Drilling: Geological Issues

- Drilling Process and Components
- Rotary system
- Mud system
- Well side geology
- Well completion - Casing & Cement
- Well coring, side wall cores
- Off shore drilling
- Horizontal drilling
- Frac’ing
- Deepwater Horizon disaster

Rotary Drilling

- Derrick
- Engines
- Hoist system
- Rotating system
- Mud system

Rotary System

- Bit on end of rotating drill pipe
- 30-foot pieces ("joints")
- Handled in 30-90-foot increments ("stands")
- Rotation at Surface to Rotate Bit Downhole
Drill pipe

Down hole hammer bit
- Percussion drilling

Drilling Rates

- Sandstones are fast
- Limestone/dolomite can be slow
- Shales are slow
- Can be used to identify formation tops

Drilling Mud System

- Drilling Mud
- Purpose/Role
  - Maintain sufficient bottom-hole pressure
  - Flush cuttings from beneath bit and upward out of hole
  - Cool bit (and drill string)

Well Cuttings

- Bentonite (clay) 9-10 lb/gal
- Barite (BaSO₄) 15-20 lb/gal
- Water based mud
- Oil based mud- used to avoid problems with swelling clays (montmorillonite)
Issue: Mud Damage to Reservoir

3061.50 m

UV fluorescence

Mud invasion on fractures?
Fractures drilling-induced or natural?

Drilling Mud-Environmental Issues

Unlined Mud Pit

Pit with oil in it
Flags to keep migratory birds off

Blow out Preventers

Boiled to top of well on seafloor

500,000 lb
(225,000 kg)
Depends on what pleases are included

60 ft
(18.2 m)

Casing and Cement

Well completion
Key decision during exploration

Conductor pipe
Surface casing
Intermediate casing
Production casing
Perforated interval

Isolating an overpressure zone

SURFACE CASING

Figure 10-6: A new method of drilling casing using all the heavy mud and then using a low mud system to get checks with light mud.

Deepwater Horizon BOP

New York Times
Types of offshore oil and gas structures

1,2) Conventional fixed platforms (1,353 ft); 3) compliant tower (1,754 ft GOM); 4,5) Vertically moored tension leg platform (4,674 ft); 6) Spar (5,610 ft); 7,8) Semi-submersibles (6,300 ft); 9) Floating production, storage, and offloading facility (4,429 ft); 10) Sub-sea completion and tie-back to host facility (7,570 ft) (2005 depth records) NOAA image

How Vertical are “Vertical Wells”?

Top View

Side Views

World record (2011) 11 km horizontal reach

PowerPak - steerable PDM (Schlumberger)
**Horizontal Well Layout**

Top View

Side View

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**Logging-while Drilling tools**

- Directional data (inclination, azimuth, tool-face)
- Formation characteristics (gamma-ray, resistivity logs, etc)
- Drilling parameters (down-hole WOB, torque, rpm)

**Geometry of Geosteering pt 1**

Vertical Log  Tie Point  USD  Well Path

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**Geosteering**

Well trajectory

Marcellus (green)

Gamma Ray Log

**Frac’ing a Well**

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**Perforating a well – Shaped charges**

Concrete target

Baumann et al. 2014
Frac Parameters

Pressure

Slurry Rate

Time (hours)

Seismic Events

Hydraulic fracturing in a wellbore

$S_h$ is maximum horizontal stress

$S_p$ is minimum horizontal stress

Zoback, 2010

FRACTURE SURFACE IN PLEXIGLAS WITH FRACTURE PROPAGATION TEXTURES (POLLARD AND FLETCHER, 2005)

Microseismic Monitoring of Frac Job

Recorded during fracture stimulation of the Holmberg 44-2H4

EXELENT "Frac separation" evidenced by multiple gaps of confined rock along the wellbore with some overlapping, which impacts the sandrock volume.

"Thai" developed QB trending natural fractures indicated in some locations.

Lateral frac wings emerge 70° on either side of the wellbore. This is consistent with our offshore sand channel searing pattern for full field development.

DeepWater Horizon Spill

Read: Accident Report on Ecampus