

European Unconventional Gas

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IHS

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Exploration in the Post-Macondo World!

Finding Petroleum, London

Definitions

Unconventional Trap

Resource plays – “continuous-type deposits ” pervasive over a large area, not significantly affected by hydrodynamic influences and lacking well-defined downdip water contacts.

Unconventional Production

“Difficult to produce” conventionally-trapped accumulations requiring distinctive completion, stimulation, and/or production techniques. (Historically the distinction frequently reflected recovery economics.)

Gaseous State

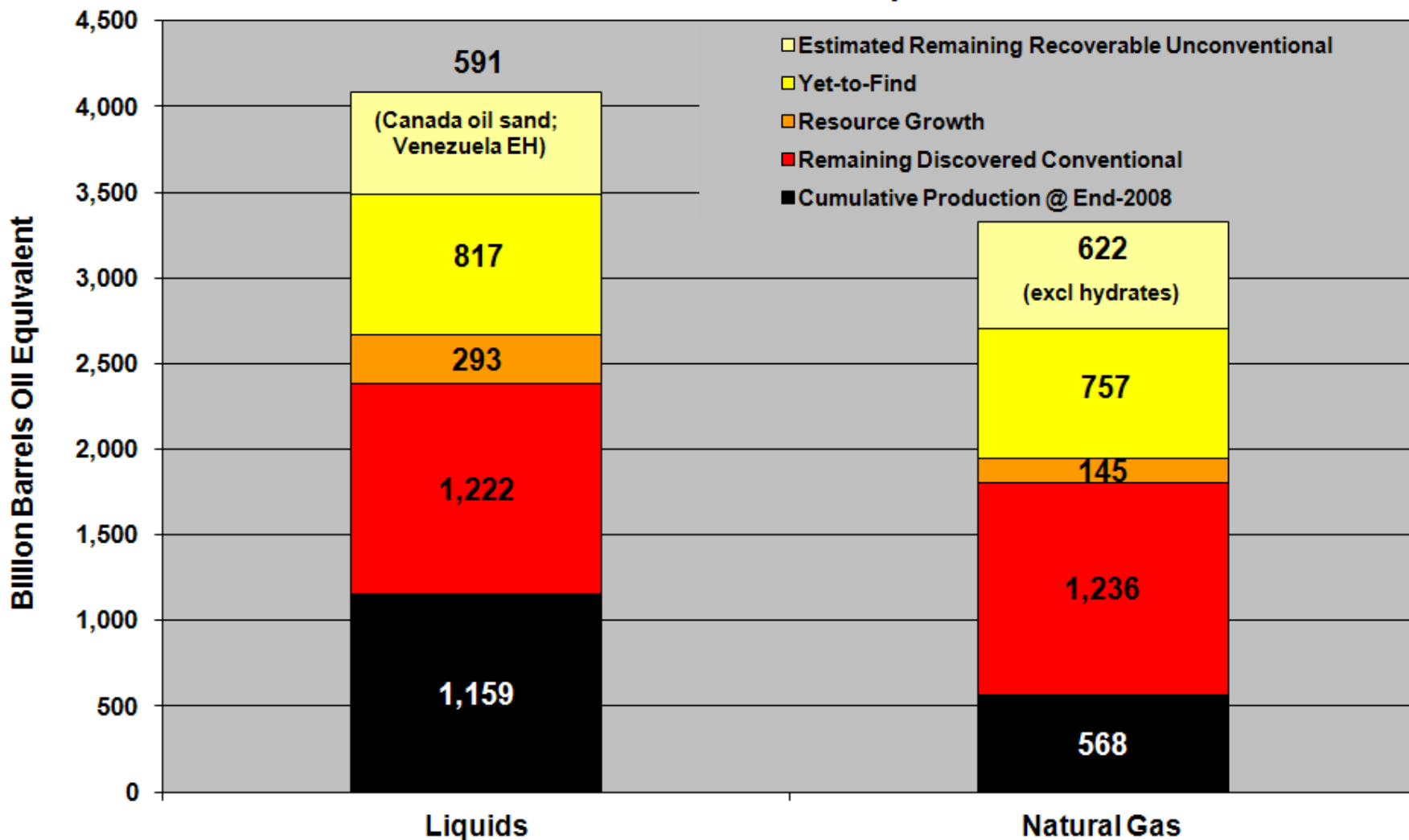
Much of the gas occurs as adsorbed gas.

Feature in Common – maximum micropore $1\mu\text{m}$

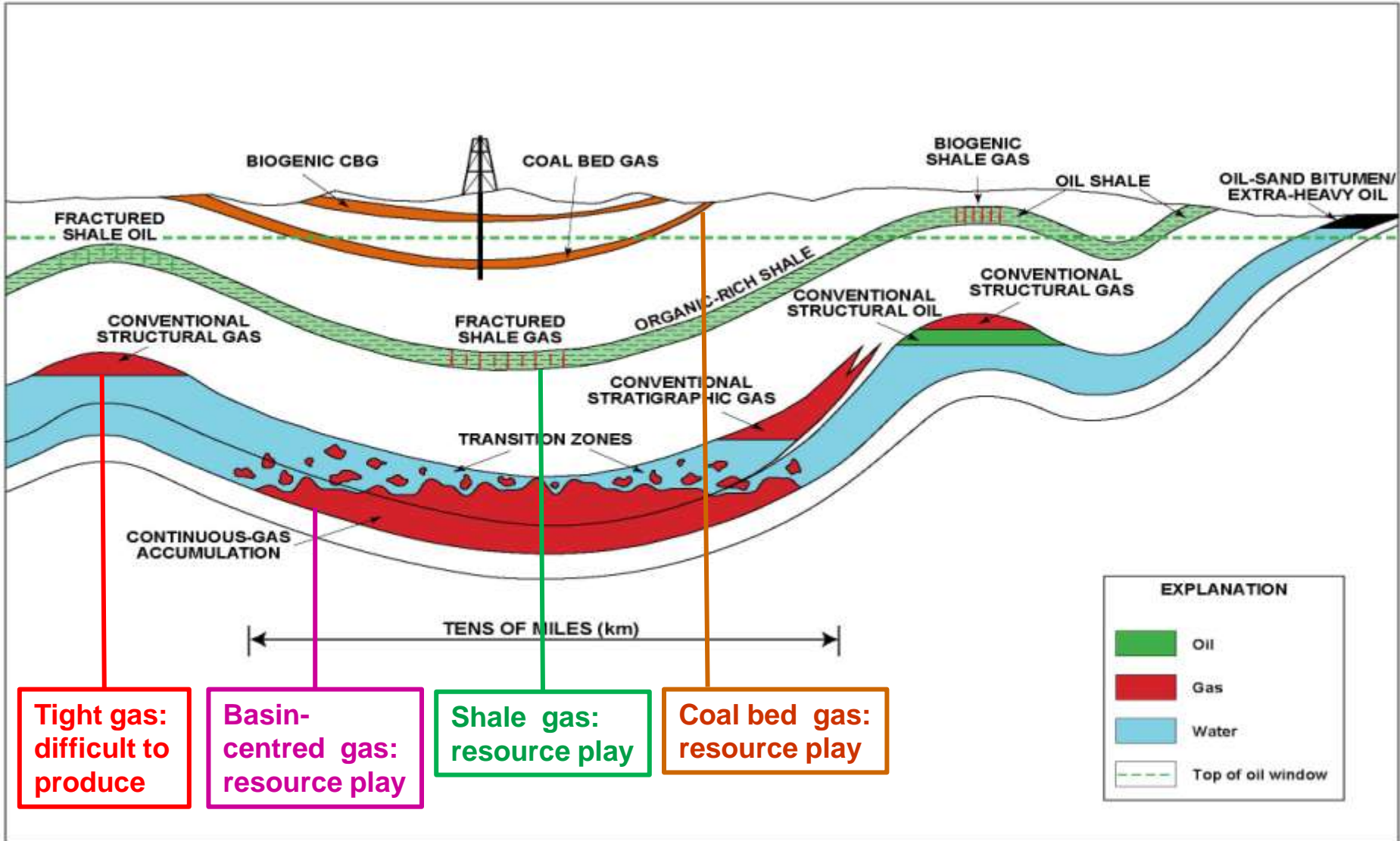
Ultimate Recoverable Hydrocarbon Resources

Summary

Estimated Ultimate Recoverable World Liquid and Gas Resources



Unconventional Resources



Tight Gas Play Characteristics

Low Permeability & Porosity

e.g. average matrix permeability $< 0.1\text{mD}$ or
 $< 0.6\text{ mD}$ effective permeability to gas.

Maximum porosity $\sim 15\%$ but large pores are not connected.

Causes

- Depositional environment;
- Post-depositional compaction;
- Cementation (quartz; carbonate; anhydrite);
- Growth of fibrous illite above 120°C
(approximates to depth / paleodepth $> 4,000\text{m}$);
- Locally, salt plugging.

Gas Resource Play Characteristics

- Regionally-pervasive with large areal dimensions and in-place volumes, therefore low exploration risk & long-life reserves;
- Not localised by the buoyancy of gas in water;
- Low matrix permeability;
- Low recovery factors;
- Low per-well deliverability;

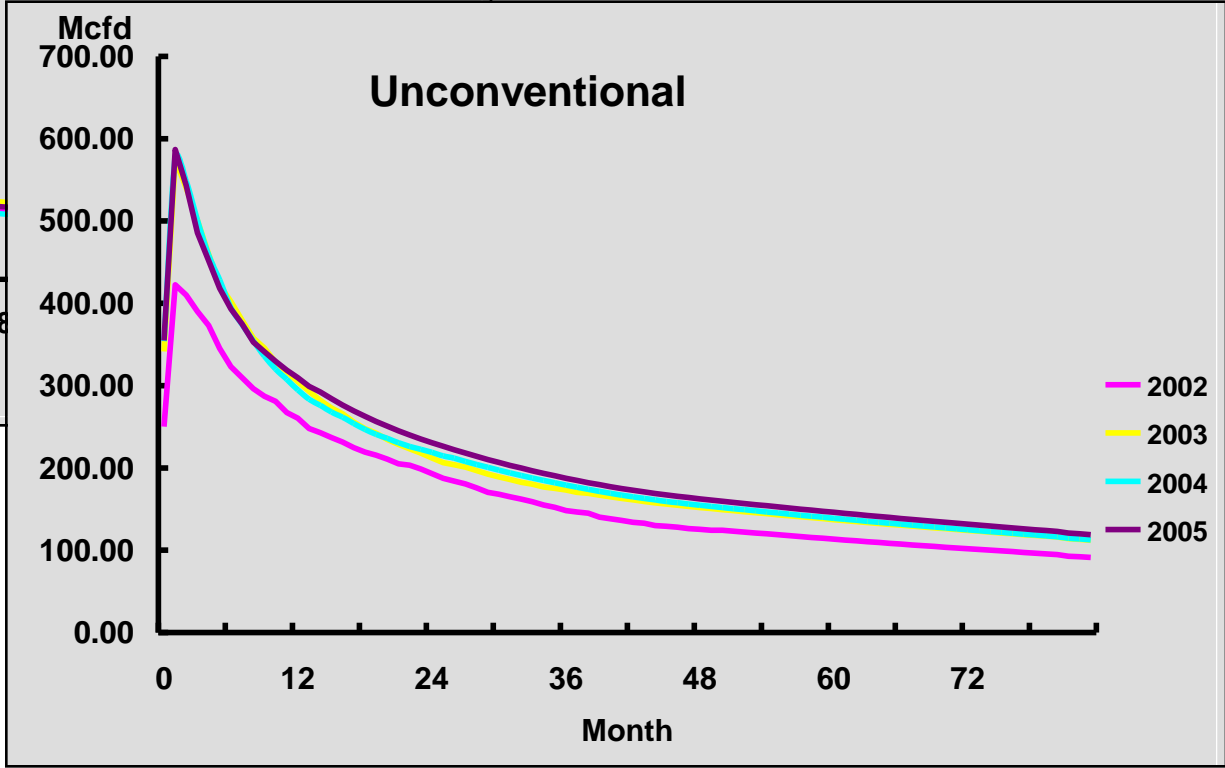
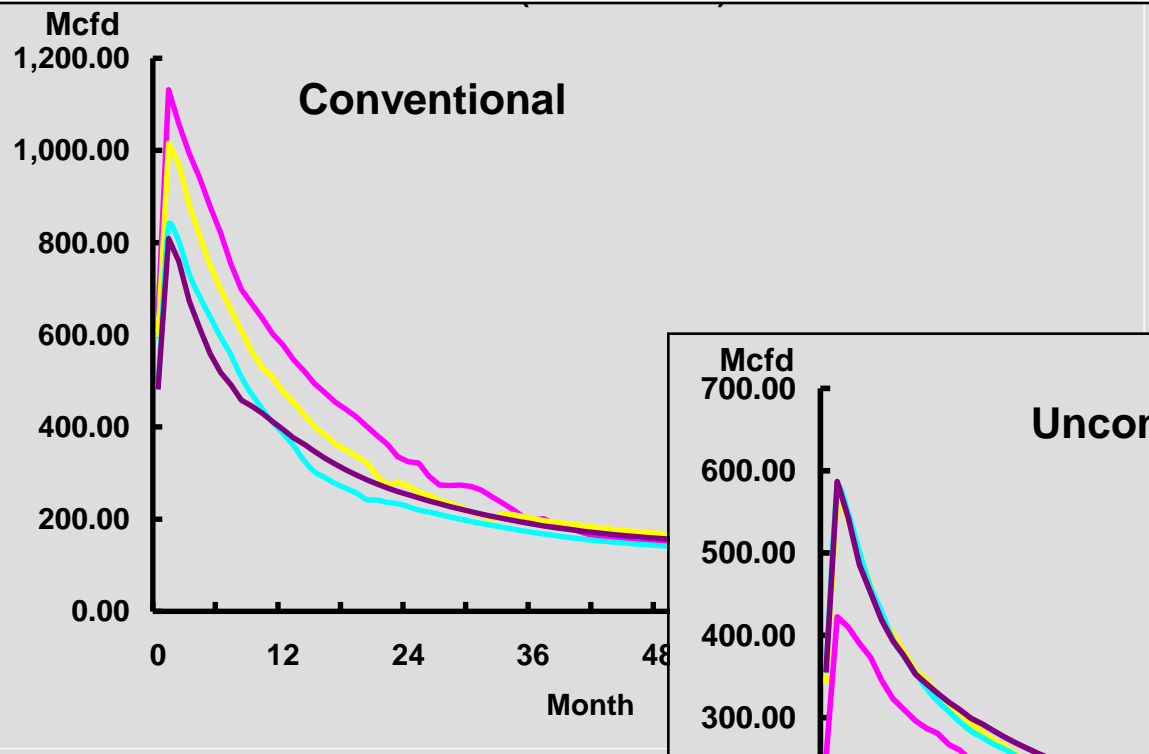
but

- Stable, predictable production;
- Assembly-line development;
- Gas decline rates decrease with time.

Resource Plays

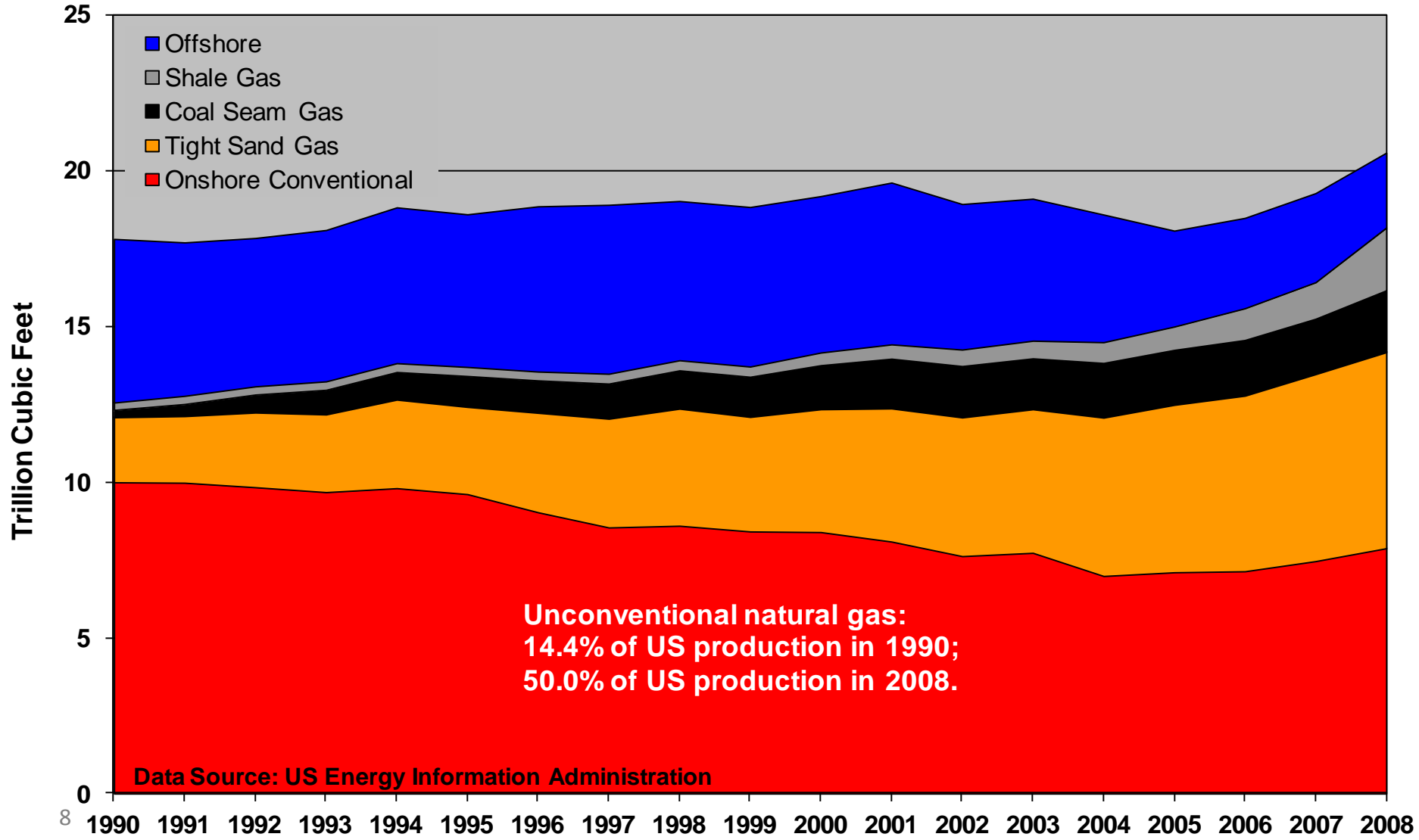
Resource Play Characteristics: Production

**US Lower 48
Normalized Type Decline
Curves: Conventional vs
Unconventional**



Gas Resource Plays

U.S. Natural Gas Production by Source



Tight Gas / Basin-Centred Gas (BCG)

Tight gas (also known as “deep gas”) - not restricted to continuous accumulations but also occurs in conventional traps (and BCG is not always deep).

BCG - gas dissolved in abnormally-pressured low-permeability aquifers in the central (generally deeper) part of basins:

- overpressured in subsiding basins
- underpressured in uplifted and eroded basins.

San Juan Basin & Greater Green River basins (USA);

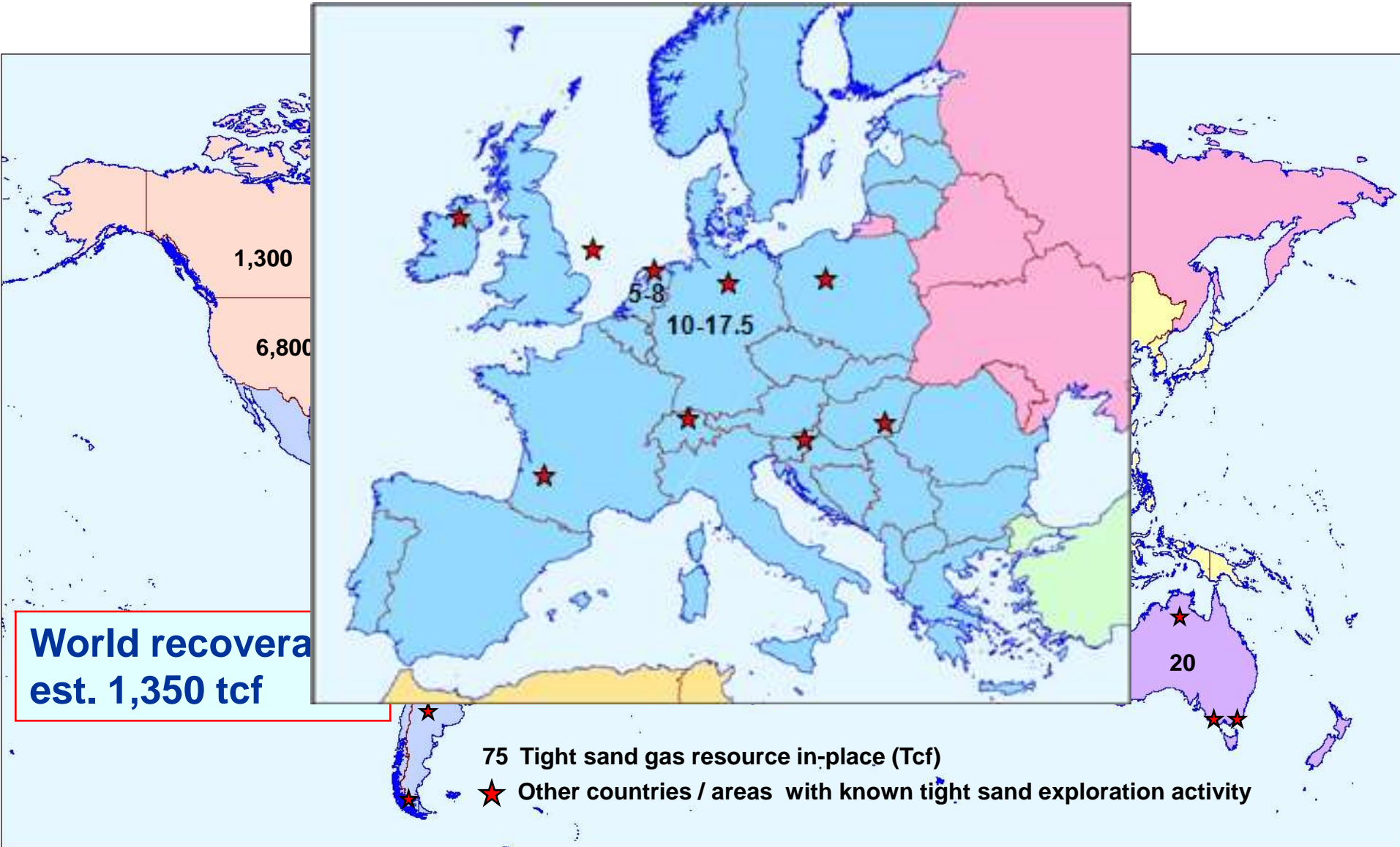
Western Canada Sedimentary Basin (southern deep basin);

Northwest Europe Permian Basin; Pannonian Basin;

Algerian basins; Oman Basin; Ordos Basin, China.

Gas Resource Plays

Tight Gas / BCG: Resource Distribution



Tight Gas / BCG: Production

What Makes a Good Tight Gas Reservoir?

Heterogeneity: higher poro-perm “sweet spots”, either sedimentological or structural (e.g. flexures).

Thick gross pay with stacked sands that can be fraced over the entire interval.

Development

Multiply-fractured horizontal wells are being employed both offshore (Southern North Sea) and onshore (Central European Upper Paleozoic Basin). 100s of horizontal and high-angle deviated wells have been drilled over the past three decades.

Coal Seam Gas

Methane-rich gas occurring in undeveloped coal beds and worked coal seams.

Self-contained source-reservoir petroleum systems; significant adsorbed gas; may have co-produced water.

San Juan & Powder River basins (USA);

Western Canadian Sedimentary Basin (Alberta);

Surat-Bowen & Sydney basins (Australia);

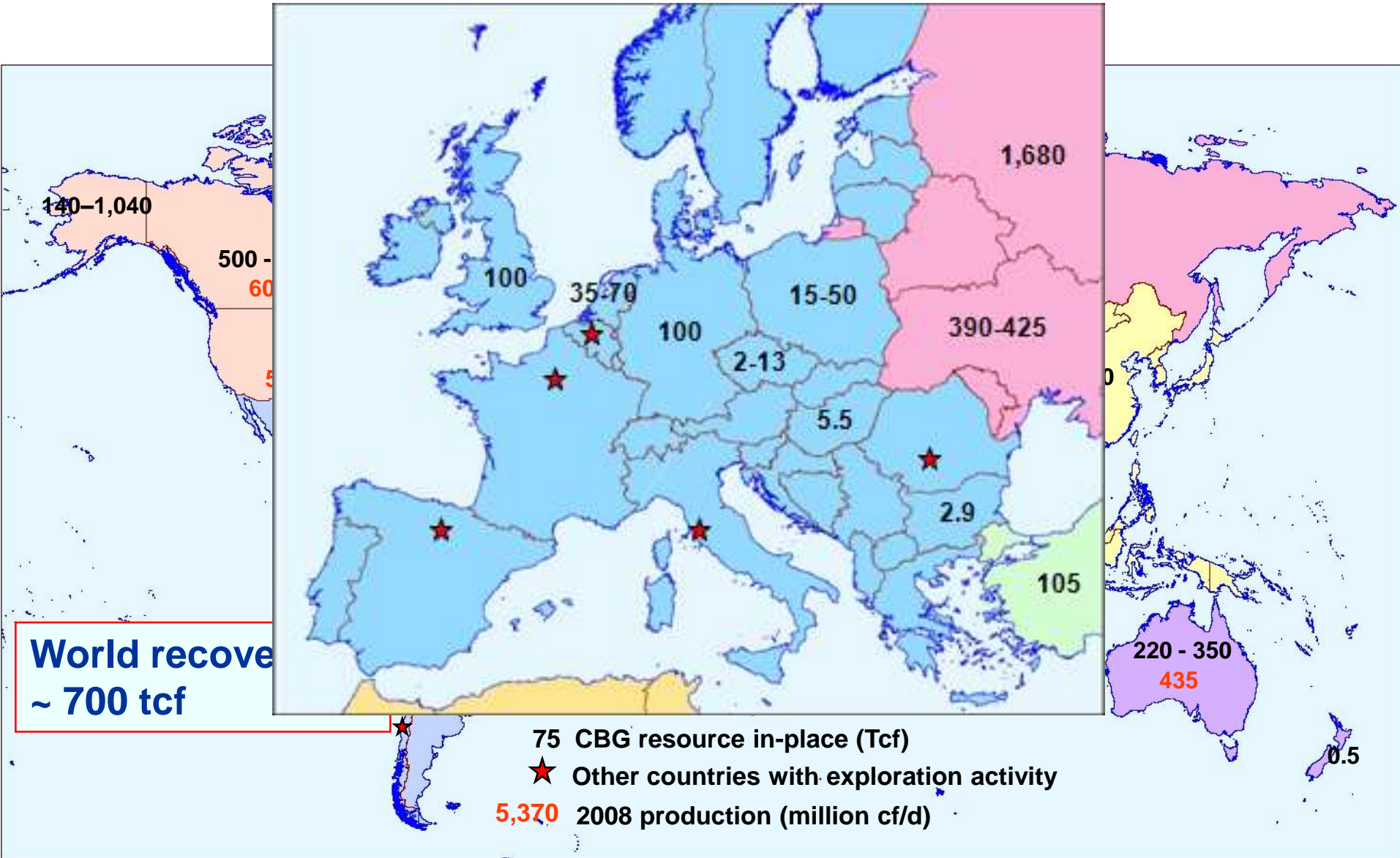
Midland Valley of Scotland (UK)

Dnieper-Donets Basin (Ukraine)

Ordos & Qinshui basins (China)

Gas Resource Plays

Coal Seam Gas: Resource Distribution



Coal Seam Gas: Resources

- Even within each basin, each coal field is unique, therefore all basins have their own unique CBG properties.
- Recoverable resource estimates are therefore extremely speculative except where there is previous production experience.
- Recoverable resources also determined by environmental regulations (well density; water disposal).
- Estimates of in-place and recoverable resources for the USA imply a recovery factor in the range 11–15%.
- EnCana estimates 40% is possible for Palliser in Alberta.
- Europe, dominated by Carboniferous coal, will be lower.

Gas Resource Plays

Coal Seam Gas: Some Players in Europe

Belgium	European Gas / Transcor Astra
Bulgaria	PDNG Sofia; Park Place Energy
France	European Gas; Elixir Petroleum(?); BG?
Germany	BG; ExxonMobil
Italy	European Gas; Independent Resources
Netherlands	BG
Poland	CETUS-Energetyka; CH4; Composite Energy / BG; EurEnergy Resources; Metanel; Pol-Tex Methane
Spain	Hidrocarburos del Cantabrico; HUNOSA; 3 others
UK	Alkane; Centrica; Coastal / Eden; Composite / BG; Greenpark (eCorp/Egdon/Star); Marathon; Nexen / IGas; Reach

Coal Seam Gas: Production

What Makes a Good Coal Seam Reservoir?

Bituminous / sub-bituminous coal ($R_0 > 0.6$ and < 1.6);

Seams $> 0.4\text{m}$ thick;

Optimum depth in range 200 – 1,200m; few wells are $> 1,500\text{m}$ but the deepest known, in northern Piceance Basin, is $\sim 2,500\text{m}$;

Well-developed cleats (fracture permeability);

Extensional stress field (avoid compressional tectonics);

Uplift without subsequent subsidence.

Coal Seam Gas: Production – Europe & CIS

- UK: trial production up to 200,000 cf/d from Airth-10 (Midland Valley Scotland), now being redeveloped (govt. approval Jan 2007). Doe Green (Lancashire Coalfield) has had commercial production (45,000 cf/d) from one well since June 2009.
- France: Folschviller 2 (Lorraine) tested but issues with water influx from mine workings and aquifer.
- Kazakhstan: CBG production;
- Russia: CBG test production (Kuznetsk Basin).
- By contrast Europe, especially Germany (~ 47 projects) & UK (~ 35 projects), is a world leader in Coal Mine Methane (CMM) production. Czech Republic, France, Poland, Kazakhstan, Russia and Ukraine also have CMM projects.

Coal Seam Gas: Issues

Production

- Establishing the most efficient well completion configuration;
- Trade-off: greater pressure & gas content with depth / coal rank but better permeability & produced water quality if shallow.

Environmental Downside

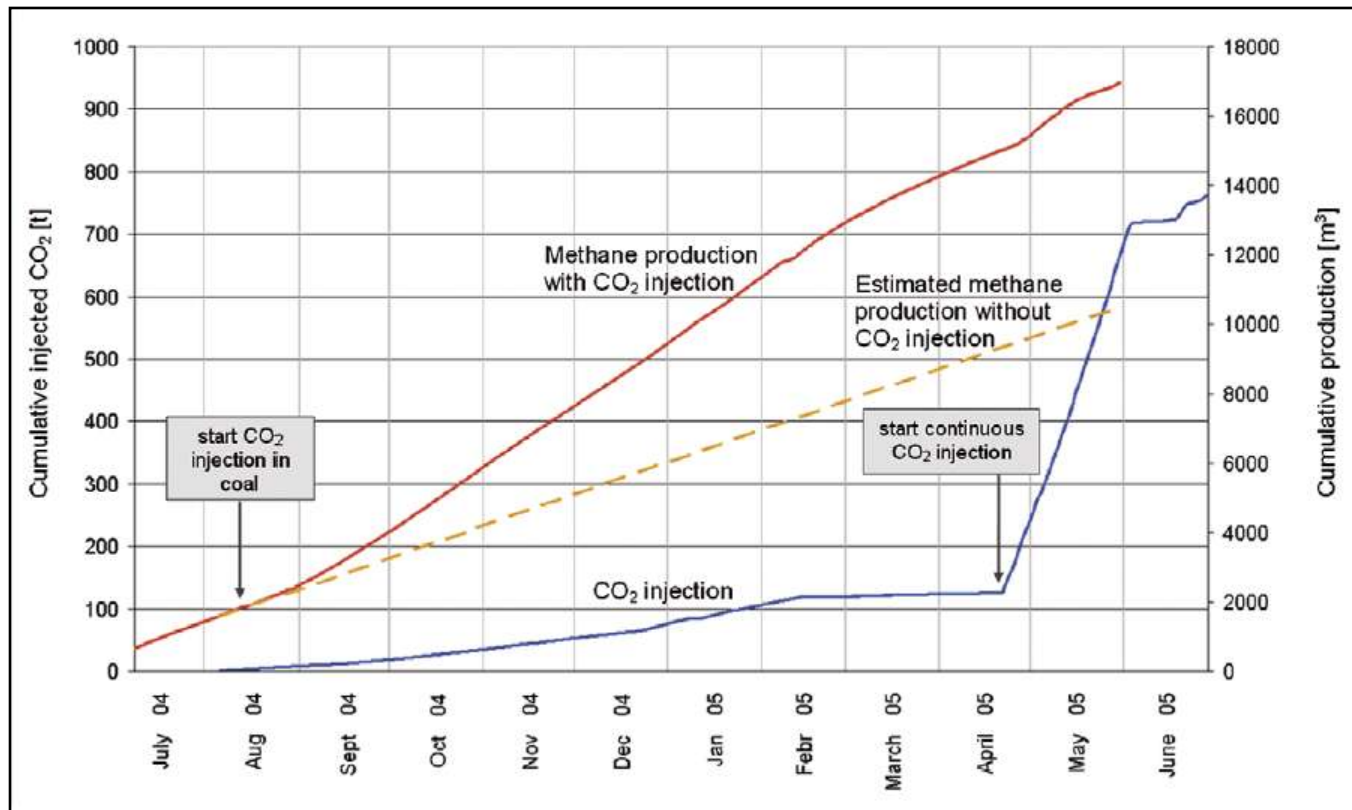
- Environmental footprint of large well numbers;
- Potential impact of hydraulic fracturing on drinking water;
- Saline brine disposal.

Environmental Upside

- CO₂ sequestration through injection for enhanced recovery;
- Use of mine methane that would otherwise be GHG.

Coal Seam Gas: Environmental Issues

CO₂ sequestration through injection for enhanced recovery:
the EU RECEPOL ECBM project, Kaniów, Upper Silesia, Poland





Edwin L Drake (right foreground)
at Oil
Creek, Titusville, Pennsylvania.

The Drake well discovered oil at a
depth of 21 metres on 27th
August 1859 and pumped initially
at 20 - 25 barrels / day.

“Tight” Self-Sourcing Natural Gas Reservoirs

Fractured organic shale; chalk.

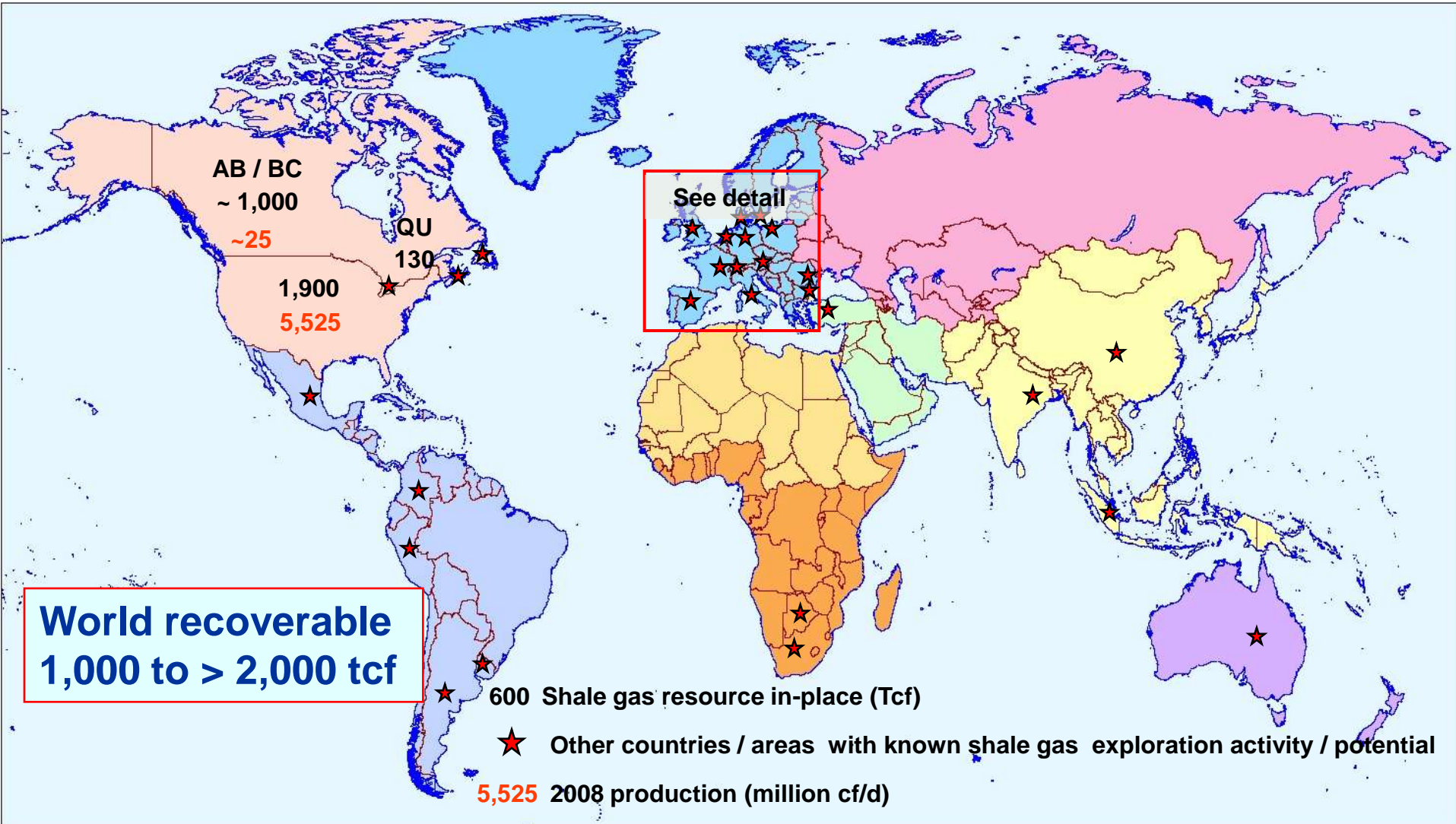
Characteristics

Self-contained source-reservoir petroleum systems; significant adsorbed gas; may have co-produced water; frequently underpressured; permeabilities in nano- to microdarcy range.

Appalachian Basin Devonian black shale (since 1825) but even here new plays are developing (e.g. Marcellus Shale);
Mississippian Barnett Shale, Fort Worth Basin;
Muskwa Shale, Horn River Basin, British Columbia;
Niobrara chalk, Denver Basin.

Gas Resource Plays

Shale Gas: Resource Distribution

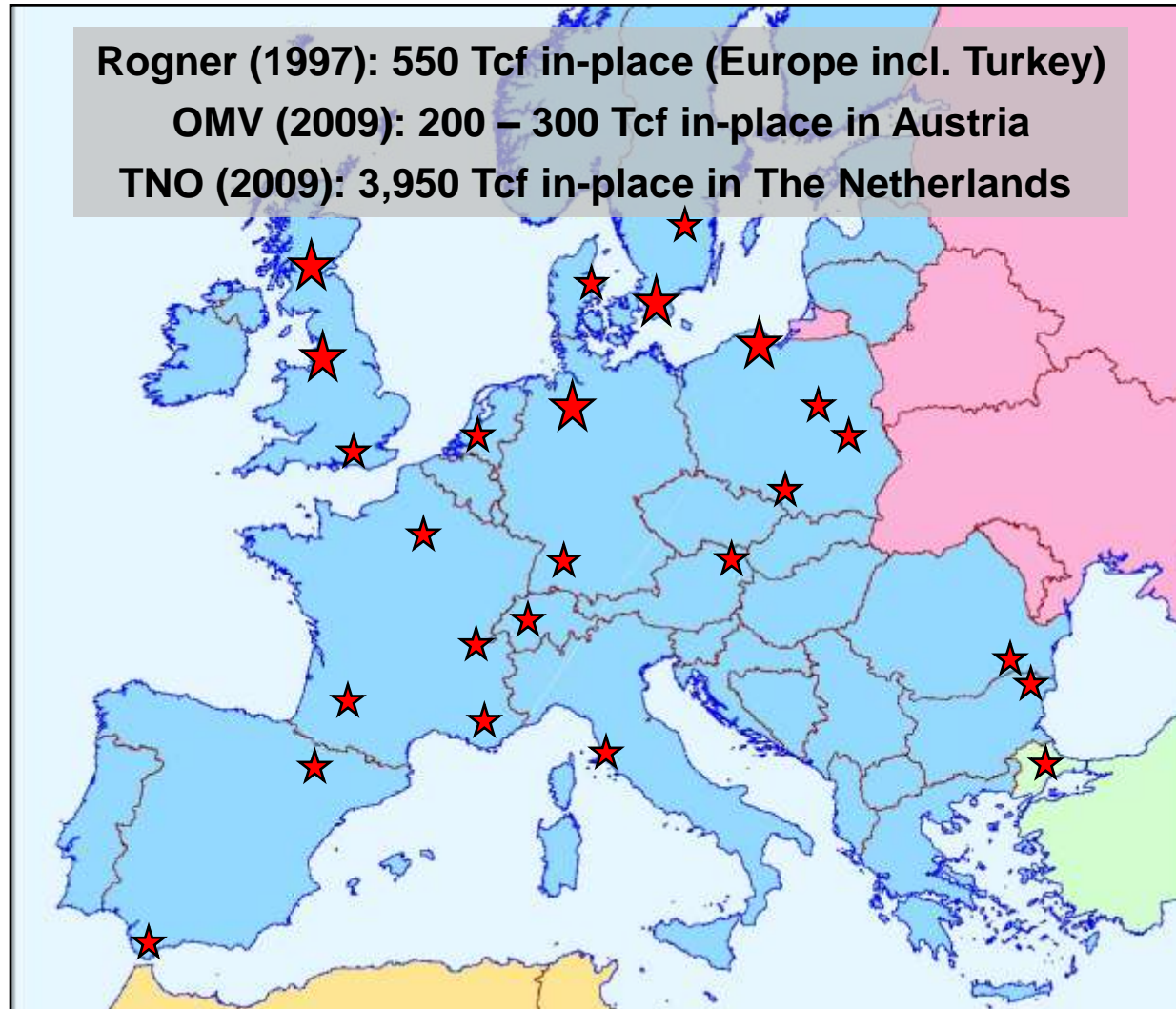


Shale Gas

European Companies Buying into US Shale Gas

- BG:** 50% of Exco's Haynesville Shale, Cotton Valley and Bossier assets, Gulf Coast Basin and Huron and Marcellus Shale assets, Appalachian Basin.
- BP:** Chesapeake's Woodford Shale interests, Arkoma Basin; 25% interest in Chesapeake's Fayetteville Shale acreage, Arkoma Basin; JV with Lewis Energy in Eagle Ford Shale, Maverick Basin.
- Eni:** 27.5% interest in Quicksilver's Barnett Shale Alliance properties, Fort Worth Basin.
- Shell** East Resources' interests in Marcellus Shale.
- StatoilHydro:** 32.5% interest in Chesapeake's Marcellus Shale assets, Appalachian Basin.
- Total:** 25% interest in Chesapeake's Barnett Shale assets, Fort Worth Basin.

Shale Gas: European Activity & Resources



Gas Resource Plays

Shale Gas: Significant Players in Europe

Austria	OMV
Denmark	Schuepbach; Total
France	3Legs; Realm; Schuepbach Energy; Total; Elixir(?)
Germany	3Legs Resources; BNK; ExxonMobil & BEB; Realm
Italy	Independent Resources
Netherlands	Cuadrilla
Poland	3Legs Resources / ConocoPhillips; BNK; Chevron; Cuadrilla; EurEnergy; ExxonMobil; Marathon; PGNiG; PKN Orlen; RAG; San Leon / Talisman
Sweden	Shell; Gripen Gas
Switzerland	Schuepbach Energy
UK	Composite Energy / BG; Cuadrilla; eCorp / Egdon / Greenpark / Star; EurEnergy; Nexen / IGas

Shale Gas

What Makes a Good Shale Gas Reservoir?

- Organic-rich: TOC > 2.0%.
- Maturity: Gas prone (mature humic type III) or gas window (over-mature sapropelic type II) or immature subject to biogenic decomposition. Thermogenic generally in range R_0 1.15 to 1.4 (wet gas); >1.4 to <3.0 (dry gas) but type III can be lower ($R_0 > 1.0$).
- Thick: > 50m; 30m minimum.
- Lithology: silt laminae desirable; hydrophobic (water-absorbing) clays detrimental as they inhibit gas desorption.
- Brittle: quartz / carbonate > 40%; low-expandable clays < 30%.
- Natural fractures (contained): enhanced if limestone bound.
- Deeper seems to be better as high / over-pressured shale favours pore gas over adsorbed gas.
- Low effective stress.

Gas Resource Plays in Europe

A Prime Target for Resource Play Development

- Large population and therefore large market;
- Proximity to market and established pipeline infrastructure improves economics of low per-well production volumes;
- Increasing demand for natural gas;
- Historically strong natural gas price and market fundamentals.

Gas Resource Play Issues

- Most plays are “statistical” in nature: many wells are needed to understand the play and best drilling / completion techniques.
- Per-well reserves and productivity can be low, and benefit from an established gas distribution infrastructure.
- Recoverable resources require good technology in order to be converted into reserves (smart wells; fracture and stimulation; micro-seismic mapping).
- To convert resources into reserves also requires large numbers of wells (10-acre spacing vs 640 for conventional).
- Environmental issues such as well footprint and produced water may limit recovery.

Shale Gas Fracturing



Thank You