Outline – “Heavy Oil - An Alaskan Sized Prize”

• Where and What is Heavy Oil?

• Current Alaska Development Challenges
  - Schrader Bluff / West Sak Formation

• Future Development Potential
  - Schrader Bluff / West Sak Formation
  - Ugnu Formation
Global Heavy Oil
Alaska is on the Map but…

Alaska
- Historical Focus on Light Oil
- Arctic challenges
- High costs

Canada
- 40 years of heavy oil development
- Cradle of Heavy Oil Technologies
- Open Data Environment

Barrels OOIP
- ~1 billion
- ~10 billion
- ~100 billion
- >1 trillion

Source: JPT, IEA, Schlumberger OFS Marketing

HO Workshop, SEG 2006
North Slope Heavy oil is a residuum formed from light oil that has lost the small (light) molecules leaving the heavy ones. These form hydrocarbon compounds characterized by long, complex molecules.

Most of the hydrogen is in the light ends so heavy oil is depleted in hydrogen.

The long molecules of heavy oil impart high internal friction resulting in high viscosity.
Viscosity – “resistance to flow”

- Viscosity is the resistance a material has to change in form….”internal friction.”
- Viscosity reduction
  - Heat
  - Solvent
  - Dilution (Diluent)
Heavy Oil – Key Properties & Considerations

- High Viscosity (Physical Property)
  - Flows very slowly: wells produce at lower rates than light oil wells
  - Developments require lots of wells
  - Waterflooding is less effective due to the viscosity contrast between heavy oil and water
  - Often produced with lots of sand
  - Thermal techniques (e.g. steam) may be required for recovery but energy balance and environmental footprint are factors

- Lower Hydrogen Content (Chemical Property)
  - Heavy oil is depleted in hydrogen relative to light oil
  - Fewer refined products are derived from heavy oil
  - Heavy oil fetches a lower price on the market
Alaska Viscous & Heavy Oil Resource

- Heavy oil resource overlies existing fields
- Oil is present in multiple reservoir zones
- **Total: 24 – 33 Bbbls Oil in Place**
  - Schrader Bluff / West Sak – ~12 Bbbls (14-22 API)
  - Ugnu – 12-18 Bbbls (8-14 API)
Alaska Fluid Viscosity
Alaska fluids range over a continuum of viscosities

North Slope Oil Fields
Oil viscosity versus Depth

- Mostly Developed
- Starting to Develop
- Potential Future development

Light Oil (like water)
Viscous Oil (like syrup)
Heavy Oil (like honey)

Technological Challenge
“Expect the piloting to take longer and be more complex (painful) than you expect”

100+ Million bbls cumulative production

Challenges:
- Geologically complicated
- Low productivity due to high viscosity
- Complex production and injection well designs
- Waterflood problems in soft rock formations
- Difficult separation of heavy oil & water
- Solids production and handling
- Higher operating costs

Rate (bopd)

vertical wells & water-flood

fractured vertical wells

horizontals multi-laterals

>$500M spent during pilot phase
Evolution of Heavy Oil Producer Well Design

Original Design
Conventional

Current Design
Multilateral

- Completion Length: ~90’ of perforations, 600’ frac
- Production Rates: Marginal
- Operability: Fair to Poor

- Cost: 2-4x conventional well
- Completion Length: Up to 25,000 ft of laterals
- Production Rates: Significantly improved
- Operability: Improved, but still solids, interventions and separation problems
Drilling from Manhattan to the Statue of Liberty

World class drilling technology has been developed for viscous oil.

300+ ft of section

1.5 mile laterals
Heavy Oil Leads to Challenging Well Designs

Total Footage Drilled: 31,564' MD
Total High-Angle Footage: 27,540' MD
Total Slotted Liner Run: 4442' MD
Total Net Pay: 16,755' MD
Heavy Oil production requires facility upgrades
Schrader/West Sak

Fill has consistency of Turnagain mud

Equipment installed to remove and dispose of solids
Heavy Oil Production Technology: A Circle of Learning for the Schrader Bluff / West Sak zones

Technology & Learnings

Heavy Oil development requires a collaborative “circle of learning”

Facilities & Operations

Reservoir Development Strategy

Drilling & Completion

Heavy Oil Production Technology: A Circle of Learning for the Schrader Bluff / West Sak zones
Ugnu Heavy Oil Challenges

“Geology is king and the reservoir dictates the recovery method.”

- Understand the resource properties and distribution
- Understand the recovery methods and cutoffs

Challenges:
- 100 times thicker than Schrader/West Sak oil
  - Shallow, colder
- NO production to date
- New technologies needed: geoscience, wells, facilities, and transportation.
- Pilot testing needed to prove commerciality
Heavy Oil Recovery Spectrum

- Less than 10% Recovery
  - High Density Vertical Wells
  - Horizontal Wells
  - CHOPS (Cold Heavy Oil Production with Sand)
  - Water Flood
    - Polymer Flood
      - NGLs
    - Solvents
      - Vapex
    - Microbial
      - CO₂

- 30 to 50%
  - Cyclic Steam Stimulation (CSS)
    - Steam Drive
  - Steam Assisted Gravity Drainage (SAGD)
  - Downhole Electrical Heating
  - In-Situ Combustion

- 99%
  - Open Pit
  - In-Situ Combustion

- Heavy Oil Depletion Tech.
  - Commercial Technologies in blue
Ugnu M80 Cold Flow Composite ‘Cold’ Flow Risk Map

Risk is driven by oil quality in the west and oil presence in the east.
Ugnu viscosities are well above the current waterflood viscosity threshold
Viscosity is within the limits of primary, chops, polymer flood, and a number of steam recovery methods

Sources: C&C Reservoirs, Dusseault et al., & Sproule
‘Cold’ Flow Recovery Methods

**CHOPS (Cold Heavy Oil Production with Sand)**

- Deliberate initiation of sand influx into perforated well
- Sustained sand production propagates further into the reservoir (representing a multi-fold increase in reservoir contact)
- Sand produced along with oil, gas, and water

**Horizontal Wells**

- Increase reservoir contact through drilling
- Relies heavily on solution gas drive
- Slotted liner limits sand production into wellbore
**There vs. Here**

**Canadian Design**
- Single well tank battery
- Oil, water and solids trucked separately
- Gas burned or vented
- Direct fired heater
- 20+ years experience

**Alaska Design**
- Safety & environmental constraints
  - No direct fired heaters in tanks
  - No venting of gas
  - No spills
  - Operate safely period
- Unknown fluid properties and behavior
- First of its kind in Alaska
Milne Point S-Pad Heavy Oil Facility
Are the CHOPS and Horizontal depletion mechanisms viable and reliable with Alaska reservoirs and fluids?

What is the well design and lift system that allows for sustainable and operable movement of a sand/oil/water/gas slurry?

What is the reliability and efficiency of high viscosity and high solids processing and transportation?
Heavy Oil Potential – “Big Dreams”

Present

Time Frame

Future

High

Risk & Uncertainty

Extremely High

Plan

Options

Vision

Primary

Southern Option

Thermal

EOR

S-Pad Pilot

S-Pad Area Development

Midz Full Field Development

Cross Unit Integrated Full Field Development

Southern Option – “Big Dreams”
Heavy Oil Value Chain

*Time dependency given viability/longevity of existing infrastructure is driver of pace*

**Conventional Value Chain**

- Wells → Transit Lines → Processing Facilities → Sales → Line → Refinery

**Cold Heavy Oil Value Chain Add-ons**
- Diluent for Transport
  - Pre-processing Kit
    - Tanks
    - Heaters
    - Associated pumps & piping

Heavy Oil Price Differential ~ $10/bbl
Heavy oil is a large Alaskan resource

- Shares footprint with North Slope Light Oil Field Developments
- Comparable to Light Oil in total oil in place

Heavy Oil Reservoirs are challenging to produce on the North Slope!!!

Schrader / West Sak production required new technologies over the past 25 years; shows promise…but remains on the margin

- geoscience,
- reservoir,
- wells, and facilities

Ugnu shows potential, but requires successful Pilots of next generation technologies