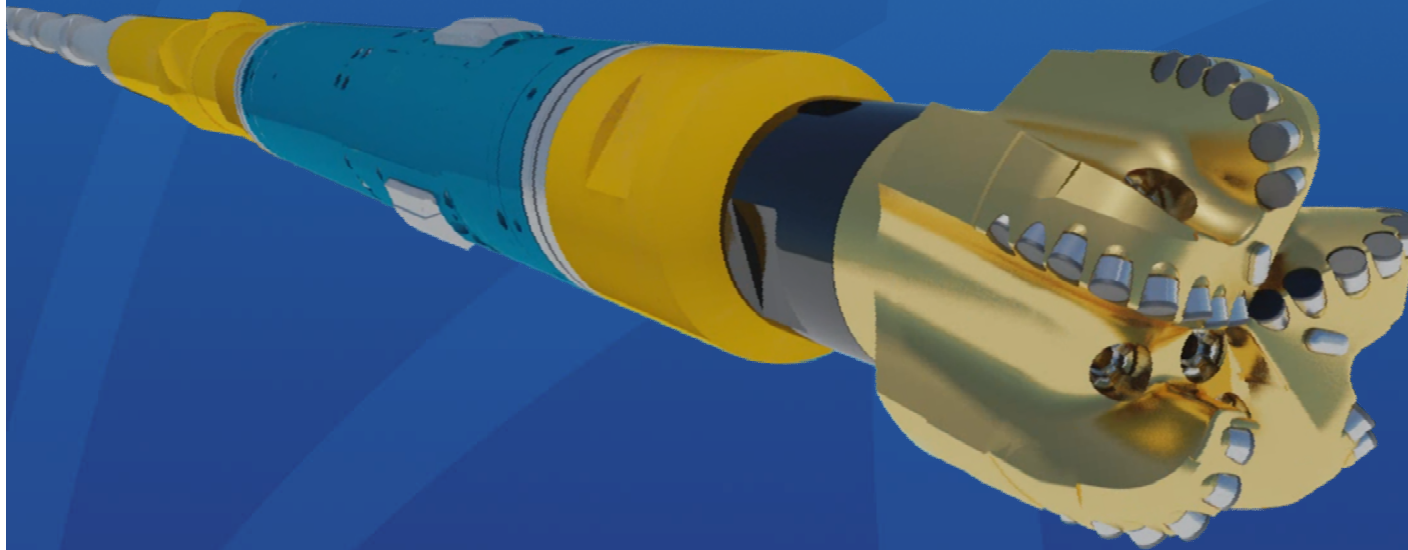


The AutoTrak Curve



AutoTrak™ Curve Rotary Steerable System

Smooth, Fast Runs to Reduce Time on Well in Unconventional Plays

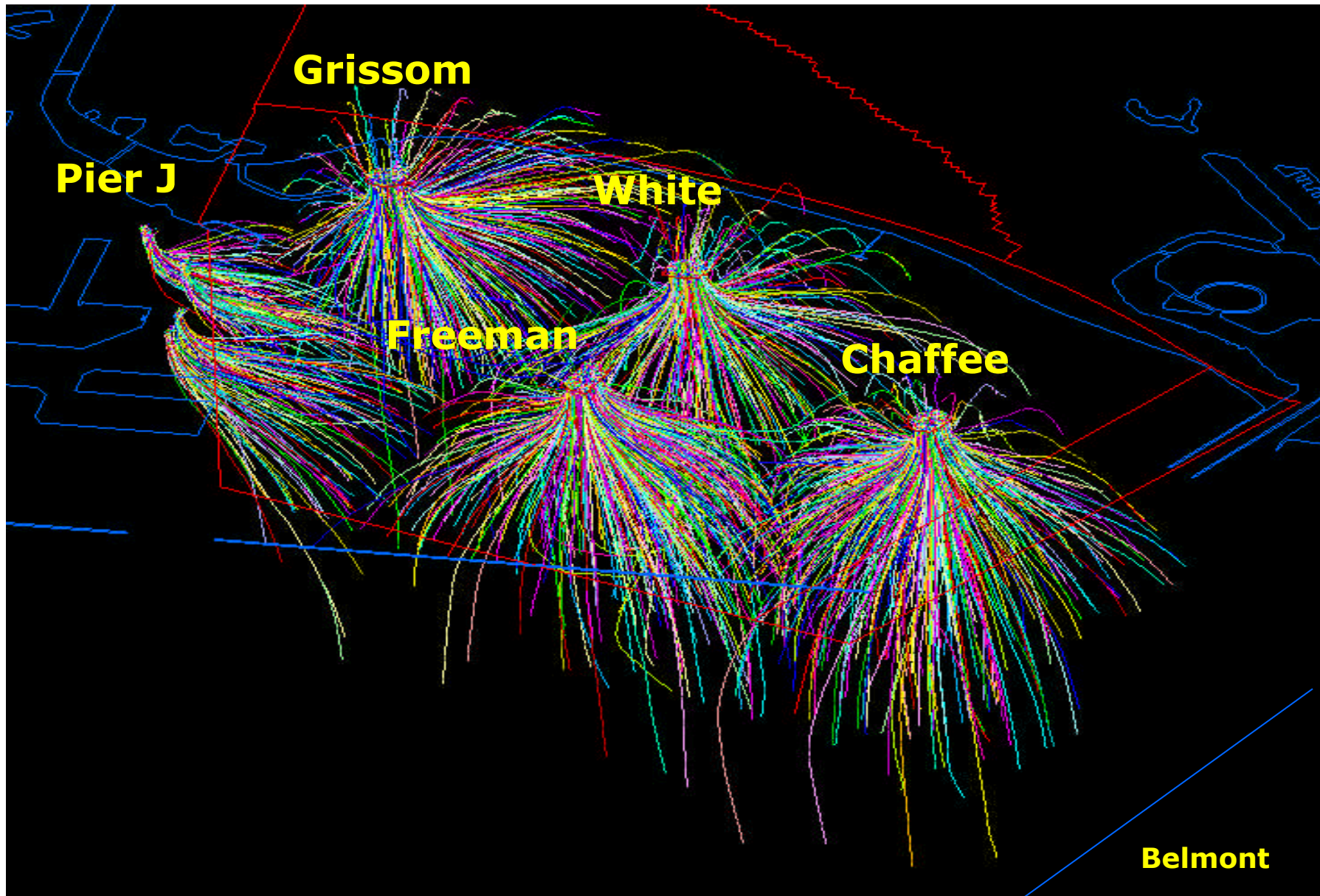


What We Do - Directional Drilling



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What We Do - Directional Drilling



What do we want to Know? - Why are we here?



Baker Atlas

Efficiency...Data accuracy...People-oriented service

- Can we make any Money?
- Is there any oil/gas down there?
 - Where is it? (Depth/location)
 - How much of it?
 - Can we get it out Economically?

Reservoir volumes

- The storage volume of a reservoir is defined as:-
7758 x Area in acres x thickness in ft x porosity = bbls (liquid)
43560 x Area in acres x thickness in ft x porosity = cu ft (gas)
(1 acre = 4047 m², 1 bbl = 159 litres)
- Multiply this by (1-S_w) for the hydrocarbon volume OIP/GIP
- This is usually converted to surface (Stock Tank) conditions using reservoir expansion factors B_o and B_g
STOOIP (Stock tank Oil Originally In Place) = OIP/B_g

The value of data - Volumes

- A reservoir of 1 square mile (640 acres), that has an oil column 200ft thick, has a porosity of 20%, a Sw of 10% and a B_o of 1.5 contains:

$$7758 \times 640 \times 200 \times .2 \times (1-0.1) / 1.5 = 120 \text{ million bbls}$$
$$= \$6 \text{ billion } (@\$50/\text{bbl})$$

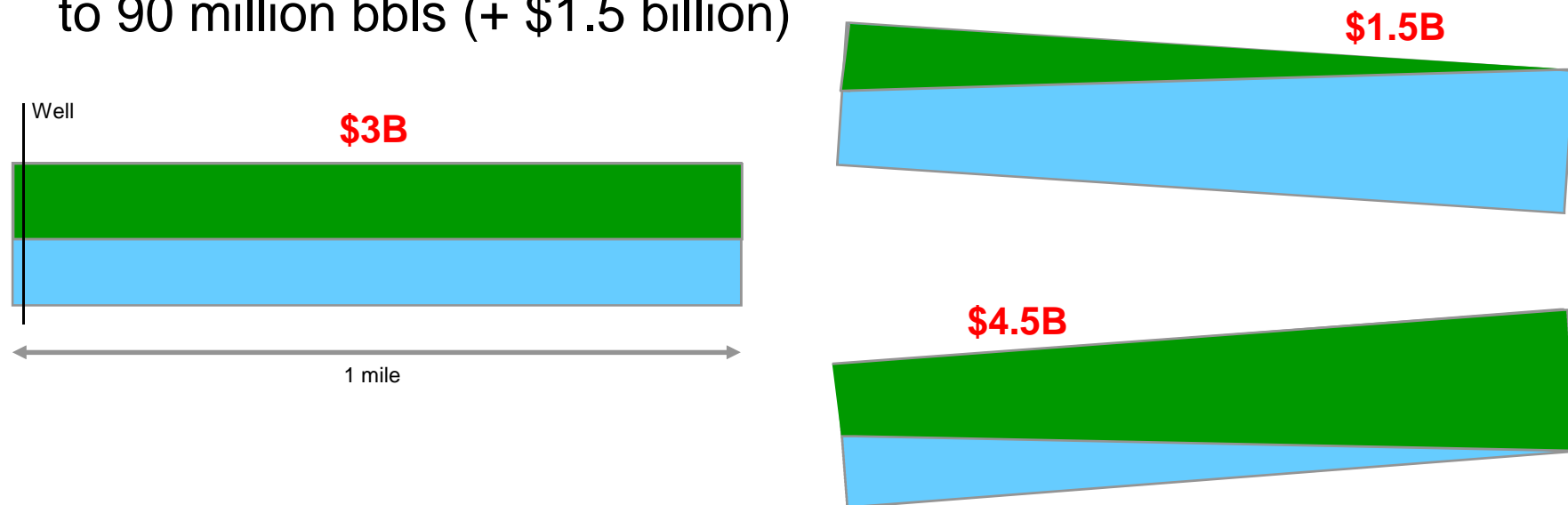
- An error of 1ft in depth/thickness is worth +/- \$30 million
- An error of 1pu porosity is worth +/- \$300 million
- An error of 1pu Sw is worth +/- \$67 million

The value of data - Structure

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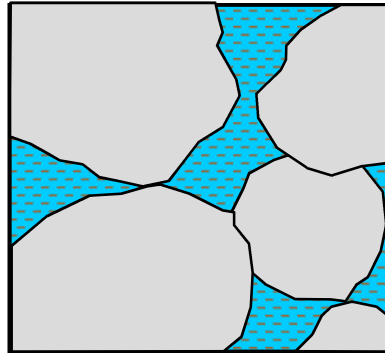
Efficiency...Data accuracy...People-oriented service

- If an exploration well was drilled at one end and encountered a 100ft thick oil column, and a 100ft thick water leg:
 - If the reservoir tilts down 1 degree then the oil volume is reduced from 60 million bbls to 30 million (- \$1.5 billion)
 - If the reservoir tilts up 1 degree then the oil volume is increased to 90 million bbls (+ \$1.5 billion)

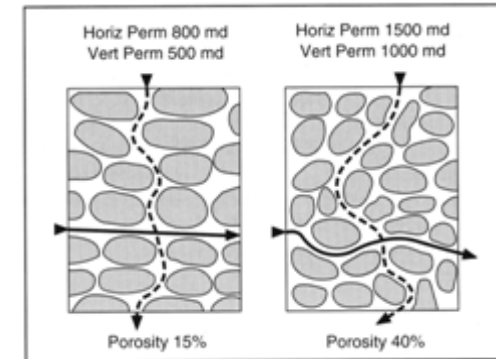


What Do We Do? – Formation Evaluation

Porosity (Φ)

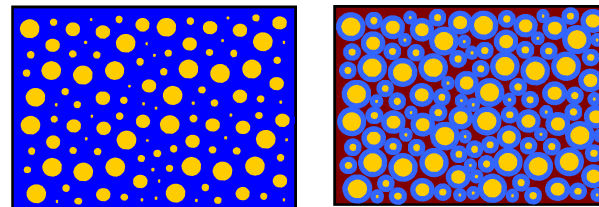


Permeability (k)

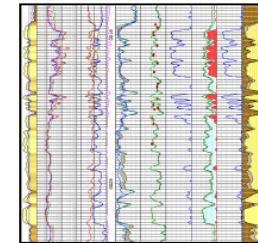


Saturation (S_w, S_h)

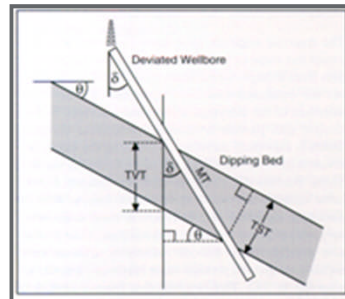
Water Sand Hydrocarbon Sand



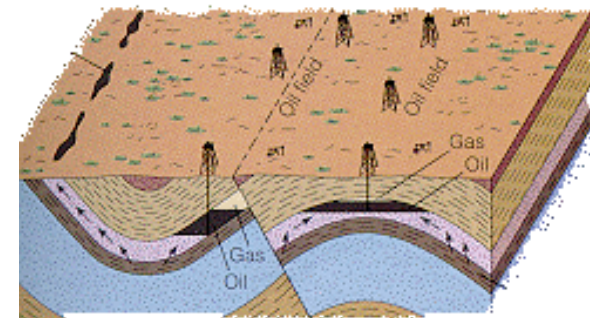
Rock Type and Fabric



Thickness



Geometry



Drainage Potential = $fn(\Phi, k, h, A, S_h, \text{compartmentalization, fluid properties, etc.})$

Be Aware That

No logging device measures porosity, saturation, permeability, or fluid type directly. Logs do not identify color of rock or define the texture of rock.

Nevertheless,

Some logging devices respond to properties that are related to porosity, saturation, permeability, or fluid type.

Combinations of different log measurements often define the above --- plus lithology!

What do the tools measure?



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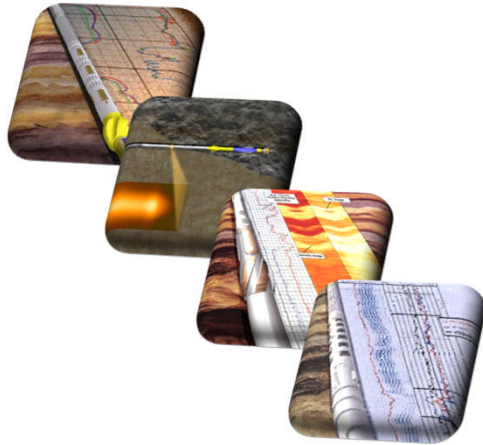
Efficiency...Data accuracy...People-oriented service

- Tool Measurements
 - Density
 - Resistivity
 - Gamma Ray
- Detector Physics
 - Voltage
 - Count rates

etc

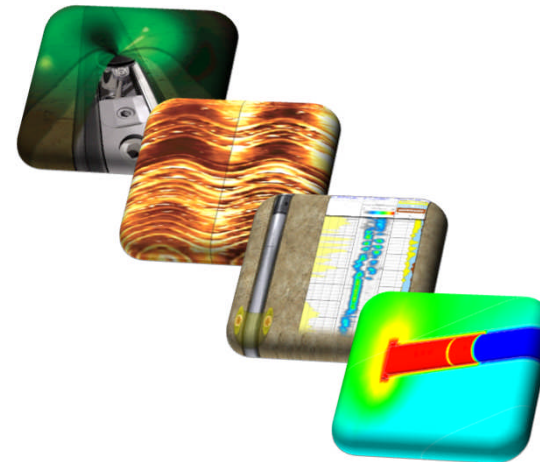
etc

BHGE Formation Evaluation Portfolio



- **OnTrak™** – Directional, Resistivity, Gamma Ray, Borehole Imaging, Annular Pressure, & Dynamics
- **AziTrak™** – Deep Azimuthal Resistivity
- **LithoTrak™** – Bulk Density, Porosity, Caliper, Borehole Imaging & Pe
- **SoundTrak™** – Advanced Acoustic Logging

- **TesTrak™** – Formation Pressure Testing
- **FasTrak™** – Formation Fluid Analysis and Sampling
- **StarTrak™** – High Definition Electrical Imaging
- **MagTrak™** – Magnetic Resonance
- **ZoneTrak™** – Resistivity at Bit



The information sequence

- Can we make any Money?



Questions



Corporate Finance

- Is there any oil/Gas down there?



Interpretation

- Formation parameters



Log analysis

- Tool Measurements



Calibration

- Detector Physics

Summery

Directional Drilling & Accurate Formation Evaluation

- Provides the necessary evidence to support answers to “**can we make money**” question
- Essential for our customer’s **reserves booking and financial statements**
- And **ultimate recovery of their reservoir assets**



QUESTIONS?

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