Heavy Oil: Developments, Challenges, Opportunities & Technologies

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Outline

■ Heavy Oil  What is it
■ Heavy Oil in Canada
■ Value Chain  -  Integrated Approach  -  Environmental
■ Schlumberger’s Solutions for Heavy Oil
■ Conclusions
What is Heavy Oil?

* Bubble size indicates production rates
Source: Oil and Gas Journal/Apr. 17, 2006, Canada NEB, SBC Team Analysis
Heavy Oil Resources in The Americas
Variance in Rock Type, H.O. Reservoir Properties & Temperature

Porosity (pu)

- Indonesia Unconsolidated Sand
- North Sea Unconsolidated Sand/Sandstone
- USA Unconsolidated Sand/Sandstone
- Canada Unconsolidated Sand/Sandstone
- Venezuela Sandstone
- China Sandstone/Dolomites
- Kuwait Fractured Carbonate
- Mexico Fractured Vuggy Dolomite

Res. Temperature (°C)

- Indonesia Unconsolidated Sand
- North Sea Unconsolidated Sand/Sandstone
- USA Unconsolidated Sand/Sandstone
- Canada Unconsolidated Sand/Sandstone
- Venezuela Sandstone
- China Sandstone/Dolomites
- Kuwait Fractured Carbonate
- Mexico Fractured Vuggy Dolomite

Permeability (Darcy)

- Indonesia Unconsolidated Sand
- North Sea Unconsolidated Sand/Sandstone
- USA Unconsolidated Sand/Sandstone
- Canada Unconsolidated Sand/Sandstone
- Venezuela Sandstone
- China Sandstone/Dolomites
- Kuwait Fractured Carbonate
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Geology
Heterogeneity
Diagenesis
Canadian Heavy Oil Segmentation

**Thermal Recovery Methods:**
- Gravity <15° API & Viscosity >25,000 cp
- SAGD, CSS, Steam floods

**Non Thermal Recovery Methods:**
- Gravity of 14° –22° API, Viscosity 10 to 25,000 cp
- Cold primary, CHOPS, Waterflood

**Annual Investments:**
Grew from 4 Billion in 2000 to almost 20 Billion in 2008

**Total Well Count:**
Grew from 25,000 to almost 40,000 in the same period

**Mining:**
- Oil sands <10 API & Viscosity > 1 million cp
Canadian Heavy Oil Regions

**Prize!**
2.2 – 2.5 Trillion bbls

Current technology \(\sim 200\) Billion Recoverable bbls
Heavy Oil Value Chain – Technologies to Optimize Asset Value

- Data Acquisition & Analysis
- Evaluation, Selection & Pilot Design
- Pilot & Full Field Development Design
- Construction (wells, surface facilities, pipelines & Upgrader)
- Operations - Control and Optimization

Smart Fast Pilots – Fully instrumented

Reservoir Evaluation, Target Selection based on Technical and Economic Evaluation – Pilots Designs

Monitoring/History Matching/Optimizing Risk Mitigation

Flow assurance, Diluent placement, Multiphase pumping?
Reduce Environmental Footprint

The **environment**: Central importance

- New techniques required:
  - To use less net water
  - To produce less waste water
  - To improve energy yield
  - To reduce local (wellsite) footprint

- Reduce GHG
  - CCS technology continues to improve:
    - Storage reservoir characterization and simulation technology
    - Improve special cements—preserve CO₂ injection well integrity
    - Improve technologies to monitor CO₂ in reservoir and on surface
    - Capture technology needs to become routine
Proof that the Planet is warming-up
Making the Unconventional, Conventional
Geology and Fluids are the Foundation

Seismic Structure Stratigraphy Petrophysics Sedimentology Facies Recognition Environments of Deposition Fluid Migration - Recharges Biodegradation – Fresh water circulation

Gather Data – Early is more valuable High Quality Seismic Complete suites of Logs: Dielectric Scanner, NMR Scanner & ECS Cores Cap Rock Strength & Thickness Inter-bedded Shale integrity w/Steam Stratigraphic & Cased observation wells Bottom-hole Fluid Samples

INDISPENSABLE PREAMBLE for MEANINGFUL OPTIMIZED DEVELOPMENT!
Viscosity Mapping

• Viscosity changes with Depth & areally within same reservoir

• Viscosity influences:
  ▪ Recovery technique selection
  ▪ Well Spacing & Length
  ▪ Water breakthrough
  ▪ Recovery Factor

• Fluid sampling is required
Steam Injection Pressure is an added challenge

At higher Injection Pressures
Less Energy in the Steam
Less Efficiency in the Process
Schlumberger Solutions for Heavy Oil

- 2005 Created a Heavy Oil Theme
- 2011: Invested > $2.5 MM/day in R&E
HEAVY OIL THEME
STARTED 2005

Drilling and Measurements
- Artificial Lift
- Completions
- Measurements
- Software

Data and Consulting
- Characterization
- Field Development
- Optimization
- Geomechanics

R & D
- Simulation
- Well Placement
- Production
- Monitor & Management

Well Services
- Wireline
- Stethoscope
- Powerdrive
- Multilaterales

Wireline
- FlexStone HT Cement [250 °C] & CO₂ resistant
- MDT
- ADT / Dielectric Scanner
- NMR

Software
- Pipesim
- Eclipse Thermal
- Petrel
- Visage

Artificial Lift
- Completions
- Wells test

Hotline 550 ESPs
- Sand Control
- MeshRite
- Sensa-Fiber Optics
- Vx Multiphase Meters
- Sampling
Heavy Oil Network

Calgary
Edmonton
Boston
Houston
Puerto la Cruz

3 Research Centers
3 Manufacturing Centers
4 Technology Centers
Improve Well Productivity: Controlling sand production & reducing Skin Damage

Traditional completion with slotted liners

MeshRite

Schlumberger
Enhanced Productivity by increasing area open to flow

High Open Flow Area is Important for Viscous Oil (or high flow rates)

Finite Element Analysis: Pressure Drop vs %OFA

Field Tests on Venezuelan Heavy Oil (Cold Production)

MeshRite SC (40% OFA)

Slotted Liner (4 % OFA)
Fishbone type well: Only Main Branch “supported”

STARS Screen Technology for Sand and Flow Control [ICD’s] along the entire well length
Dielectric Scanner

Tool measuring dielectric formation properties

- In use in Venezuela since Jan.2008
- Quantifies $Sw$ independently of its Salinity
- Determines Water Salinity
- Precise information on Crude Mobility
- High Vertical Resolution: 1”
- Depth of investigation: 1” to 4”
- Ideal for reservoirs with $< 20,000$ ppm [90%]
Producción Monitoring

Temperature Distributed Sensors - Fiber Optics [DTS]

Multiphase Flow Meters [MPFM]

- Measure up to 4-phases [O, W, G + D]
- Measures Gas Production even if it is trapped as part of Foamy Oil
DTS – Fiber Optics: Temperature Measurement

- Detect: Water entrance
- Flow rate changes
- Leaks
- Multiple-point injection
- Steam stimulation efficiency distribution
New approach for reservoir optimization incorporating DTS

Integrating Data from DTS into simulation models

Better Calibrated models enhancing optimization capabilities
Field Development Plan Optimization

Producción Acumulada de Petróleo (MBN)
Producción Acumulada de Agua (MBN)

Tiempo (Años)
**EOR/Thermal Challenges**

**Goal:** Profitably Increase Recovery Factor

Can the thermal recovery methods applied in Canada be successfully adapted to the Latin American reservoir conditions?

**What are the applicable thermal recovery methods for my Reservoir?**

![Diagram showing recovery factor and production methods]

Low Recovery Factor

Cold Production

High Recovery Factor

Thermal
HEAVY OIL BURNING ISSUES

Complexity
Blending
Measurement
Transportation
Flow Assurance
Surface Facilities
Chemical Treatment
Energy Management
Steam + In-situ Combustion
Integration: Downstream – Upstream
CO$_2$ & Environmental Considerations
The Heavy Oil initiative is alive and Vibrant!
Schlumberger has been preparing for years to help obtain the right information to reduce the uncertainty of the decisions, to study and select the viable alternatives to optimize through properly planned pilots the development of Heavy Oil Reservoirs!
Heavy Oil

Can not be taken lightly!