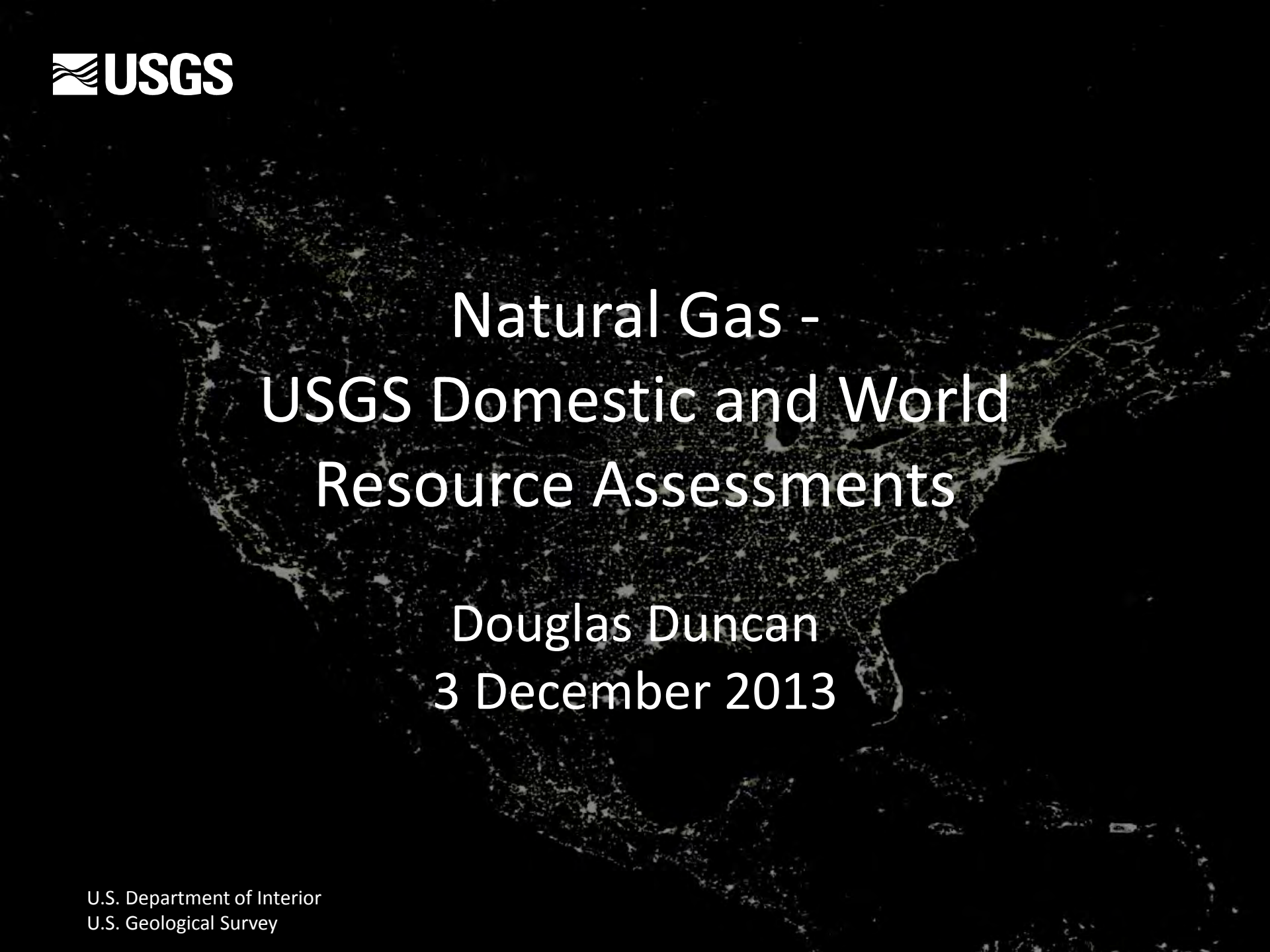


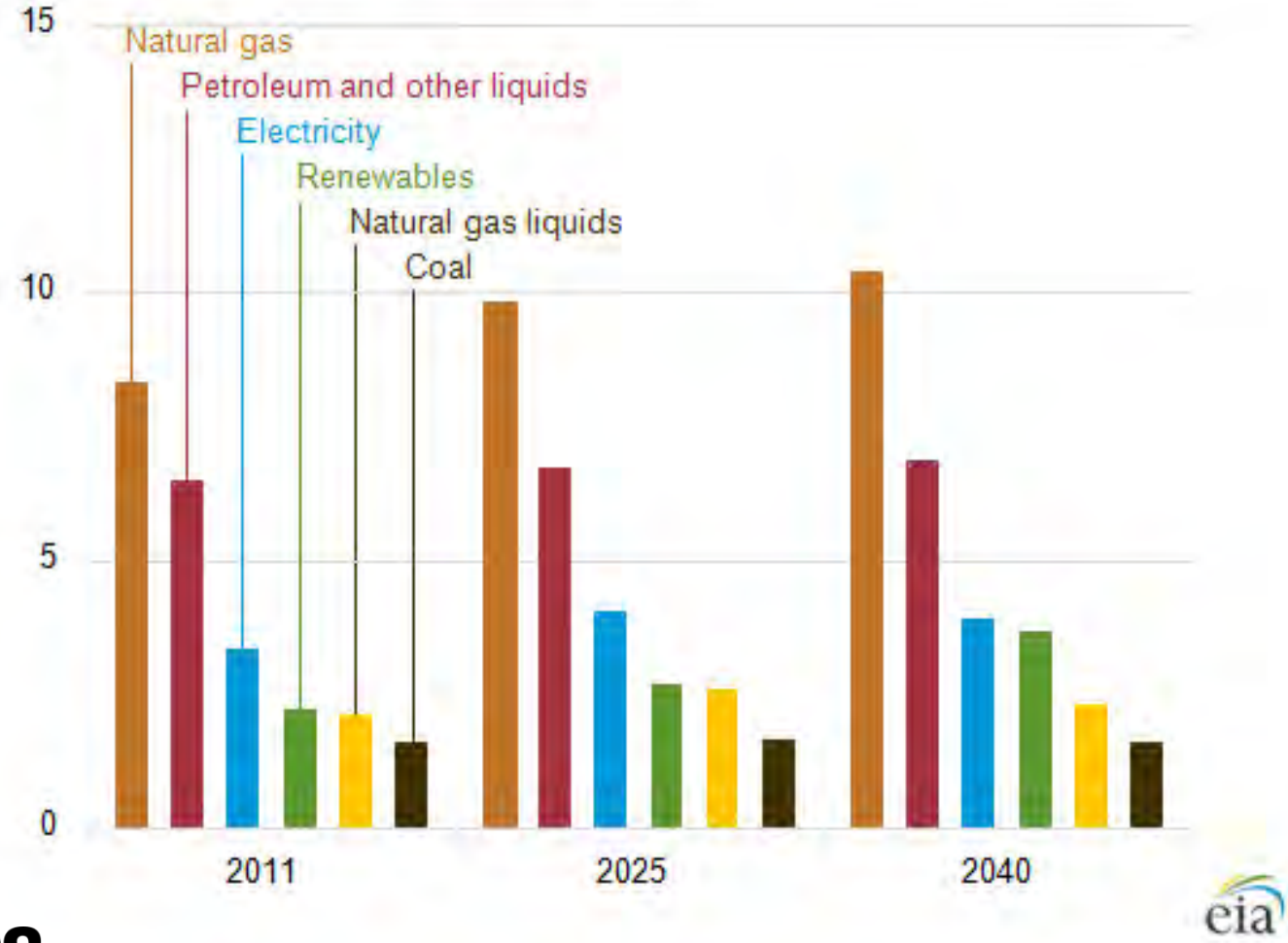
Natural Gas - USGS Domestic and World Resource Assessments

Douglas Duncan

3 December 2013

U.S. Department of Interior
U.S. Geological Survey

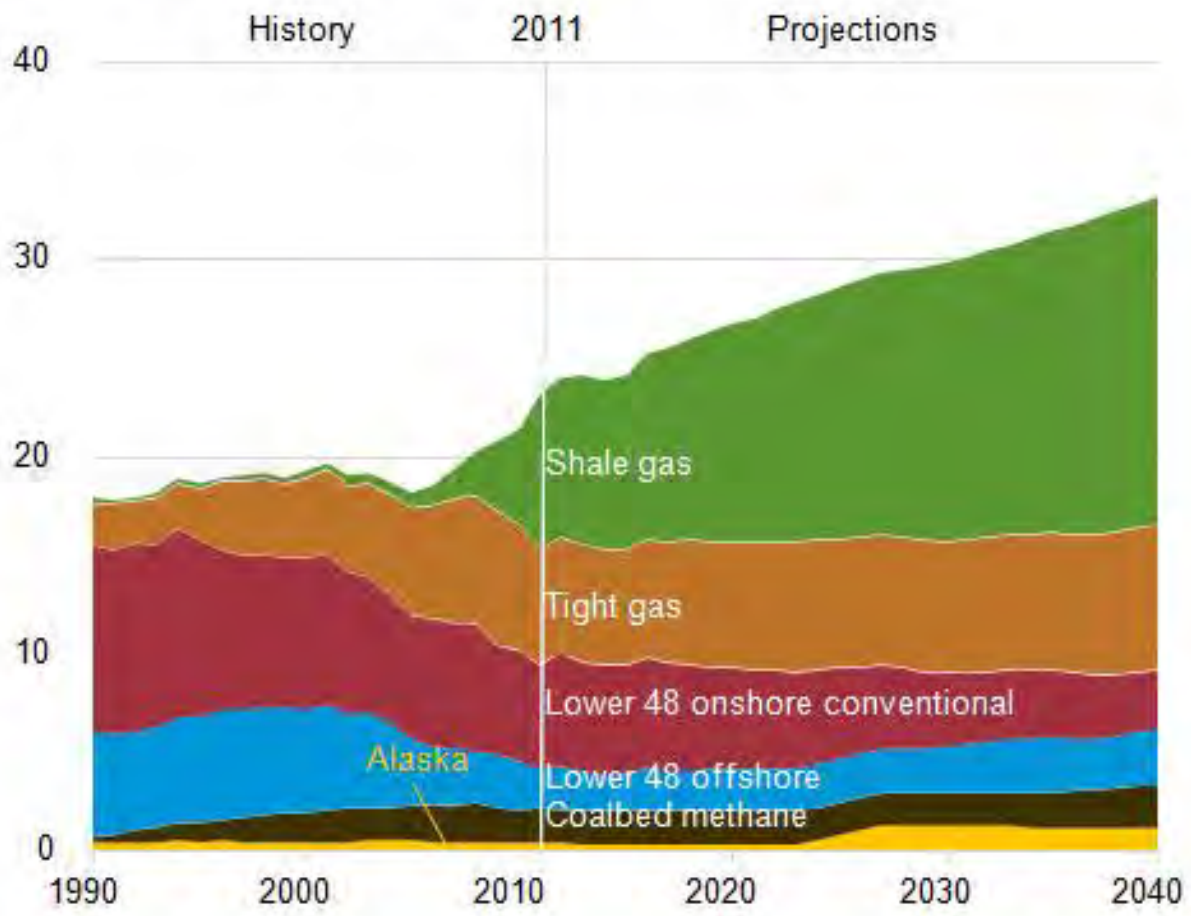
Figure 64. Industrial energy consumption by fuel, 2011, 2025, and 2040 (quadrillion Btu)



USGS

EIA Annual Energy Outlook 2013

Figure 91. Natural gas production by source, 1990-2040 (trillion cubic feet)



USGS

eia

EIA Annual Energy Outlook 2013

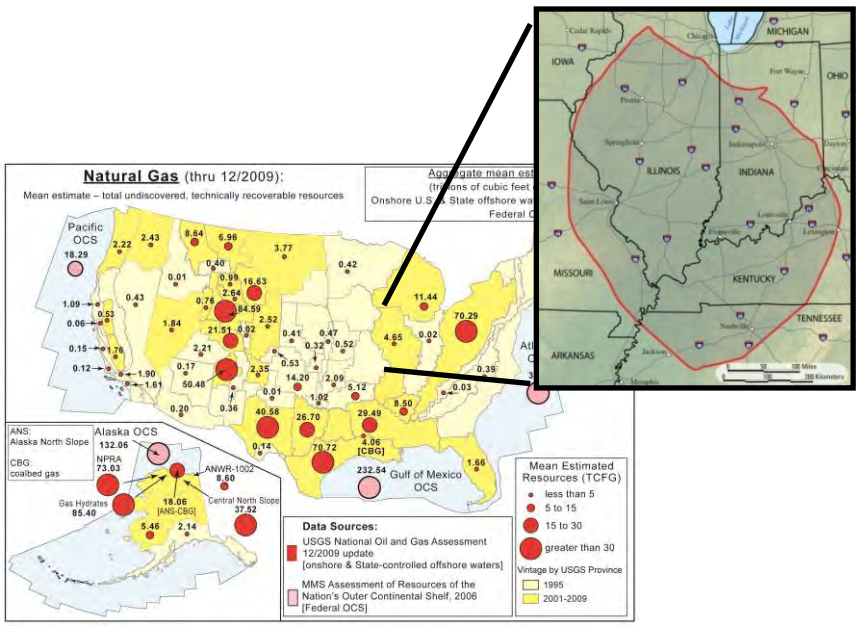
Overview: USGS Energy Resources Program

ERP Mission:

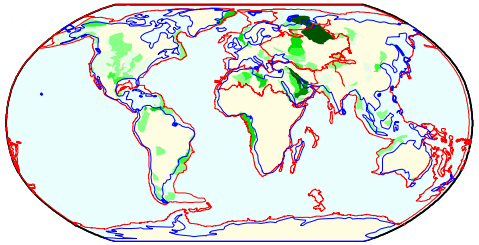
(1) Understand processes critical to formation, accumulation, occurrence, and alteration of geologically based energy resources,

(2) Conduct scientifically robust assessments of those resources, and

(3) Study impact of energy resource occurrence, production and use on environmental and human health.



World Petroleum; Circum-Arctic Resource Assessment



regional

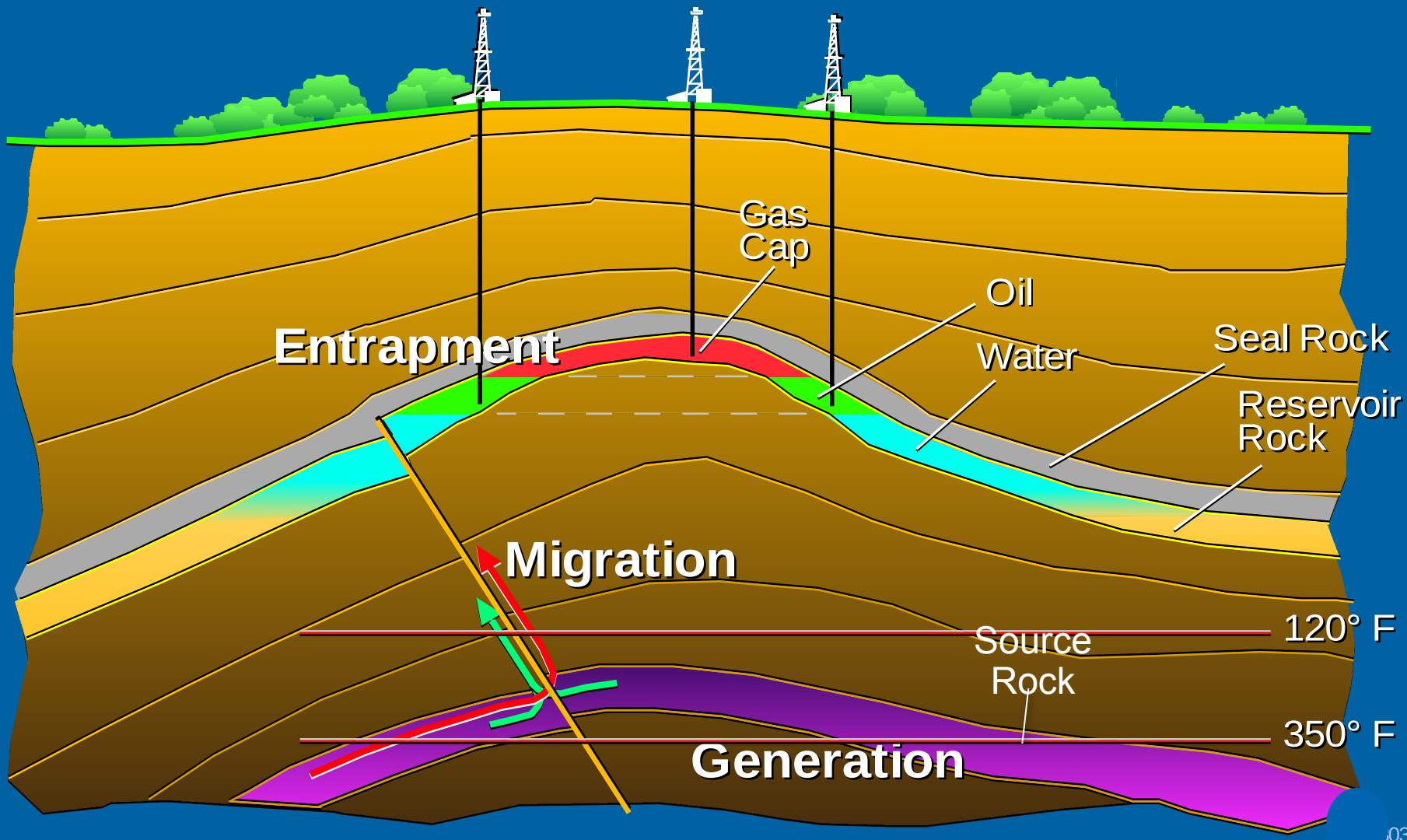
national

international

USGS

Petroleum System Elements

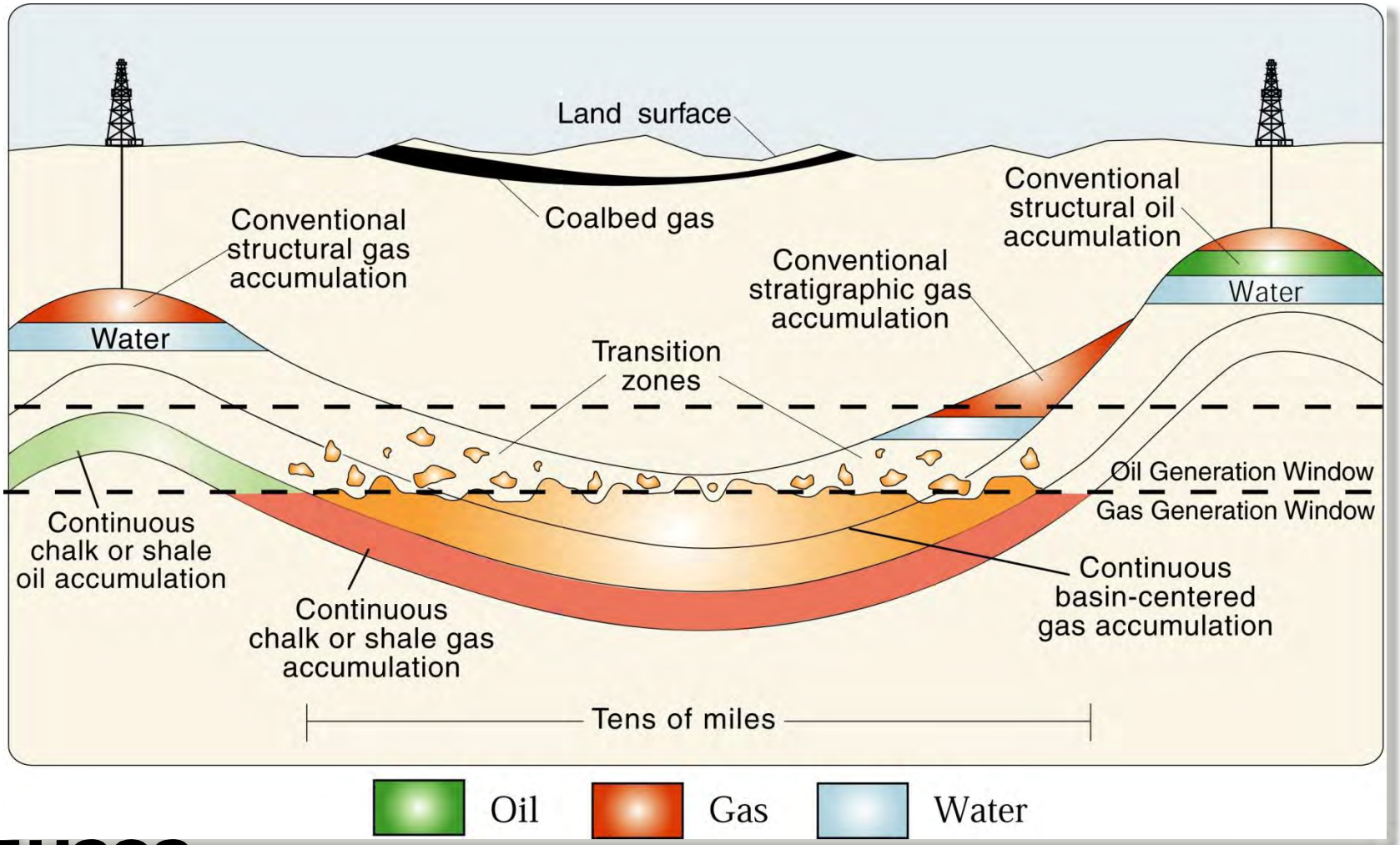
Total Petroleum System



USGS

Armentrout, 2001

Conventional *vs* Unconventional
Defined geologically by USGS



USGS

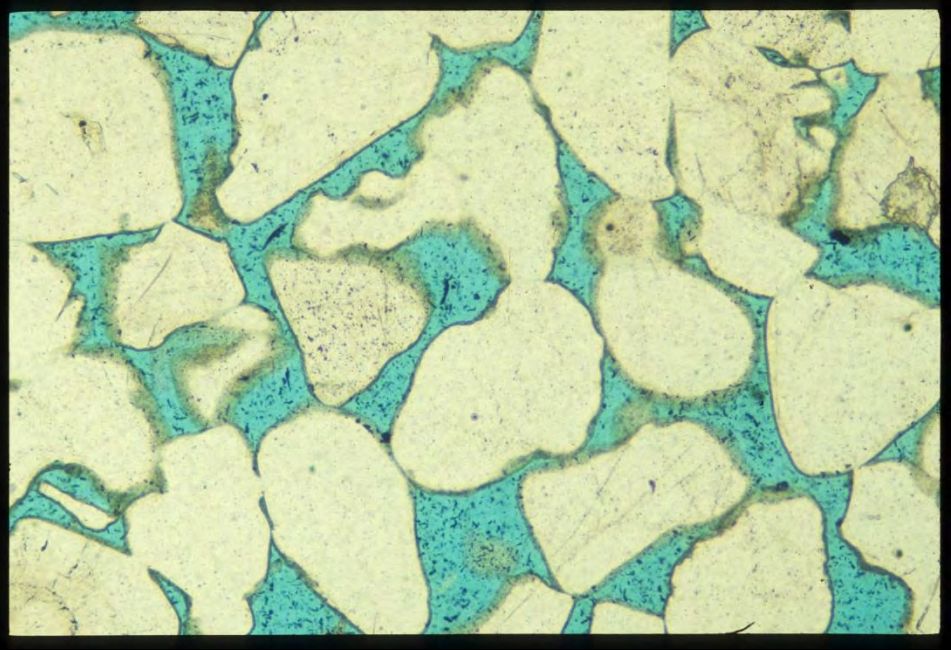
From Schenk and Pollastro (2003)

Conventional Reservoir

Spiro Sandstone

Core slab

Medium-grained, cross-bedded sandstone

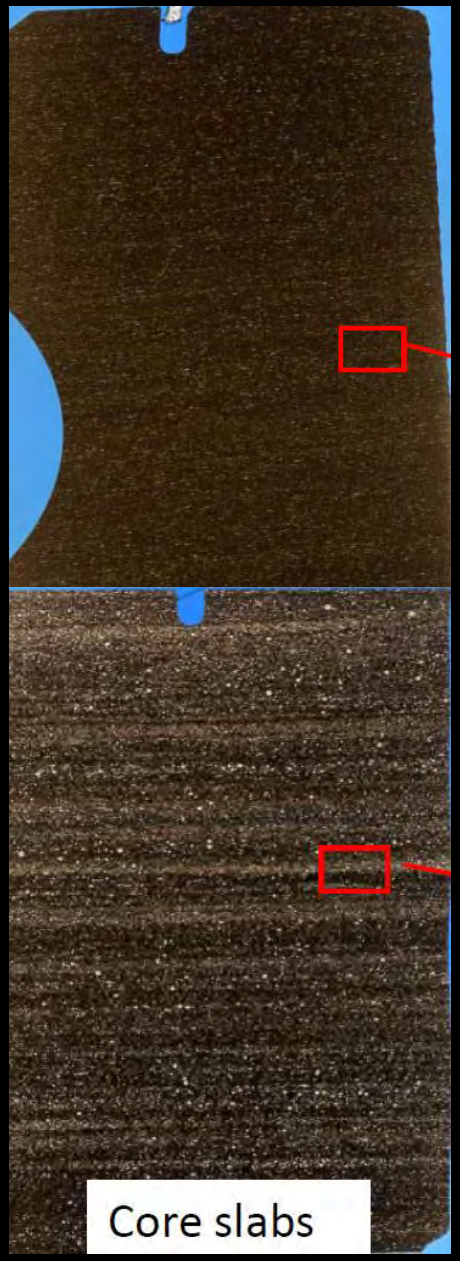


Thin section photomicrograph

USGS

Continuous Reservoir

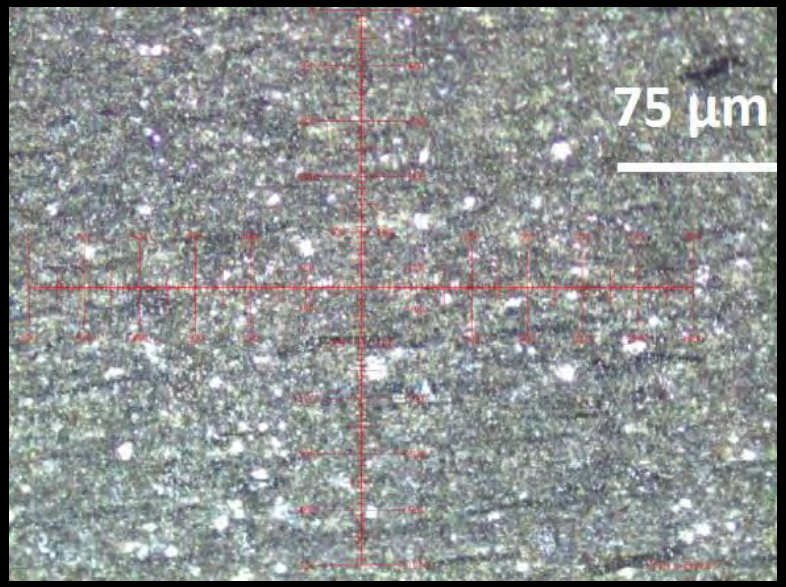
Woodford Shale

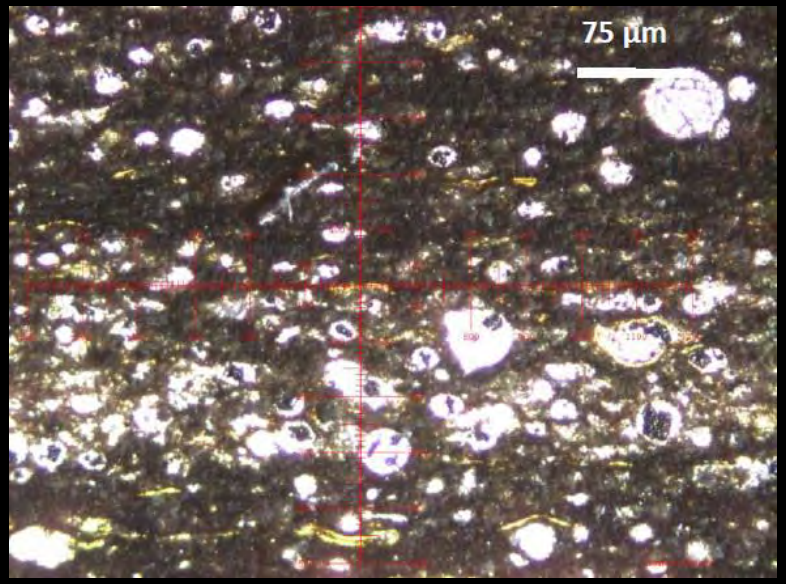


(Slatt and others, 2011)

Weakly Laminated Shale

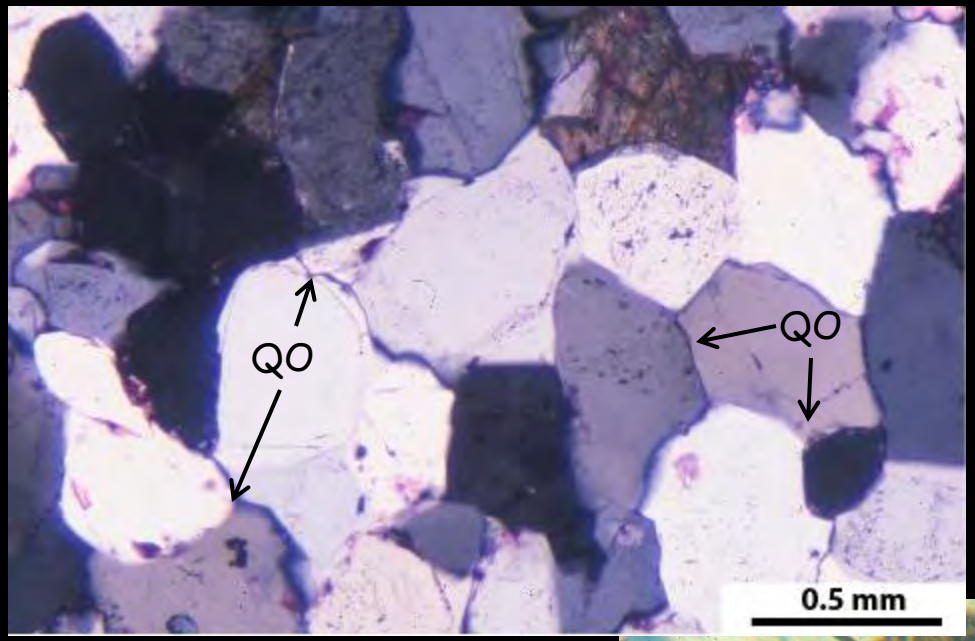
Strongly Laminated Shale





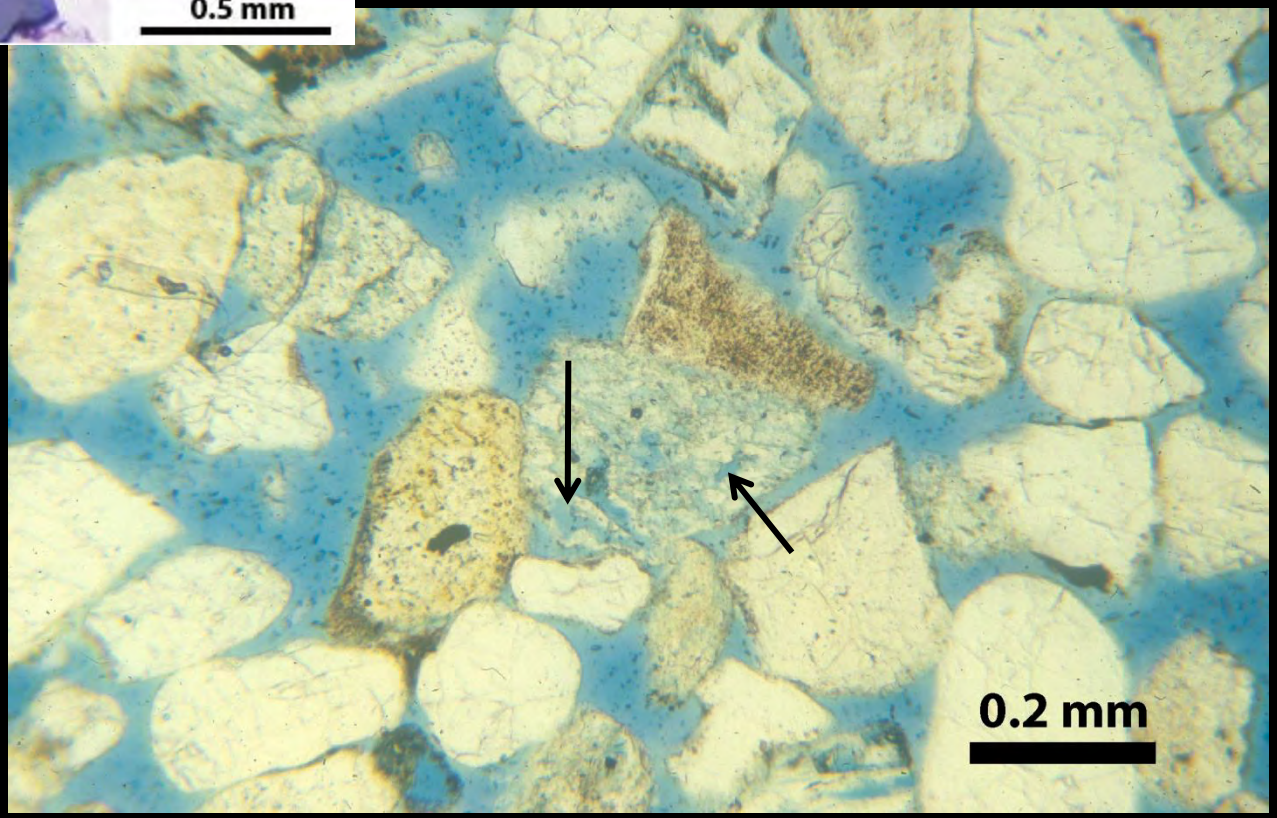
Thin section photomicrographs

USGS



Photomicrograph from a tight sandstone in the **Bossier Fm**. It is tight due to abundant quartz overgrowths (QO), and porosity exists between adjacent quartz overgrowths

Photomicrograph of an uncemented sandstone from the **Jurassic Morrison Fm**. Blue is epoxy that fills primary pores (between grains) and some secondary pores that have developed from partial dissolution of some detrital feldspar grains.



USGS

Continuous (Unconventional) Oil and Gas

Enabled by directional drilling and hydraulic fracturing
Majority of domestic gas production (39% from shale)
One field (Bakken/Three Forks Formation) is ~10% of U.S. oil production
Concern over impacts include:
- Water supply and availability – consumptive use
- Aquifer contamination
- Landscape and ecological impacts
- Induced seismicity from waste fluid disposal

Undiscovered, Technically Recoverable Resources Defined

Undiscovered - Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations.

Technically recoverable - Those resources producible using currently available technology and industry practices.

No economic viability analysis!

USGS

Goal of USGS Assessments

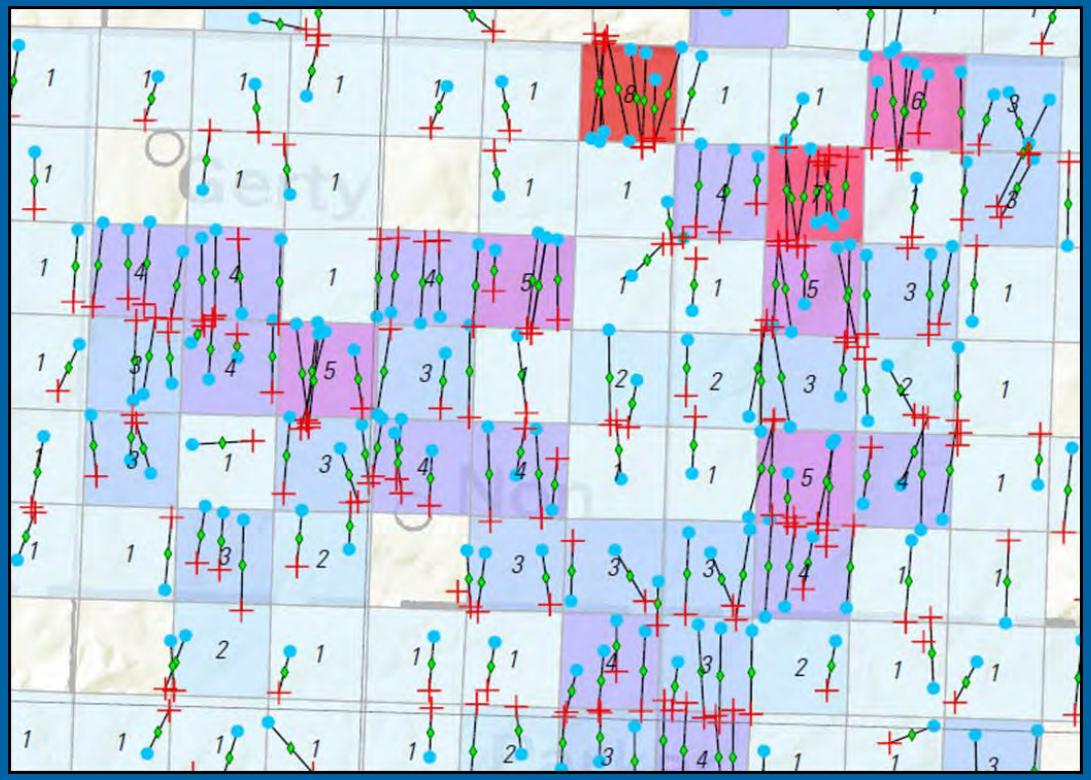
Develop geologically based and statistically sound hypotheses concerning the quantities of oil and gas that have the potential to be added to proved reserves in the U.S. and the world. USGS produces estimates of undiscovered, technically recoverable resources.

Assessment includes an estimate of measurement uncertainty, expressed quantitatively

USGS

Continuous Methodology

- Geologic characterization of assessment units
- Drainage areas of wells (cell sizes)
- Number of potential cells (tested and untested)
- Engineering data – well production and performance
- EUR (estimated ultimate recovery) distribution

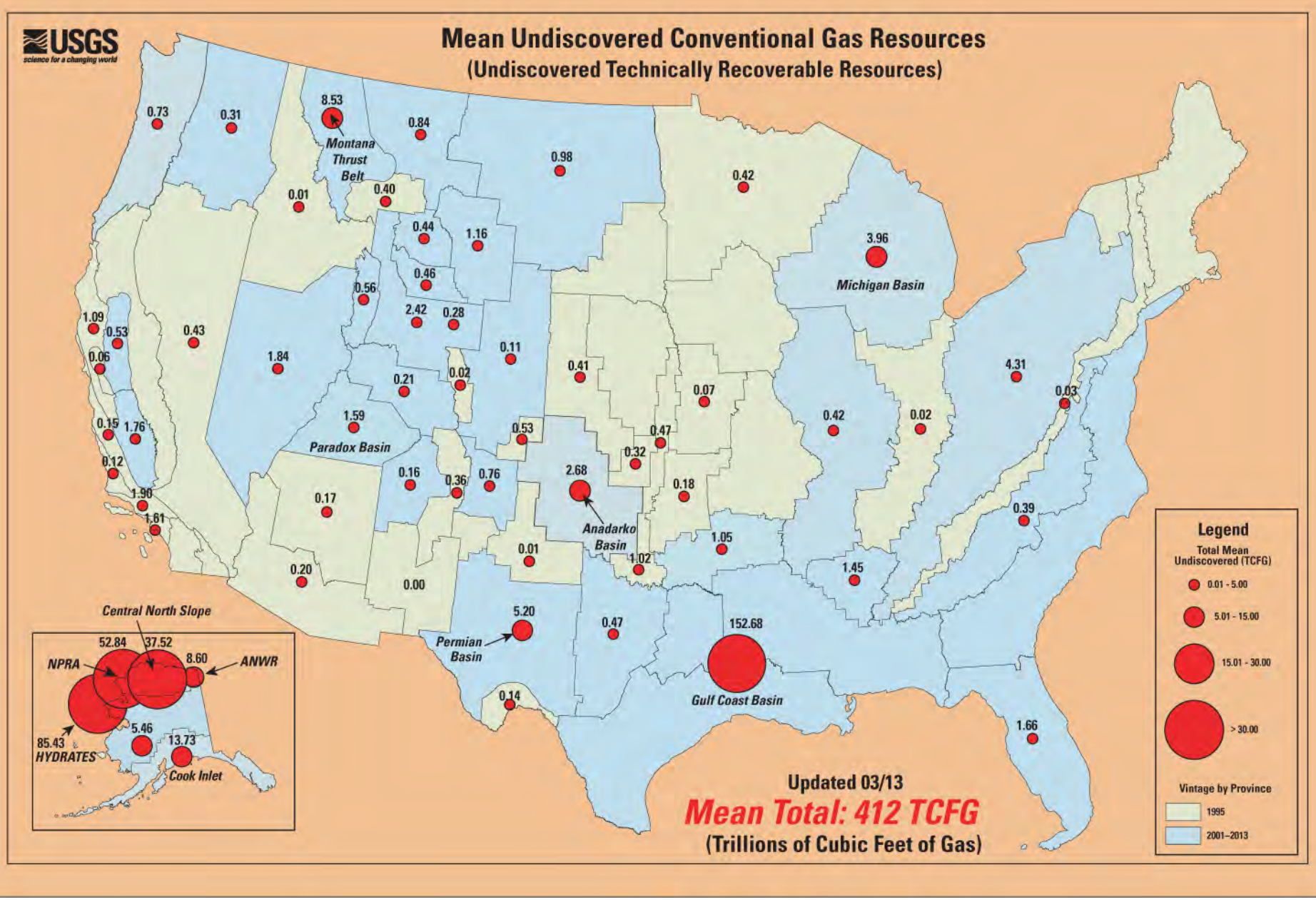


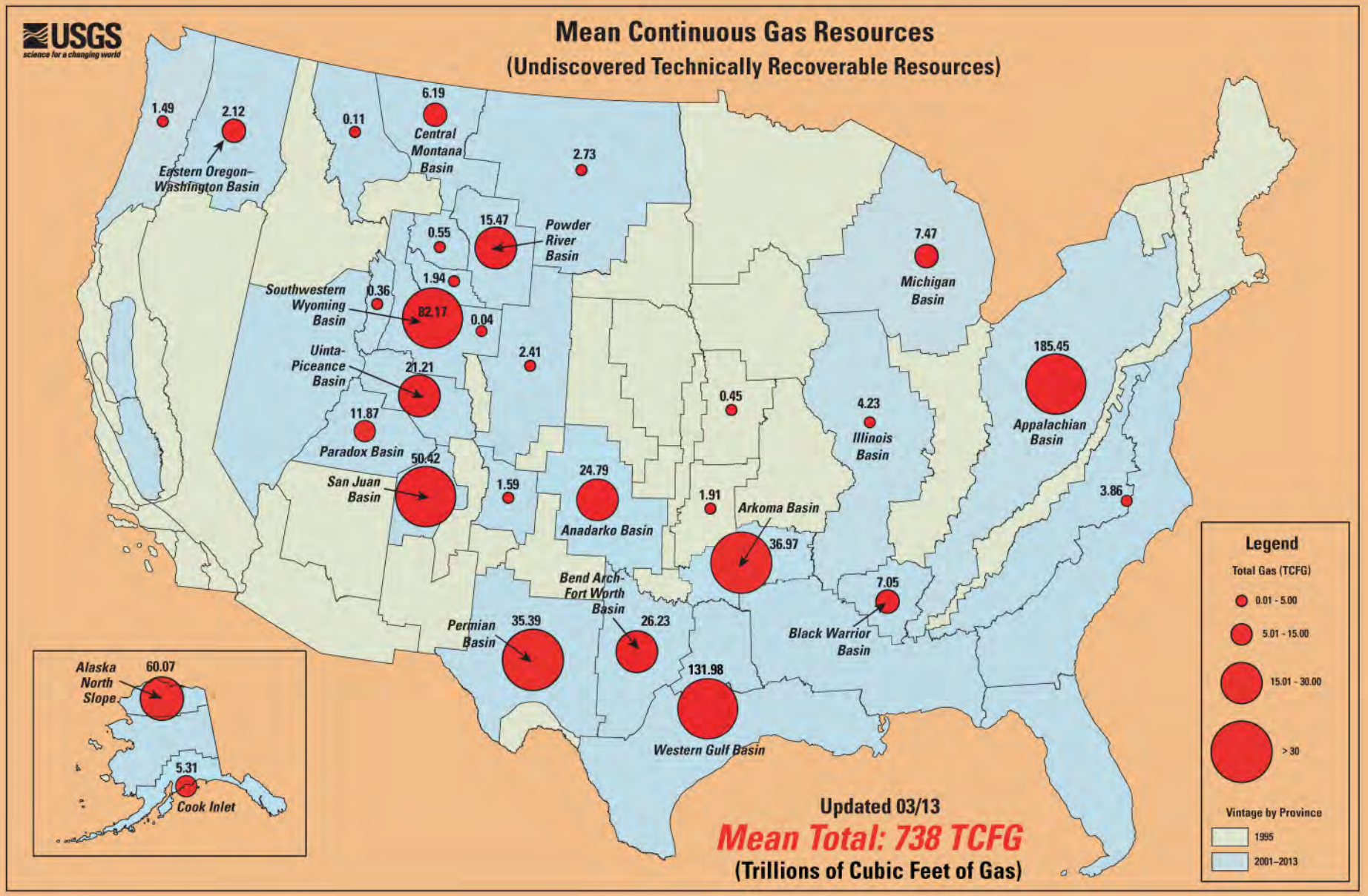
Woodford Shale – Horizontal Well Density

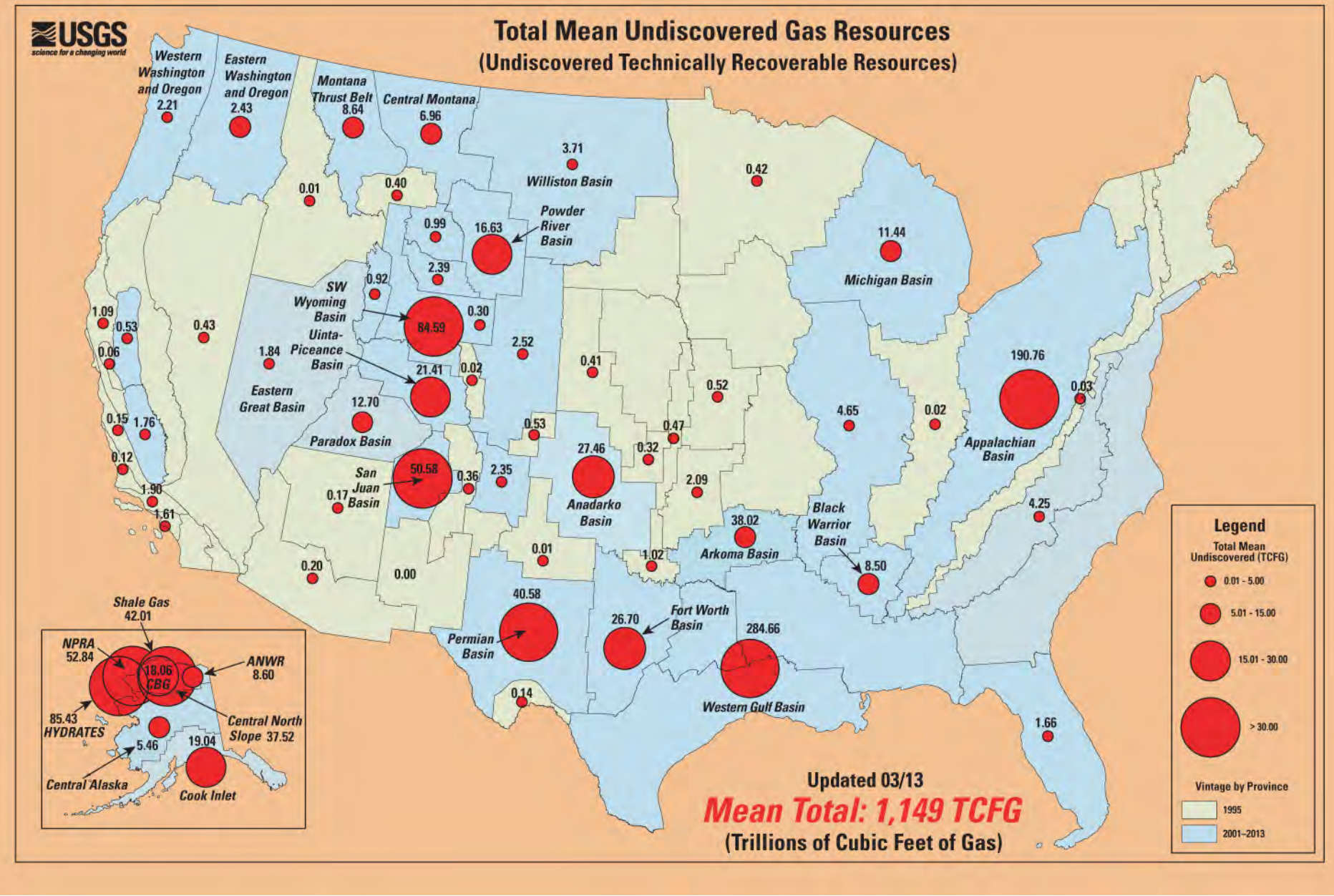
USGS

Map of Assessed Shale Gas in the United States, 2012

USGS


USGS
science for a changing world
Mean Undiscovered Conventional Gas Resources
(Undiscovered Technically Recoverable Resources)
0.73
0.31
8.53
Montana Thrust Belt
0.84
0.98
0.42
0.01
0.40
0.44
1.16
3.96
Michigan Basin
0.46
0.56
2.42
0.28
1.09
0.53
0.43
0.11
0.41
4.31
0.06
1.84
0.21
0.02
0.07
0.03
1.59
Paradox Basin
0.53
0.47
0.42
0.02
0.15
1.76
0.32
0.12
0.16
0.36
0.76
2.68
0.18
1.90
0.17
Anadarko Basin
0.39
1.61
1.05
0.01
1.02
1.45
0.20
0.00
Central North Slope
5.20
0.47
152.68
Permian Basin
52.84
37.52
8.60
NPRA
ANWR
Gulf Coast Basin
0.14
1.66
85.43
HYDRATES
5.46
13.73
Cook Inlet
Legend
Total Mean Undiscovered (TCFG)
0.01 - 5.00
5.01 - 15.00
15.01 - 30.00
> 30.00
Vintage by Province
1995
2001–2013
Updated 03/13
Mean Total: 412 TCFG
(Trillions of Cubic Feet of Gas)

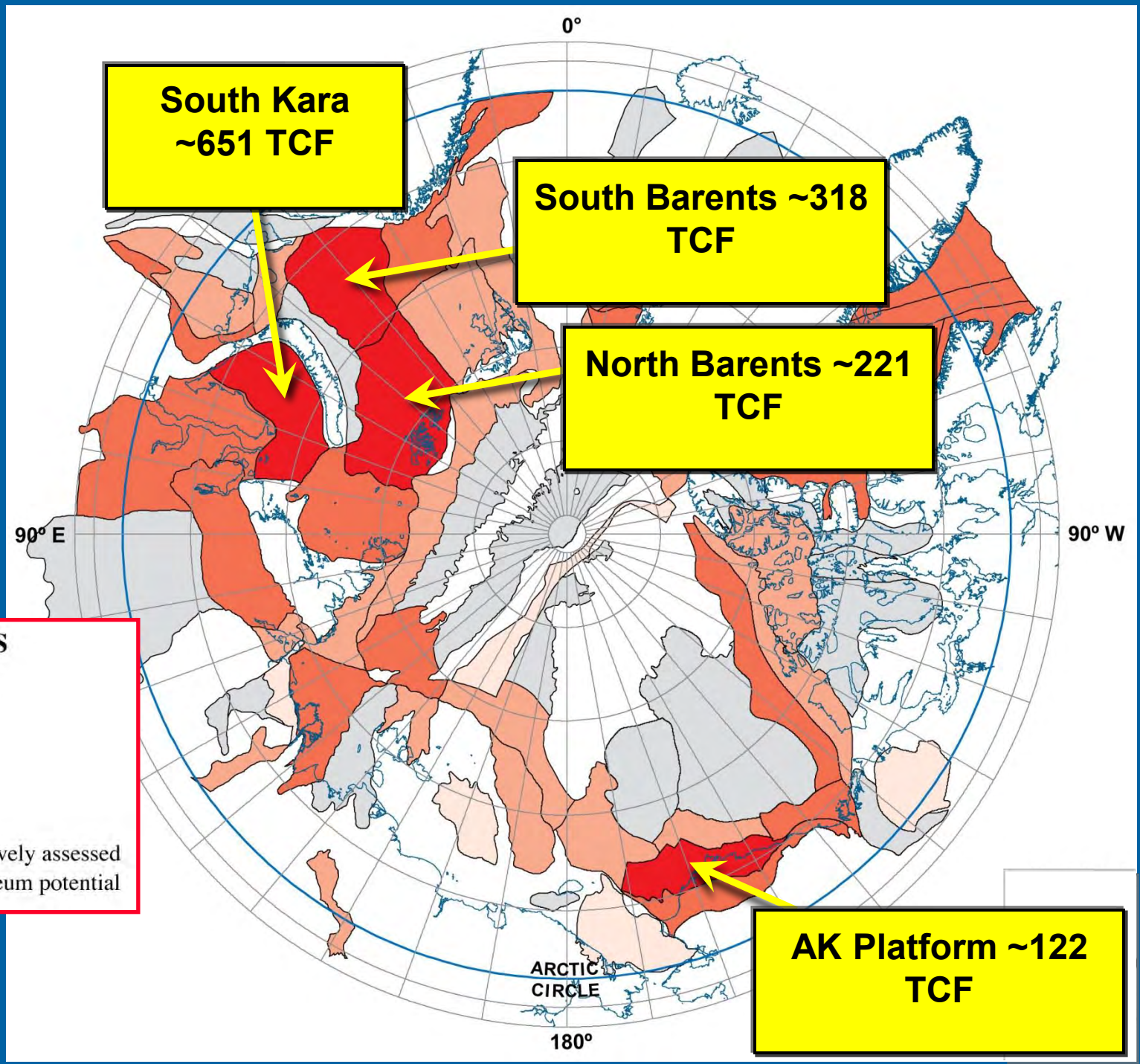

USGS
science for a changing world
Mean Continuous Gas Resources
(Undiscovered Technically Recoverable Resources)
1.49
2.12
Eastern Oregon–Washington Basin
0.11
6.19
Central Montana Basin
2.73
15.47
Powder River Basin
0.55
1.94
0.36
Southwestern Wyoming Basin
82.17
0.04
2.41
Uinta-Piceance Basin
21.21
11.87
Paradox Basin
50.42
San Juan Basin
1.59
24.79
Anadarko Basin
0.45
1.91
Arkoma Basin
36.97
4.23
Illinois Basin
7.47
Michigan Basin
185.45
Appalachian Basin
3.86
7.05
Black Warrior Basin
Bend Arch-Fort Worth Basin
26.23
Permian Basin
35.39
131.98
Western Gulf Basin
Alaska North Slope
60.07
5.31
Cook Inlet
Legend
Total Gas (TCFG)
0.01 - 5.00
5.01 - 15.00
15.01 - 30.00
> 30
Vintage by Province
1995
2001–2013
Updated 03/13
Mean Total: 738 TCFG
(Trillions of Cubic Feet of Gas)



Plus 398 Tcf Outer Continental Shelf (BOEM 2011 Assessment)

Natural Gas

Largest Total Gas AUs



USGS

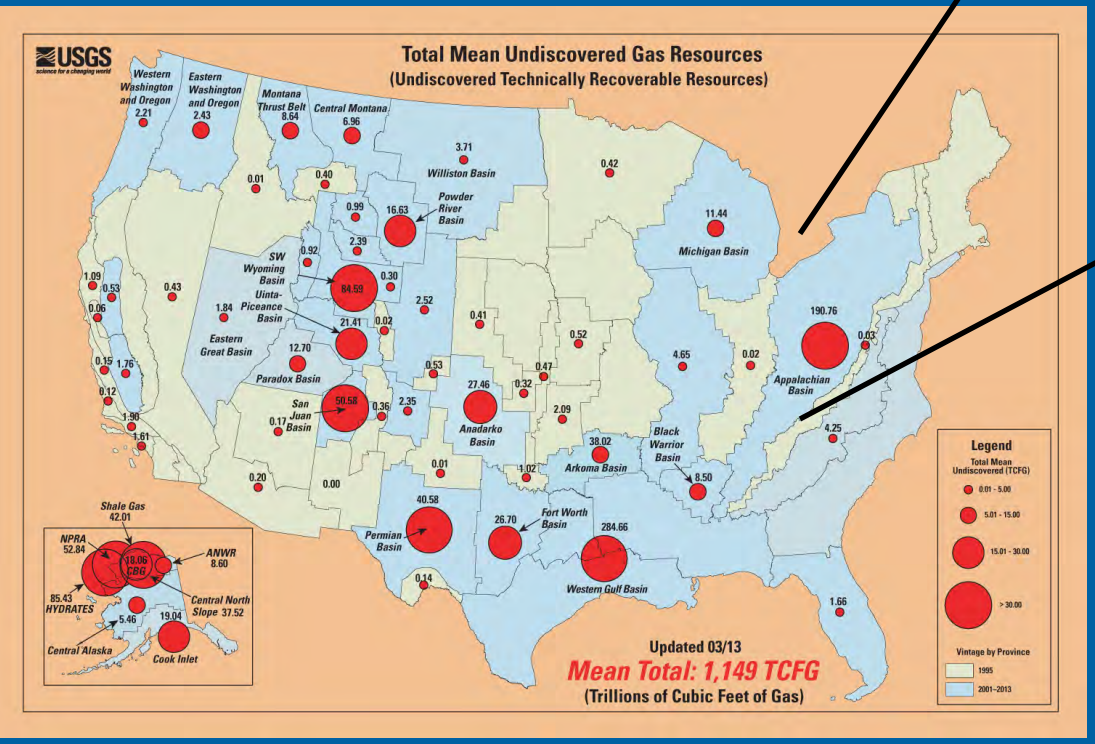
CARA Gas Estimate

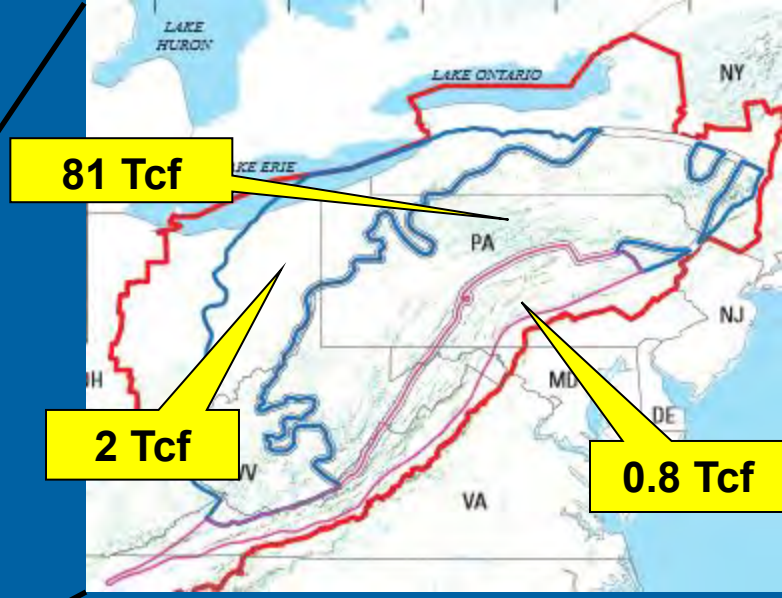
- Mean undiscovered gas: 1,670 TCF
- This is ~ 30% of global undiscovered gas
- Two thirds in just four CARA AUs:
  - South Kara Sea ~ 651 TCF
  - South Barents Basin ~ 318 TCF
  - North Barents Basin ~ 221 TCF
  - Alaska Platform ~122 TCF

USGS

Resource Assessments Change Over Time

Example: Marcellus Shale (2011)





Mean total = 84 Tcf

USGS 2002 Devonian Black Shale Continuous Gas Plays: 2 Tcf

USGS 1995 Devonian Black Shale Continuous Gas Plays: Not Assessed

USGS

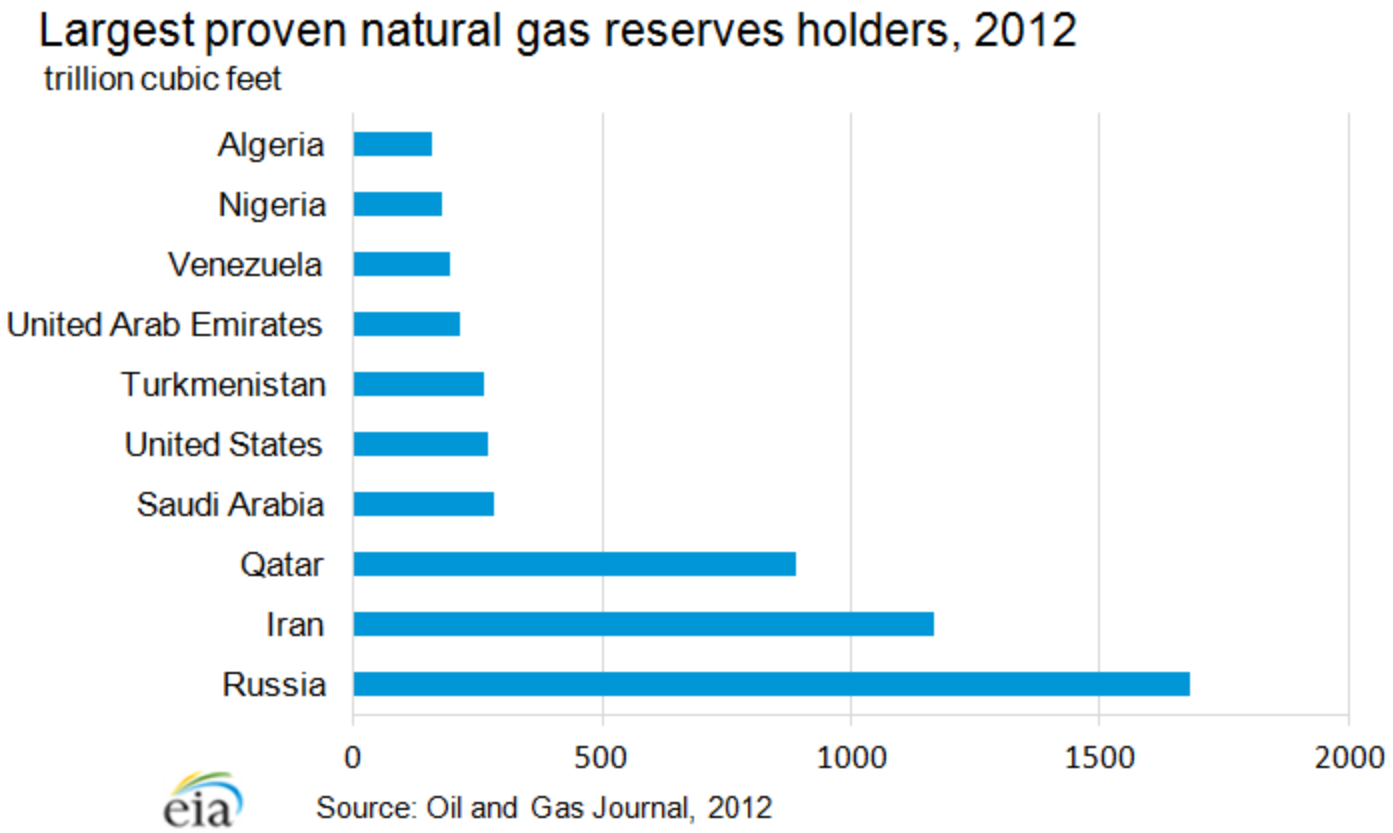
Changes result from improved geologic understanding, technological developments, other factors

Summary of USGS World Conventional Oil and Gas Resources, 2012

- Oil: 565 BBO mean
- Gas: 5600 TCFG mean
- Liquids: 166 BBO mean

USGS

Global Gas Reserves and Resource Estimate



USGS

Reminders

- USGS undiscovered, technically recoverable resources do not consider economics
- USGS world unconventional assessment is underway (results not presented today)
- Gas hydrates

USGS


http://energy.usgs.gov
USGS