Shale Gas/Oil media “buzz”

Canacol, ExxonMobil eye Magdalena shale oil play

Hopes rise again for ‘Gatwick Gusher’

Alberta’s Duvernay shale – a liquids rich gas opportunity

South Africa accused of ignoring shale gas fracking dangers

Third major joins Canacol in Colombia shale oil quest

Argentina shale oil reserves rank fourth behind Russia, China and US, says latest energy report

Scottish government accused of shale gas doubts

Duvernay might be Alberta’s ‘motherlode’

New fracking technology opens deposits to past opaque terrains, Canada
And we owe it all to....

In 2001, Devon bought Mitchell Energy for US$ 3.1 Billion
• We know that pad drilling of Horizontal (Hz) wells has revolutionized shale gas / oil pursuits & lowered costs & footprint.

• We may take this for granted in N. American shale / unconventional ....but the idea is less common internationally, And the kit required to make it happen is less available / more costly than in N. America.
Outline

- **What is it?**
  - i.e., definitions: dry gas, wet gas, condensate, volatile oil vs black oil shale vs tight etc., halo plays, ‘conventional unconventional’

- **Where is it?**
  - i.e., Countries/basins, endowment (thickness, extent, brittleness), remoteness

- **Where Economic/Commercial presently?**
  - i.e., Why? What works? What doesn’t?

- **Future commercial shale areas?**

- **Positives & Negatives**
  - i.e., the nuances, “watchouts”, challenges & strengths of the future areas?
Definitions

• Shale gas / oil / liquids
  • - a true source rock, TOC > 2%, e.g., Duvernay

• Tight gas / oil / liquids
  • - may or may not be ‘source rock’ e.g., Montney

• Halo plays
  • Oil-bearing or gas-bearing low perm facies in existing conventional oil & gas fields
  • a.k.a. ‘conventional unconventional’ 😊
  • E.g., Viking Fm Doddsland, Cardium Pembina

• At the end of the day…
  • Any horizon that produces oil or gas using a Hz wellbore and multiple frac stages 10-30+
Vacca Muerta shale oils/condensates of (L-R) lighter to heavier API, Neuquén Basin, Argentina. Can be predicted pre-drill with increasing accuracy with each new well.

Wikipedia: Ghawar (Arabic: الغوار) is an oil field located in Al-Ahsa Governorate, Eastern Province, Saudi Arabia. Measuring 280 by 30 km (174 by 19 mi), it is by far the largest conventional oil field in the world. [https://en.wikipedia.org/wiki/Ghawar_Field#Production](https://en.wikipedia.org/wiki/Ghawar_Field#Production)

Source: map: YPF public presentation by T Garcia de Blanco Nov 9 2011 CWC Conf Houston
maturity phases, volatile oil etc: [http://petrowiki.org/Oil_fluid_characteristics](http://petrowiki.org/Oil_fluid_characteristics)
Shale Gas & Shale Oil Basins of the World

Source: EIA & USA Energy Dept, June 2013, Figure 1, 137 Shale Fms in 42 countries globally
Technically Recoverable
Shale Gas Resources
(Tcf)

1. U.S. 1,161
2. China 1,115
3. Argentina 802
4. Algeria 707
5. Canada 573
6. Mexico 546
7. Australia 437
8. South Africa 390
9. Russia 285
10. Brazil 245
11. Others 1,536
TOTAL 7,795

Source: EIA & USA Energy Dept, June 2013, Figure 1, 137 Shale Fms in 41 countries globally

Legend
- Assessed basins with resource estimate
- Assessed basins without resource estimate

Shale Gas & Shale Oil Basins of the World

Canada 5  
USA 1  
Mexico 6  
Argentina 3  
Brazil 10  
S. Africa 8  
Russia 9  
China 2  
Australia 7  

Gardiner – CSPG International Division – Feb 21 2018, Calgary, Alberta, Canada
Shale Gas & Shale Oil Basins of the World

Source: EIA & USA Energy Dept, June 2013, Figure 1, 137 Shale Fms in 41 countries globally

Legend
- Assessed basins with resource estimate
- Assessed basins without resource estimate

Technically Recoverable Shale Oil Resources (Billion Barrels)

1. Russia 75
2. USA 48
3. China 32
4. Argentina 27
5. Libya 26
6. Australia 18
7. Venezuela 13
8. Mexico 13
9. Pakistan 9
10. Canada 9
11. Others 66
TOTAL 335

Source: EIA & USA Energy Dept, June 2013, Figure 1, 137 Shale Fms in 41 countries globally
Is in Top 10 for both oil …and….gas
Key Messages:

1. Overwhelming large technical endowment worldwide
   - Scary, plentiful abundance for next 35-100 years

2. And that’s just onshore, the rocks extend offshore, under oceans
   - see parallels with conventional oil exploration history:
     - 1880-1960’s onshore
     - 1965-1990 shallow water (< 200m) shelf offshore
     - 1990-present deep water (200-3000m) offshore

3. Commercial / above ground aspects will drive winners & losers

4. “Choose wisely”
Can Score & Rank Shale investment opportunities worldwide, based on desired criteria
Score 1-5  “Pick the Kind of Pain you Like”

Pick the Kind of Pain you Like
Top 10 ‘International’ Typical Shale/Unconv Challenges* “DEAL BREAKERS” or “FATAL FLAWS”

1. Attractive Fiscal Terms and legislation in place for shale/unconventional
2. Land ownership / access to obtain land / easy access to surface
3. NIMBY / anti frac
4. Water
5. Proppant
6. Kit (rigs, frac equipment, crews)
7. Labour Costs / Unions / competitiveness
8. Pipeline / Markets / Monetization
9. Product pricing
10. Execution pace (rig moves, roads, culture, zipper fracs)

*assuming the country possesses rich, attractive, below ground endowment and is prospective

http://www.who.int/mediacentre/factsheets/fs310/en/
Where is international shale commercially produced, presently?:

- **Canada**
  - Triassic Montney, Devonian Duvernay
- **USA**
  - Wolfcamp, EF, Marcellus, SCOOP/STACK, Bakken, Niobrara
  - Jurassic Vaca Muerta, Los Molles, Agriol
- **Argentina**
  - Jurassic Vaca Muerta, Los Molles, Agriol
  - Paleozoic Ordos, Sechuan
- **China**
  - Jurassic Ras Qattara, Anathatha
- **Egypt?**
  - Jurassic Ras Qattara, Anathatha
- **Possibly Russia, Saudi Arabia?**
  - Jurassic Bazenov, Cinhan, Jurassic (Hanifa, Tuwaiq Mtn)

**“On deck”:**

- **Mexico**
  - Eagle Ford extension,
  - La Luna, Rosa Blanca, Tablazo, Villeta
- **Colombia (Mid Mag, Put)**
  - Devonian
- **Algeria (Beniene, Ahmat)**
  - Devonian
- **UK (Lundian, Blanc, Weald)**
  - Carboniferous, Jurassic
- **Australia (Georgina, Cooper, Amadeus, Canning)**
  - Precambrian, Perm Ordov, Devonian
- **Brazil (Reconcavo, Solimoes)**
  - Lwr Cret. Gomo, Devonian
- **Turkey (SE Anatolia)**
  - Silurian Didas
- **Northern Europe**
  - Permian, Carboniferous, Jurassic Schiste Carton, Posid
- **Ukraine**
  - Dneiper-Donets Devonian & Carboniferous
However, unconventional development in Europe, Asia and Latin America remains behind the United States and Canada.

Country evolution on unconventional development curve

- Exploration:
  - 5 years
- Development and production:
  - 15 years
  - +30 years

CAPEX

- China
- Brazil
- Australia
- Mexico
- Argentina
- S. Africa
- Algeria
- Russia
- Colombia?

‘Analysis of basins and plays’
- There are no drilled wells
- Largely “known” basins
- Limited data (reservoir quality, well productivity)

‘Reduction of risk’
- Exploratory drilling
- Information acquisition focused in reservoir quality and well productivity

‘Pilot Commercial development’
- Secure markets access
- Drilling/well design optimization

‘Massive development’
- Progress has been made in the learning curve
- Focus on long term well performance

‘Consolidation’
- Consolidation / optimization of basins and/or shale oil-gas plays

- It has taken at least 35 years for the US shale industry to reach its current scale

Source: McKinsey and Company


www.pemex.com
Some examples of specific challenges internationally:

- Argentina
- Colombia
- Australia
- Mexico
- Brazil
- UK
- Ukraine
- Algeria
- Russia
- Turkey
Root Cause Diagnosis

Example 1: **Colombia**

**Observation:** Delays in execution of O&G program/drilling, erodes NPV

**Symptom / Challenge:** Government decreed ‘popular consults’

**Real issue:** Royalties distribution to areas/depts. by Federal (central) Government

Example 2: **Personal Health**

**Observation:** Can’t concentrate at work / school

**Symptom / Challenge:** Have headaches / migraines

**Real issue:** Brain tumor
Example 3: Eagle Ford

Observation: In early days, was “excellent” candidate for shale gas/oil


Real issue(s): 1) Loss of foram content toward NE causes loss of brittleness, and defines the play limit in that direction

2) Within the brittle areas, ultimately ‘overpressure’ defines best wells, at shallowest drill depths
Method / Work Flow (below ground)

• Gather all published papers on source rock attributes: (via AAPG search etc., confs, Ph.D. theses)
  - Areal extent
  - thickness, well log character, vertical contiguity, frac barriers
  - TOC %, kerogen type
  - Maturity %VRo, phases, API, GOR, Hz well performance (type curves if available)
  - thickness, well log character, vertical contiguity, frac barriers
  - Brittleness (facies maps, % clay, % silica or % carbonate)
  - Depth maps, overpressure data
  - Stress regime data
  - Identify data gaps or missings, and severity/impact on risk; remedies or mitigation plan if any

• Georeference all maps in ArcGIS

• Identify areas of favourable vertical coincidence of all above criteria
Method / Work Flow (above ground)

- Gather all published information on:
  - culture, i.e., population centres, nearby cities, towns
  - surface water (rivers, lakes)
  - roads, rail
  - Areas of national parks, environmentally protected areas, indigenous reservations,
  - Any ‘stay away areas’ or ‘bad guys’
  - Main pipelines, access to tidewater
  - Oil & gas pricing, monetization likelihood or ease
  - Political landscape
  - Availability of service co’s (rigs, frac)

- Georeference all maps in ArcGIS

- Identify areas of favourable vertical non-coincidence of all above criteria

- Identify ‘sweet spot’
  - Overlay below ground favourable areas with above ground favourable areas
Geologic Ages of Shales - Paleozoic & Mesozoic - N. America & selected Global

<table>
<thead>
<tr>
<th>Geologic Age</th>
<th>Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. Cretaceous</td>
<td>Eagle Ford</td>
<td>USA</td>
</tr>
<tr>
<td>Jurassic</td>
<td>Kimmeridge</td>
<td>UK</td>
</tr>
<tr>
<td>Vaca Muerta</td>
<td></td>
<td>Argentina</td>
</tr>
<tr>
<td>Bazenov</td>
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<td>Russia</td>
</tr>
<tr>
<td>Triassic</td>
<td>Montney</td>
<td>Canada</td>
</tr>
</tbody>
</table>

**Geologic Ages:**
- Cambrian
- Ordovician
- Silurian
- Devonian
- Carboniferous
- Permian

**Countries:**
- Australia
- Sweden
- China
- Saudi Arabia
- Algeria
- Portugal
- Poland
- Turkey
- Saudi Arabia
- China
- Australia
- Ukraine
- Algeria
- Brazil
- Argentina
- China
- Australia
- Ukraine
- Brazil
Thank you!