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PRESENTATION

Application of shale play fracking techniques to non-us conventional reservoirs in mature basins – *What's the prize?*

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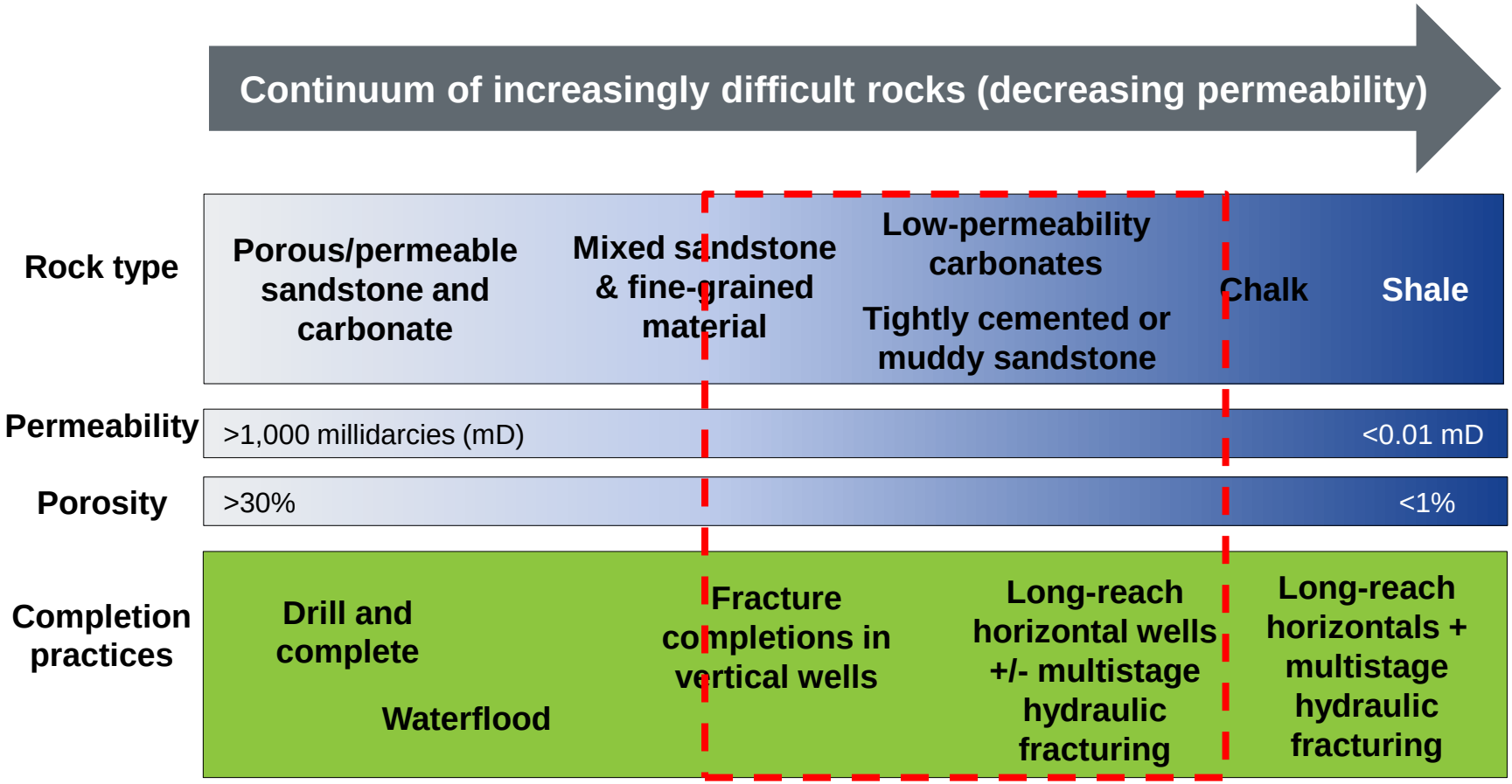
Outline

- Defining the targets
- Some North America examples – what can be achieved?
  - Granite Wash
  - Cardium
- An international example – Saint Martin de Bossenay field, France
- Resource estimation criteria
- Resource magnitude and distribution
- Commercial and operational success criteria
- Conclusions

Defining the targets

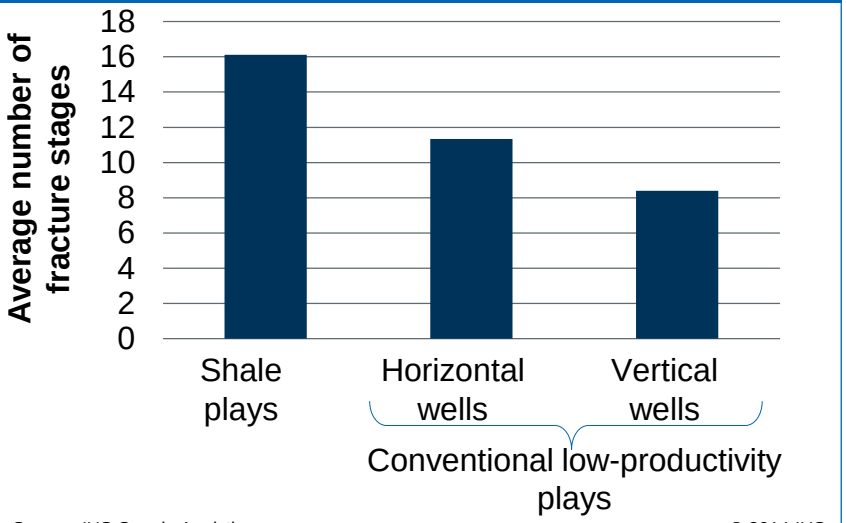
Conventional resources move along a continuum of permeability into unconventional resources



Source: Upstream Industry Future, Plays & Basins

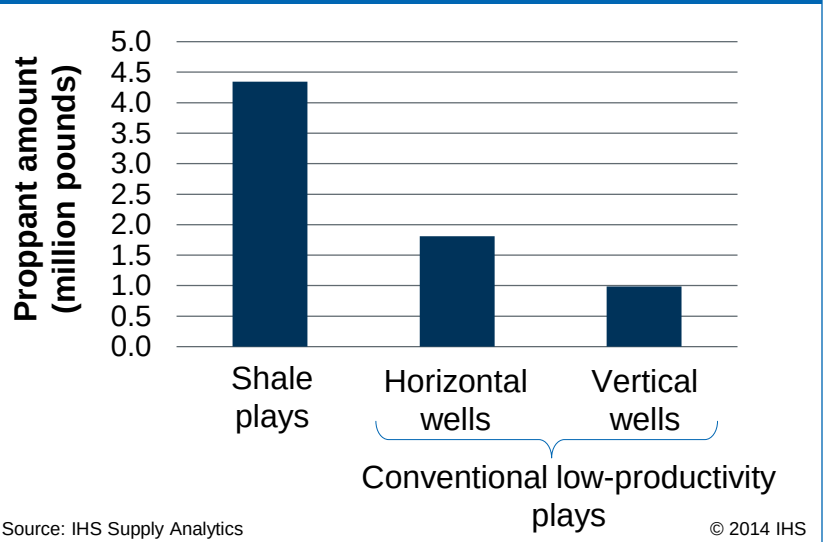
Big cost drivers - fewer fracture stages and less proppant used in low-productivity conventional plays than in shale

Average number of hydraulic fracture stages by different play and well types



Source: IHS Supply Analytics

Average amount of proppant used in hydraulic fracture stimulation by different play and well types



Source: IHS Supply Analytics

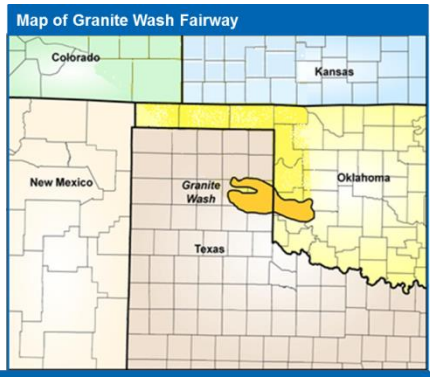
Source: Upstream Industry Future, Plays & Basins

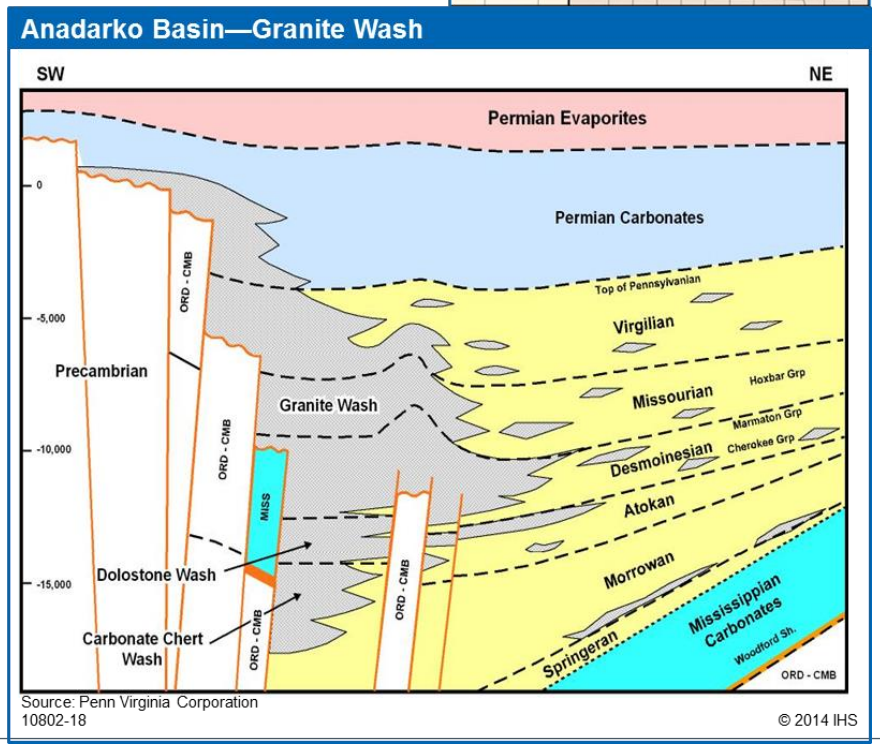
Low-productivity conventional plays revitalised with unconventional techniques: two examples

Granite Wash play, Texas and Oklahoma

Unique geology of the Granite Wash has low porosity and permeability, but great thickness

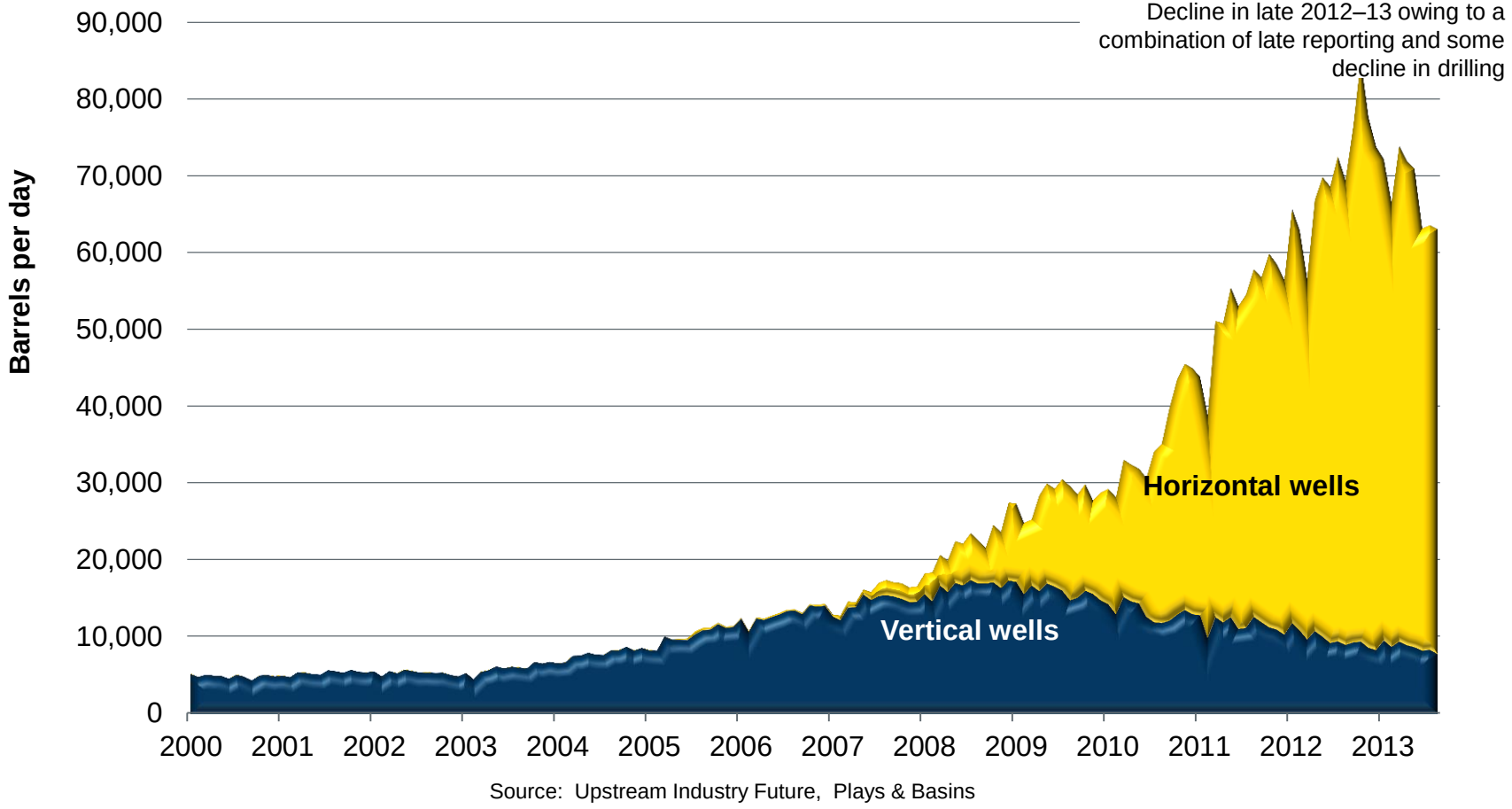
- Uplifted granite rocks eroded, depositing sands in subaqueous fans. Nonmarine fluvial fans form wedge of discontinuous sand and silt bodies.
- Over 5,000 ft of stacked reservoirs each 100–200 ft thick, porosity from <0.1% to 16% and permeability from 0.005 to 100 mD.
- Producing since 1956 with vertical wells targeting fairly tight reservoir; some wells were stimulated with traditional fracking treatments.
- Results from unconventional well technologies sparked regeneration of the play and activity has grown steadily since 2007.
- Unconventional techniques have led to a fivefold increase in production.





Granite Wash oil is producing more than 10 times the rate it was producing 10 years ago

Granite Wash oil production by well type



Source: Upstream Industry Future, Plays & Basins

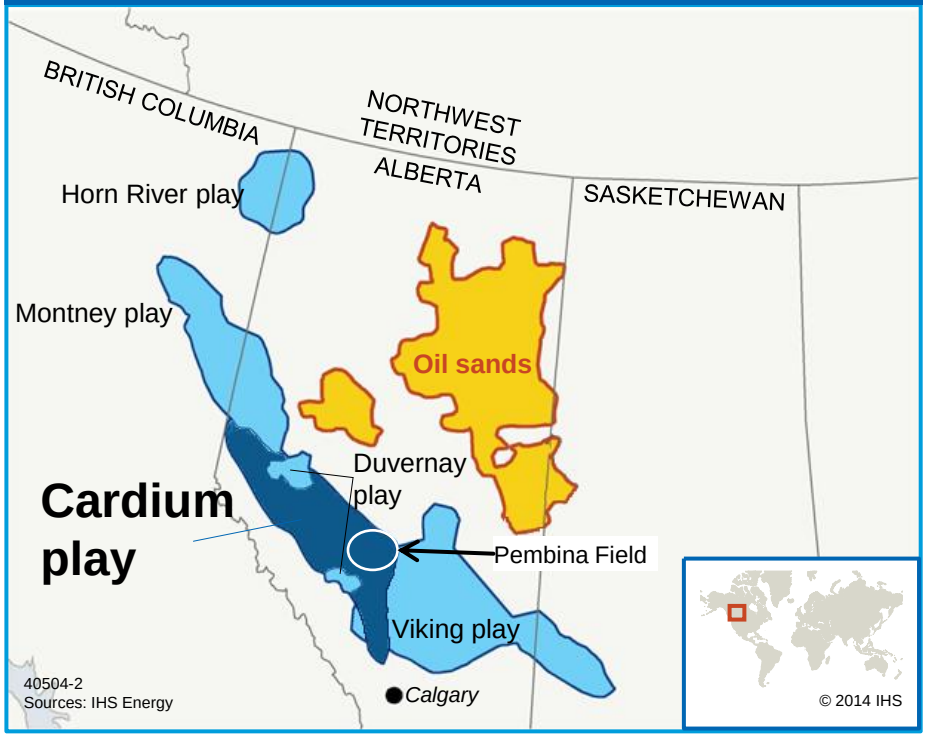
Cardium play Alberta, Canada

Upstream Industry Future

Cardium play regeneration

- Play located among the prime Canadian shale plays: Montney, Duvernay and Horn River
- The Upper Cretaceous Cardium Formation was deposited mainly in shallow marine environments.
- The Cardium has been producing from vertical wells since the 1950s.
- Dominant rock types are mudstone and sandstone with small of patchy and discontinuous conglomerate fractions.

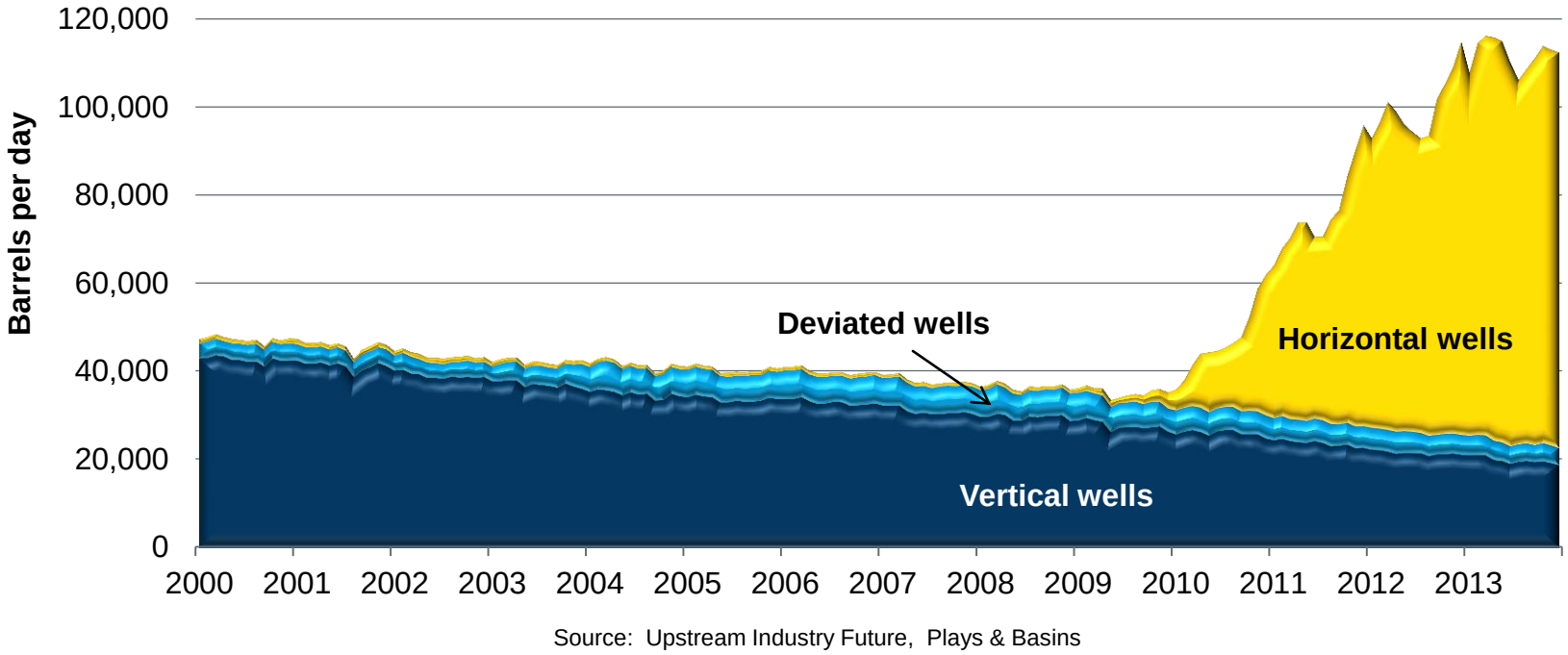
Cardium play location



Source: IHS North America Supply Analytics

Cardium oil production surged with horizontal wells, which now account for 80% of total production

Cardium oil production by well type



Source: Upstream Industry Future, Plays & Basins

- Production increased from 33,000 bd in mid-2009 to nearly 114,000 in 2013, adding over 82 million barrels of oil in just 4.5 years.

Few good examples outside North America: Saint Martin de Bossenay, Paris Basin

Saint Martin de Bossenay: New life for an abandoned field

- Discovered by Shell in 1959, the Saint Martin de Bossenay field in the Paris Basin was developed with vertical wells.
- By 1996, water cut had reached 98% and the field was abandoned. Gaz de France with Geopetrol studied the possibility of transforming the field into gas storage.
- With rising oil prices Societe Petroliere de Production & Exploitation (SPPE) acquired the concession to redevelop the field with modern technology, specifically targeting non-produced portions of the field as defined on modern seismic.
- Using horizontal wells, the recovery factor improved from 40% to 44% adding 1 million barrels (MMbbl) to the 2P (proven plus probable) reserves.

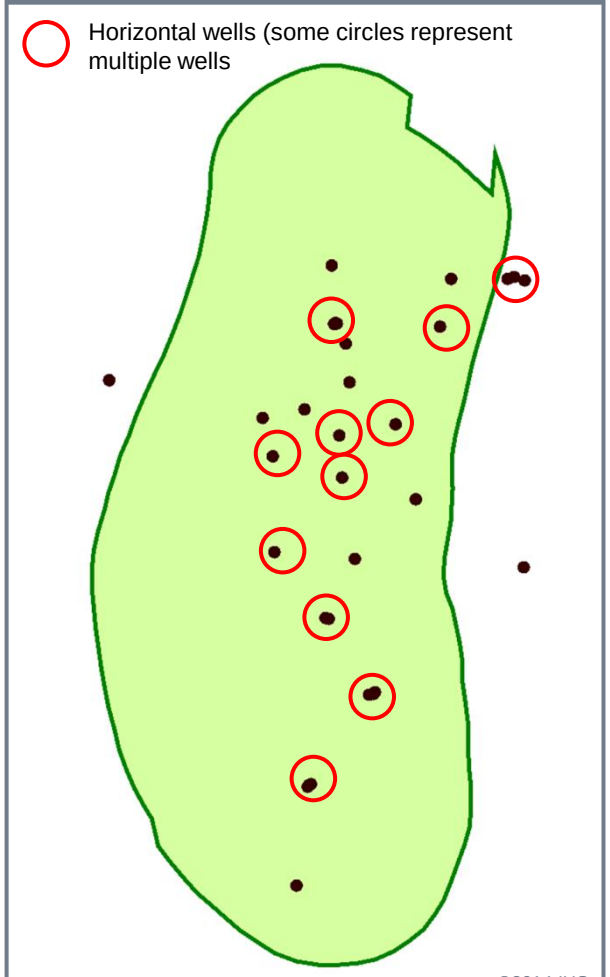
Rebirth of an abandoned field at Saint Martin de Bossenay field, France

- Producing under primary production from the Jurassic Dogger series since 1959, the field's production peaked at over 2,500 barrels per day (b/d) in 1961. It was under waterflood from 1963 until it was abandoned in 1996.
- In the Paris Basin porosity generally ranges between 10% and 16%, and the average permeability is ~15 mD.
- Top reservoir at the Saint Martin de Bossenay field is 1,200–1,300 metres (m). Net reservoir interval is no more than 25 m.

Rebirth of an abandoned field at Saint Martin de Bossenay field

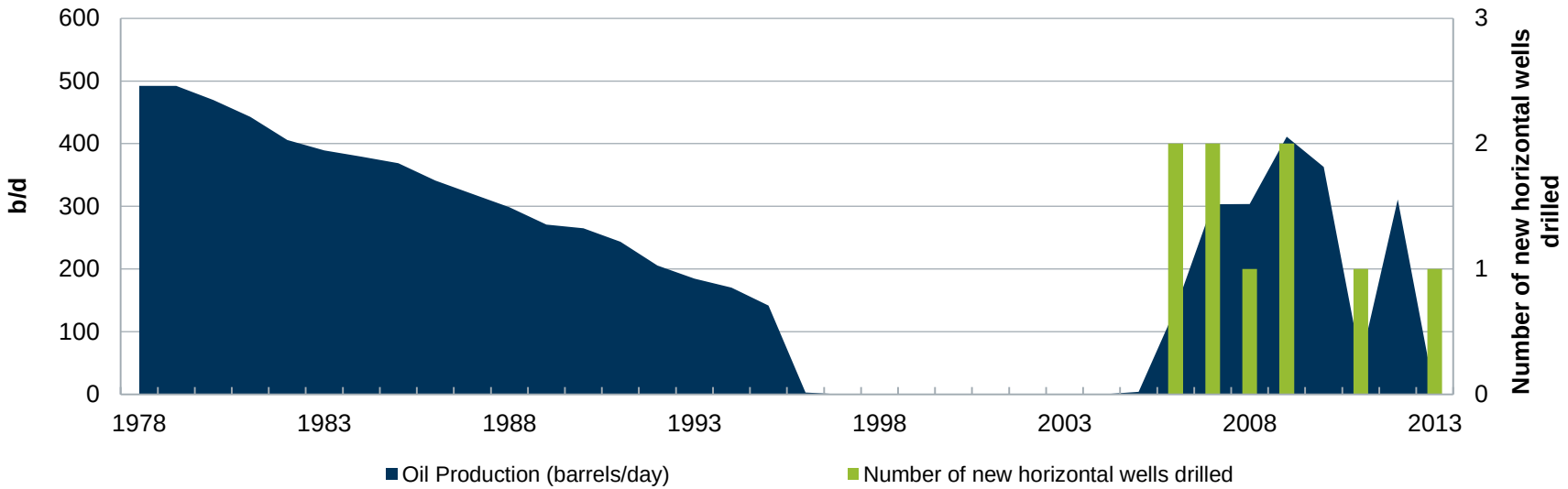
- There are 24 horizontal wells or horizontal sidetracks off of originally vertical wells. Not all producing.
- Little information is available on the horizontal wells
- Wells not fracked, due to ban on the practice in France; might not have been a beneficial anyway because of close proximity of the oil/water contact.
- Shallow depths, relatively short lateral lengths and ability to sidetrack existing wells means drill days kept short. These factors combined with the lack of fracking keeps costs low.

Saint Martin de Bossenay Field with well locations



New horizontal wells have brought production back to 1980's levels

Saint Martin de Bossenay field production and horizontal wells



Source: Upstream Industry Future, Plays & Basins

- Similar to drilling in shale, new wells must be brought on to maintain production levels. Declining production in 2011 may have resulted from the lack of any new completed wells in 2010.

Two other examples - from BP

- Azerbaijan
  - ➢Geo-engineered completion design allowing better targeting of frack zones techniques developed in Eagle Ford now being applied in Azerbaijan AGC fields.
  - ➢Using fibre optic sensors to study detailed reservoir behaviour and to detect and minimise sand production.

- Oman - Khazzan-Makarem tight gas field
  - ➢Similar techniques being applied to a Cambrian to Lower Ordovician reservoir with an average 6% porosity and 5 md permeability.
  - ➢The field is now expected to recover 10.5 TCF and achieve plateau production of 1.5 bcfd (up from 1 bcfd previously)

Screening for potential incremental oil opportunities outside North America

Upstream Industry Future

Screening criteria for low-productivity reservoirs

	Likely needs hydraulic fracture stimulation	May not need hydraulic fracture stimulation
Oil recovery factor	<20%	
or permeability	<= 20 mD	>20 mD and <=50 mD
or porosity	<15%	
If a field did not meet the above criteria, we also considered mature, low productivity	Fields having produced less than 50% of 2P reserves over a two-decade period (exclude giant fields developed in phases)	
Exclusions	Small fields (2P oil <5 MMbbl), deepwater, heavy oil (°API < 20), unconventionals	

Source: Upstream Industry Future, Plays & Basins

Incremental recovery estimates

Potentially about 140 billion additional barrels in existing fields

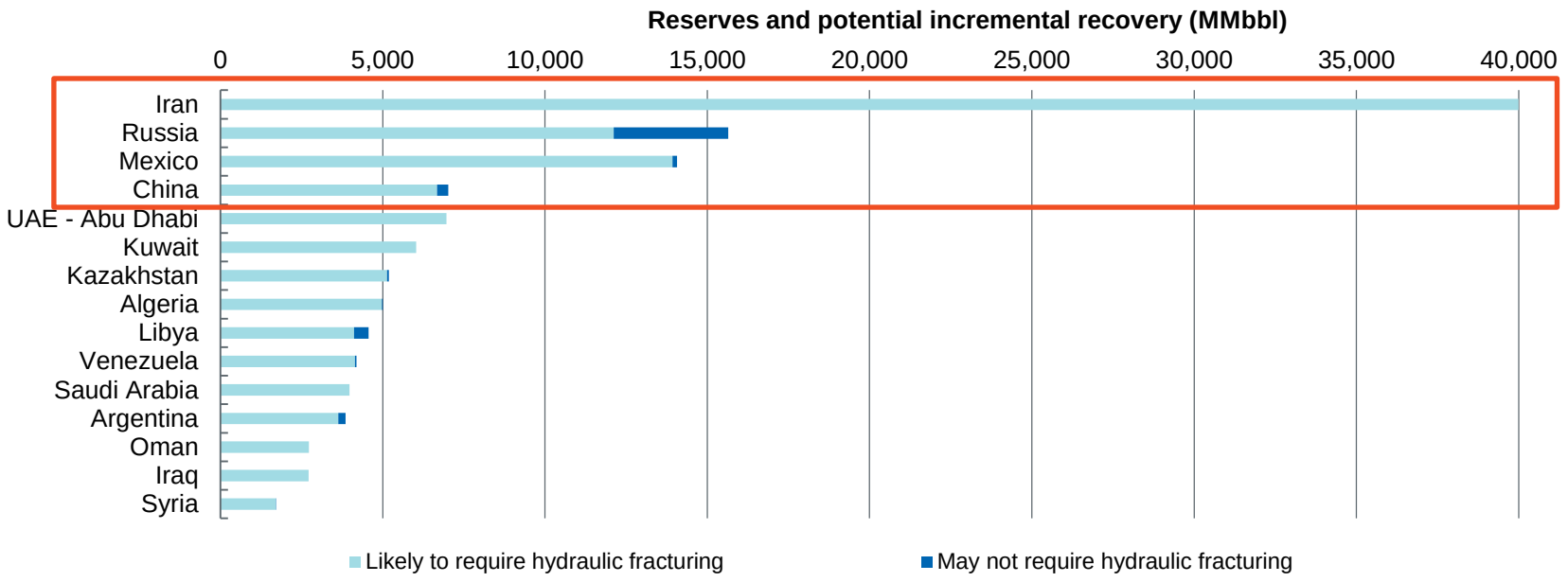
- Over 80% of these incremental volumes are in the Middle East, Russia and Latin America.
- Over 90% of this increment will require fracking which is costly and will require similar service company infrastructure and support as unconventional production.

Region	Incremental oil recovery in fields assumed assuming 10-pt improvement in recovery factor (MMbbl)	Number of existing fields
Africa	12,917	423
Australasia	395	149
Russia	18,208	752
Europe	4,539	559
Asia (excluding Russia)	9,372	708
Latin America	24,874	482
Middle East	65,175	339
Total	**135,480**	**3,412**
Incremental oil recovery in fields that may not require fracking	**6,360**	**765**
Global Total	**141,840**	**4,177**

Source: Upstream Industry Future, Plays & Basins

Top four countries hold more than 50% of potential incremental recoverable

Top countries outside North America for incremental oil recovery in low productivity conventional plays



Source: Upstream Industry Future, Plays & Basins

- Mexico, in third place, holds substantial incremental oil and the opening of the upstream sector may see new investment in these types of resources.
- Most of the top 15 countries have limited access for IOCs.

What are the technical keys to commercially successful exploitation of the resource?

- Several factors have contributed to the success of developing unconventionals in North America.
  - A strong service industry infrastructure
    - ❖ Abundant and expert service company support
    - ❖ Drilling crews experienced in horizontal drilling, fracking and completion techniques
    - ❖ Efficient procurement and supply chains
  - Region and field specific knowledge
    - ❖ Comprehensive and accurate subsurface model supported by high quality structural control
    - ❖ Detailed understanding poroperm and fracture distribution and trends
  - ❖ Technological advances
    - ❖ **Well construction manufacturing approach**. Companies manage drilling, stimulation, completion and hook-up as a “Manufacturing Process” This includes standardisation and automation, data-driven continuous improvement, remote drilling support and integrated planning and supply chains.
    - ❖ **Unconventional development high-iteration learning**. Short cycle times and high frequency activity of the North American unconventional development promote continuous innovation and allow producers quickly to come down the cost curve. This approach allows companies to adopt successful technologies quickly, to tailor technology to specific needs of a region.

Conclusions

- There's a massive potential prize
- Success in North America should technically be replicable elsewhere
- As with unconventionals, successful commercial exploitation will require world class technology and favourable above ground conditions
- Much of the potential is in geographies where the most technically qualified companies have very restricted or no access and where above ground conditions are rarely favourable for such companies
- Mexico could become a significant exception.
- Increased production from this resource is only likely to make a significant impact in the medium to long term so it is unlikely to have an impact on the 5 year oil price outlook.