Unconventional petroleum: **Tight oil** (and gas)

BHP Billiton Petroleum fracking operation in the Eagle Ford Shale (Texas)

Oil shale, shale oil, and tight oil: Source of confusion

Tight oil and tight gas are extracted from ‘**shale plays**’

- **Shale oil** (unconventional) is produced from oil shale
- **Tight oil** (conventional) is produced from ‘tight’ source rocks via hydraulic fracturing (‘fracing’)
- Tight gas = ‘**Shale gas**’ (gas from fracking)
Bakken (ND) and Eagle Ford (Texas) are major oil plays; Marcellus (Penn & New York) is a huge gas play.

Paradox:
- Source rocks (mudstones) are high in OM but have very low permeability
- Catagenesis produces high fluid pressure that microfractures source rock
- Fractures create permeability
- Note both upward and downward expulsion (primary migration)
- This process is less than perfect…
  - Significant volume of oil (and gas) remains trapped in source rocks (shale)
  - This ‘trapped’ hydrocarbon is the target of a ‘tight’ (shale) play

Tight oil: Return to the basics…

Source rocks and “primary” migration

Take home message: In a very crude sense, we can think of a tight play as a ‘low grade’ ore body; we need a significant volume for economic feasibility. A conventional (sandstone) reservoir would represent a ‘high grade’ ore body.
Fracking 101:

- Shale plays are **mature** to slightly over-mature source rocks with residual oil / gas
- Basic idea: Somehow increase **permeability** of the source rock
- Process involves **directional drilling** and **hydraulic fracturing**
- Best plays involve brittle / rigid ‘shales’ (mudstones)
  - Maintains fracture openings better

Fracking 101:

- Drill vertical well to depth of shale layer (typically fairly deep)
- Drill horizontal ‘laterals’ (1 – 3 km)
- Inject water (+ other goodies) at extreme pressures
- Fracture the shale along the laterals
  - Induces locally enhanced permeability
- ‘Proppant’ (typically sand) included with fracking water to ‘prop’ open the fractures
Horizontal drilling increases ‘contact’ with shale layer
Each ‘stage’ of fracking increases ‘footprint’ (zone of influence) of the well
Length scale of fracture zone is 10s – 100s meters
Fracking process requires a few days (injection / recovery)
Once fracking fluids are recovered, oil/gas extraction can begin

Fracking 101:
- Hydraulic fracturing of shale units at depth requires tremendous fluid pressures and discharges (flow rates)
- Flow rate (Q) can exceed 3500 gallons per minute (GPM)
- Fluid pressure can exceed 100 MPa (1000 x atmospheric)
Typical hydraulic fracturing operation
A typical fracked well requires 2 – 6 million gallons of water

Halliburton
What goes down the well during fracking?

~ 90 % water
~ 10 % ‘proppant’
~ 1-2 % chemicals (acids, surfactants, gels, antifreeze, …)

Natural proppant: Ultra ‘mature’ sand from Wonewoc Formation (upper Cambrian)

Synthetic proppant: Ceramic beads
What properties does a ‘good’ frac sand possess?

Williston Basin: The Bakken Formation
The Bakken Shale Play

- In 2014, production from the Bakken topped one million barrels per day, i.e. 1 Mbbl/day (max of 1.4 Mbb/ day)
- Production rate decreased thereafter (economics)
- Fundamental problem with all tight-oil production (not just the Bakken) is the extremely rapid decline rates of individual wells (> 50% per year in some cases)

Recovery from primary drive in Bakken is 2 – 7%

Secondary drive?
• Increased production in the Bakken driven by **increased drilling**
• Production companies are **highly leveraged**
• Companies carry too much **DEBT**

The Red Queen syndrome

"The Red Queen has to run faster and faster in order to keep still where she is. That is exactly what you all are doing!"