IOGCC

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U.S. Shale
Reserves and Production

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Bureau of Economic Geology

Jackson School of Geosciences, The University of Texas at Austin

Outline

- The Role of Shale
- Reserves and Production Forecasting
- Implications and Considerations

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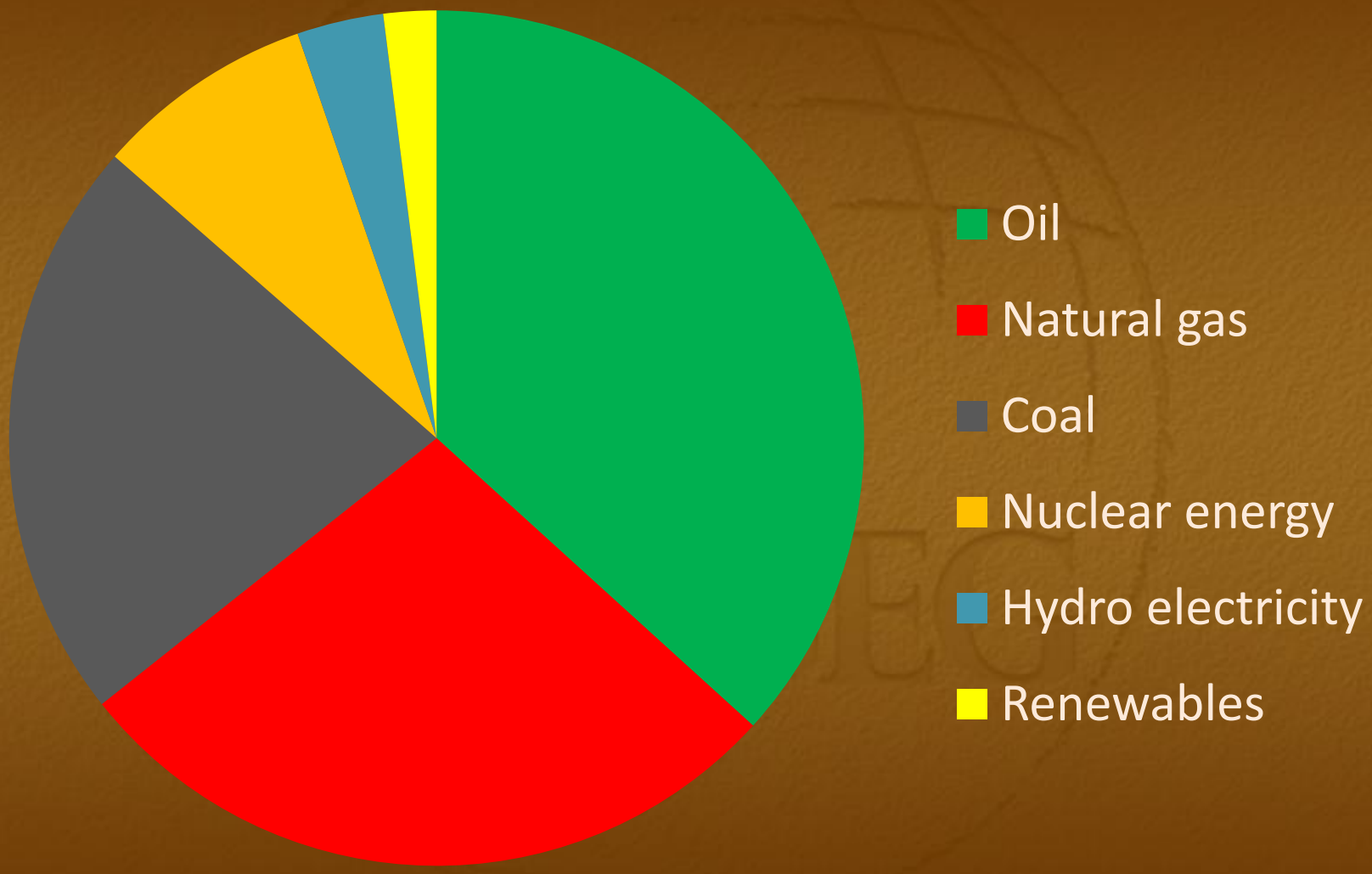
U.S. Energy Mix (%)



Source: EIA, 2012

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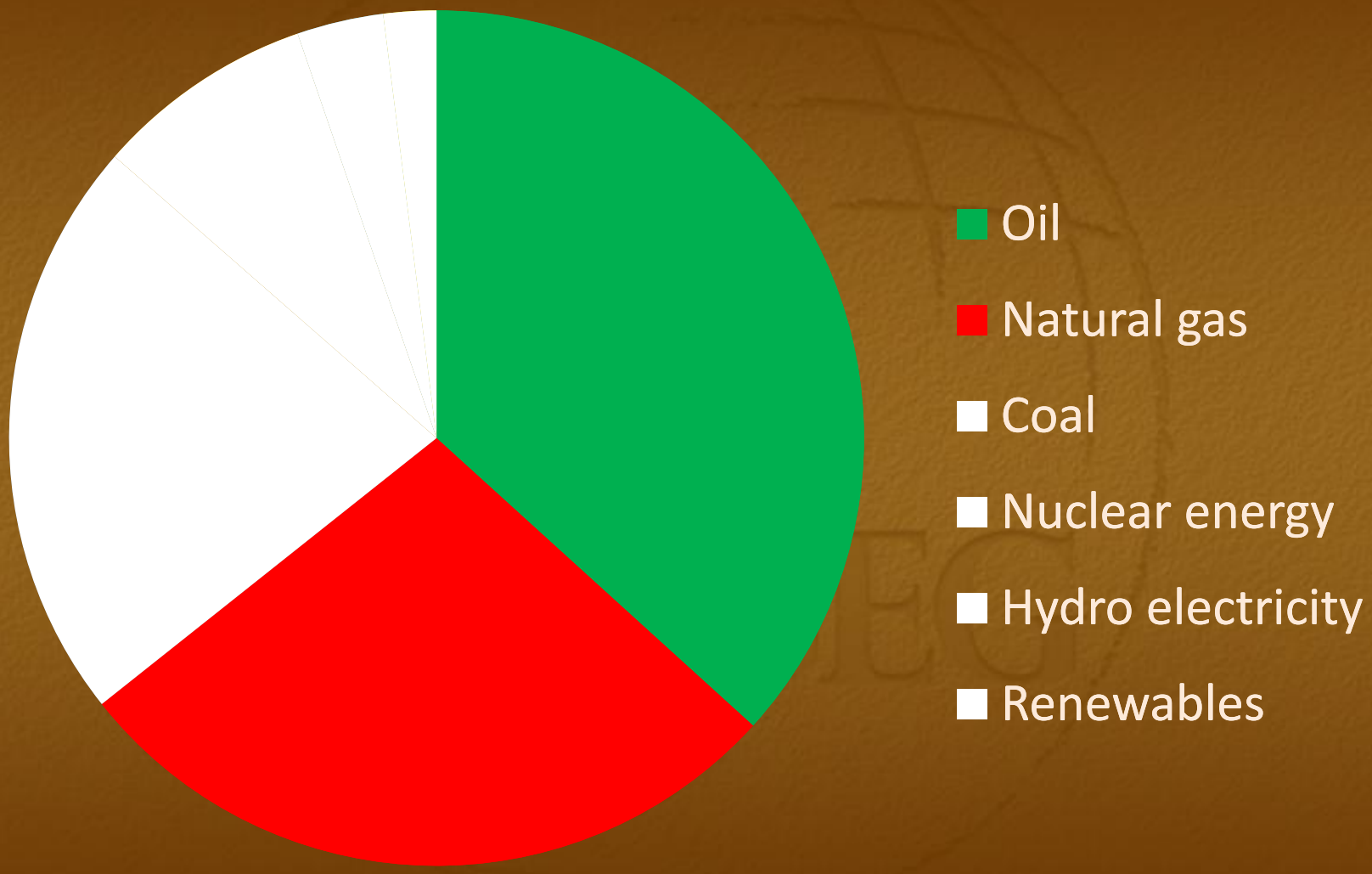
U.S. Energy Mix (%)



Source: EIA, 2012

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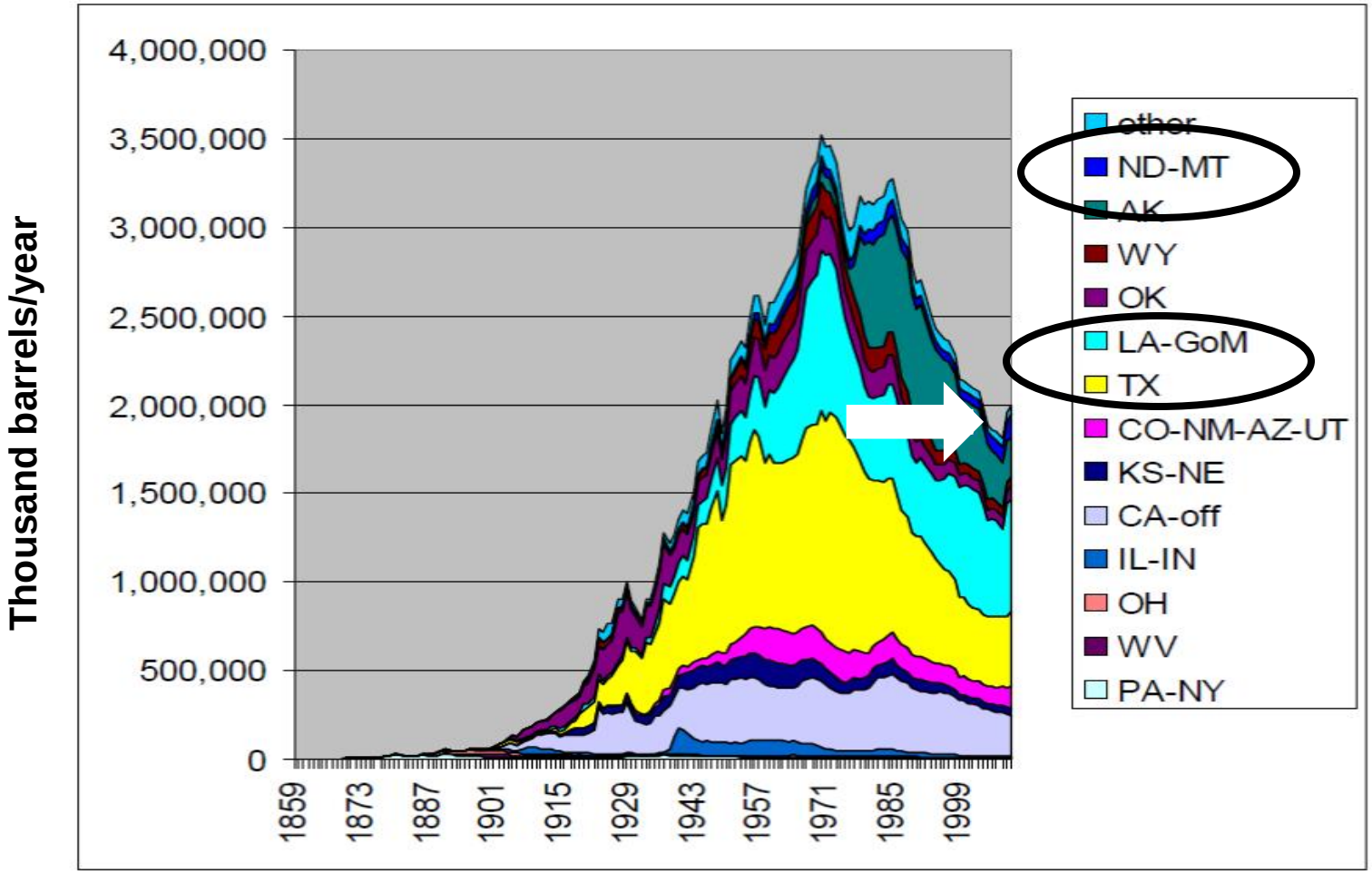
Annual US Oil Production



From: James D. Hamilton, Working Paper 17759, NATIONAL BUREAU OF ECONOMIC RESEARCH, 2012

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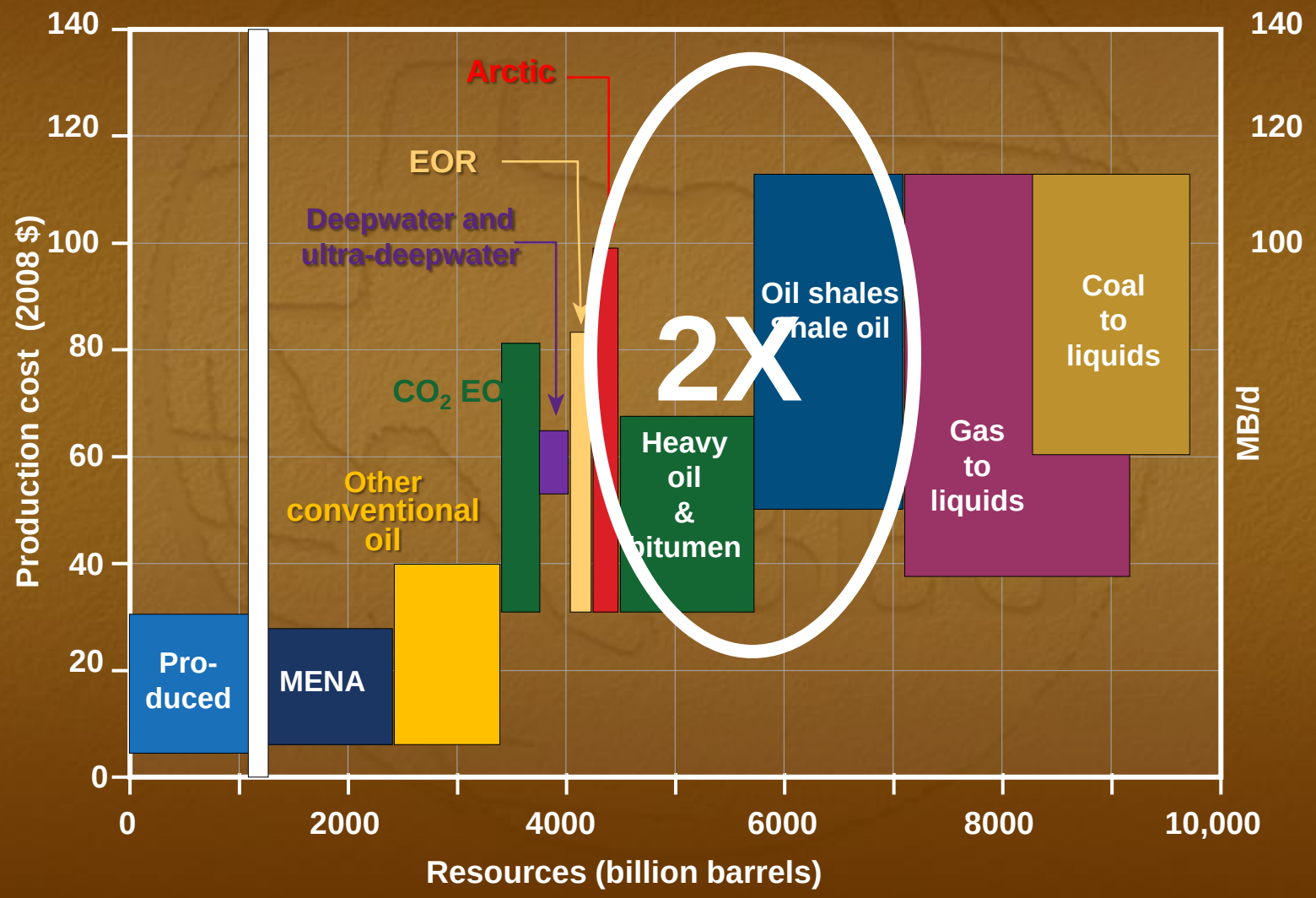
Long-Term Oil Supply

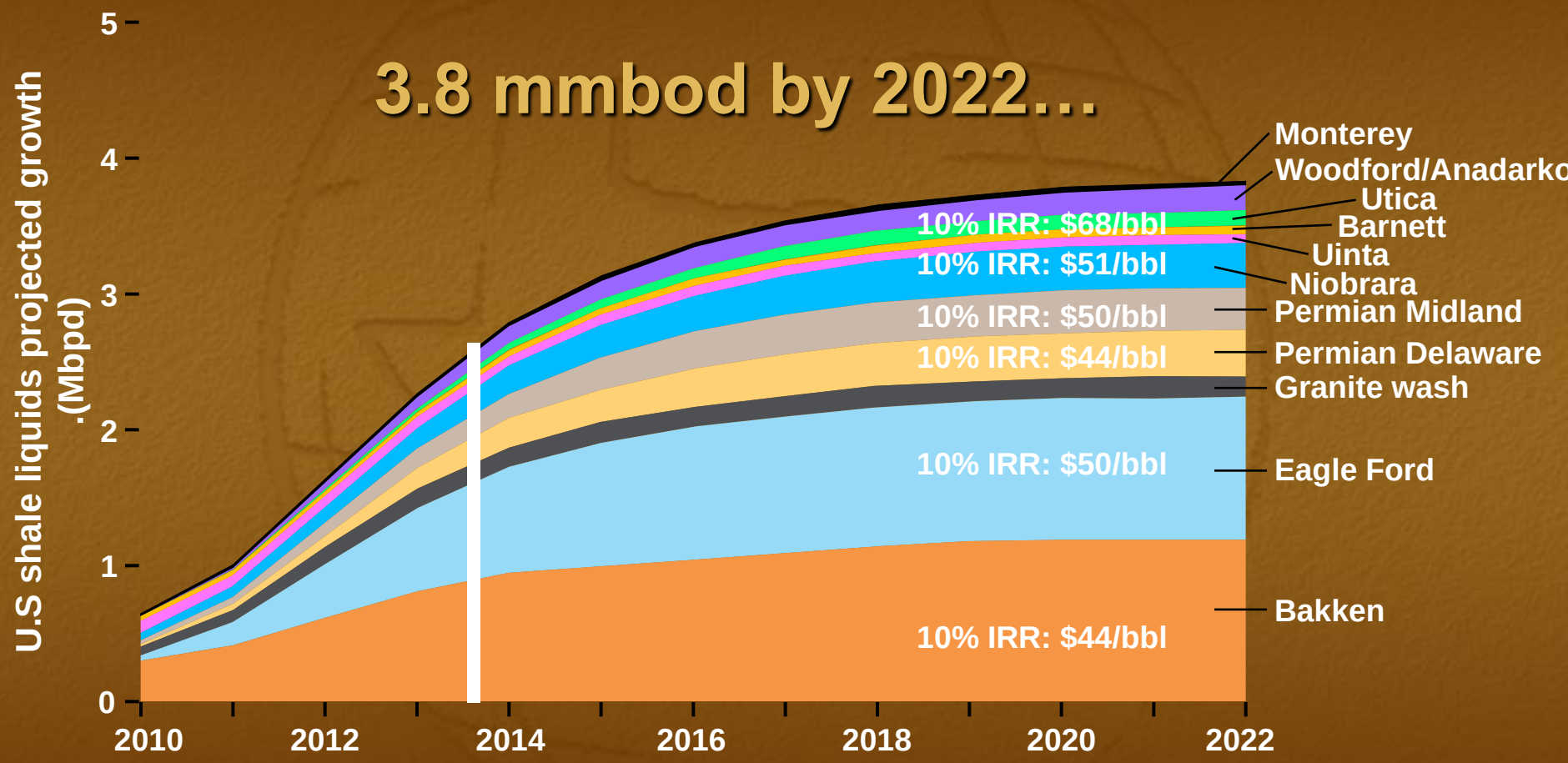
Resources and Cost



Source: IEA World Energy Outlook (2009)

2010 U.S. SHALE LIQUIDS *PROJECTION*

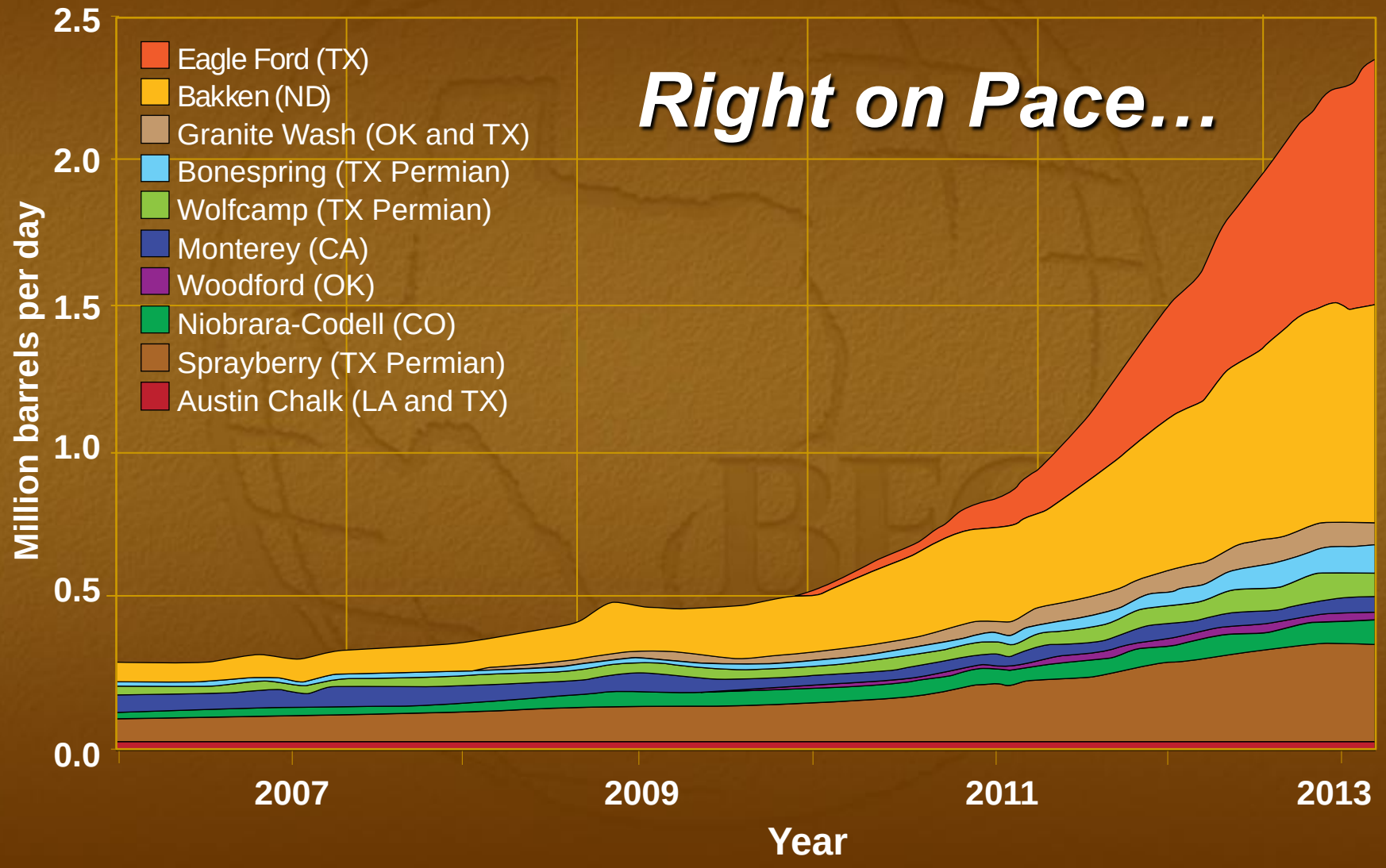
3.8 mmbod by 2022…



After Morse et. al., 2012, Energy 2020: North America, the new Middle East: Citi GPS: Global Perspectives & Solutions, figure 14, p. 17.

IRR Source: Rystad Energy

US Shale and Tight Oil Production



Source: U.S. Energy Information Administration

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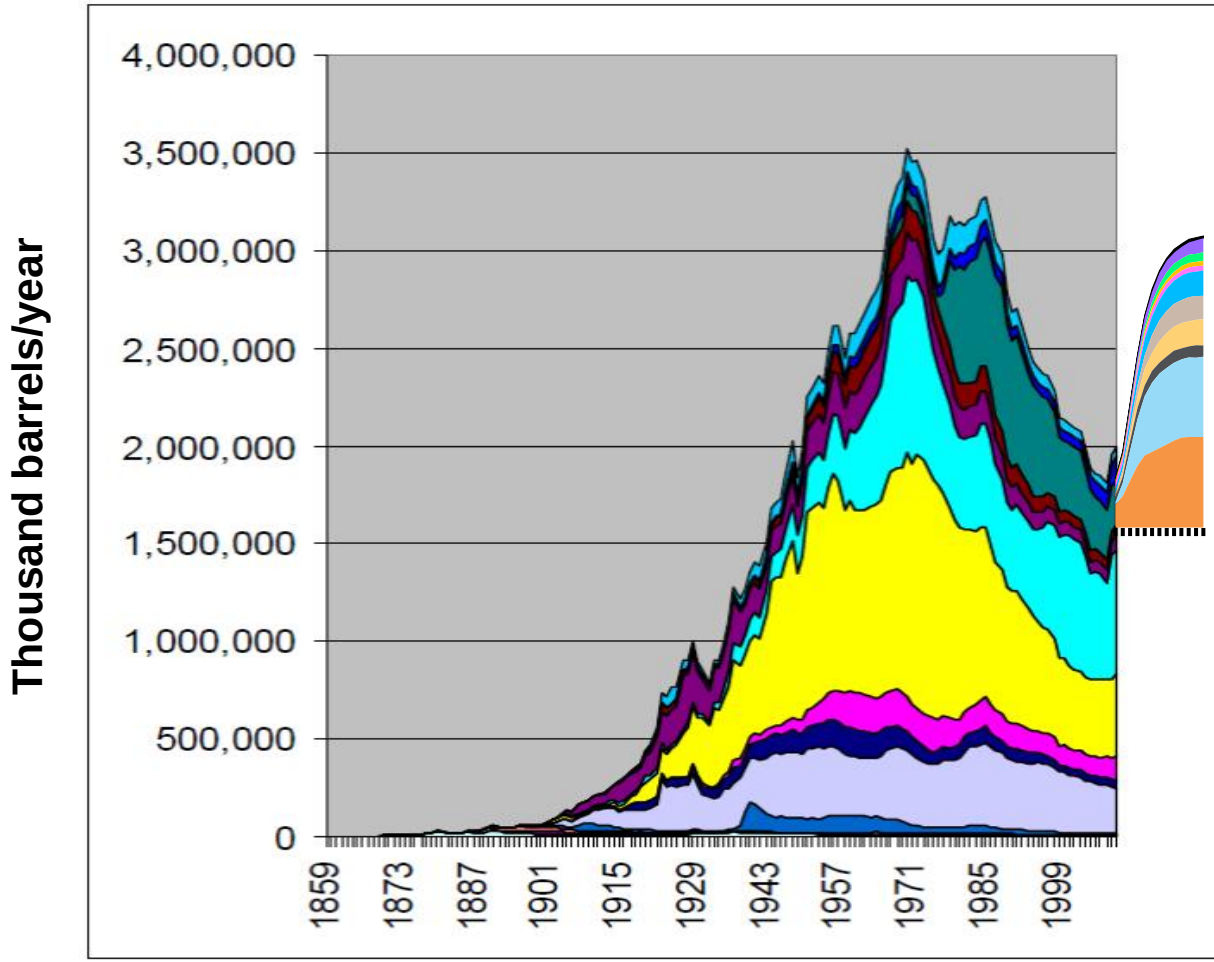
Annual US Oil Production



1.4 Bby shale oil by 2022

From: James D. Hamilton, Working Paper 17759, NATIONAL BUREAU OF ECONOMIC RESEARCH, 2012

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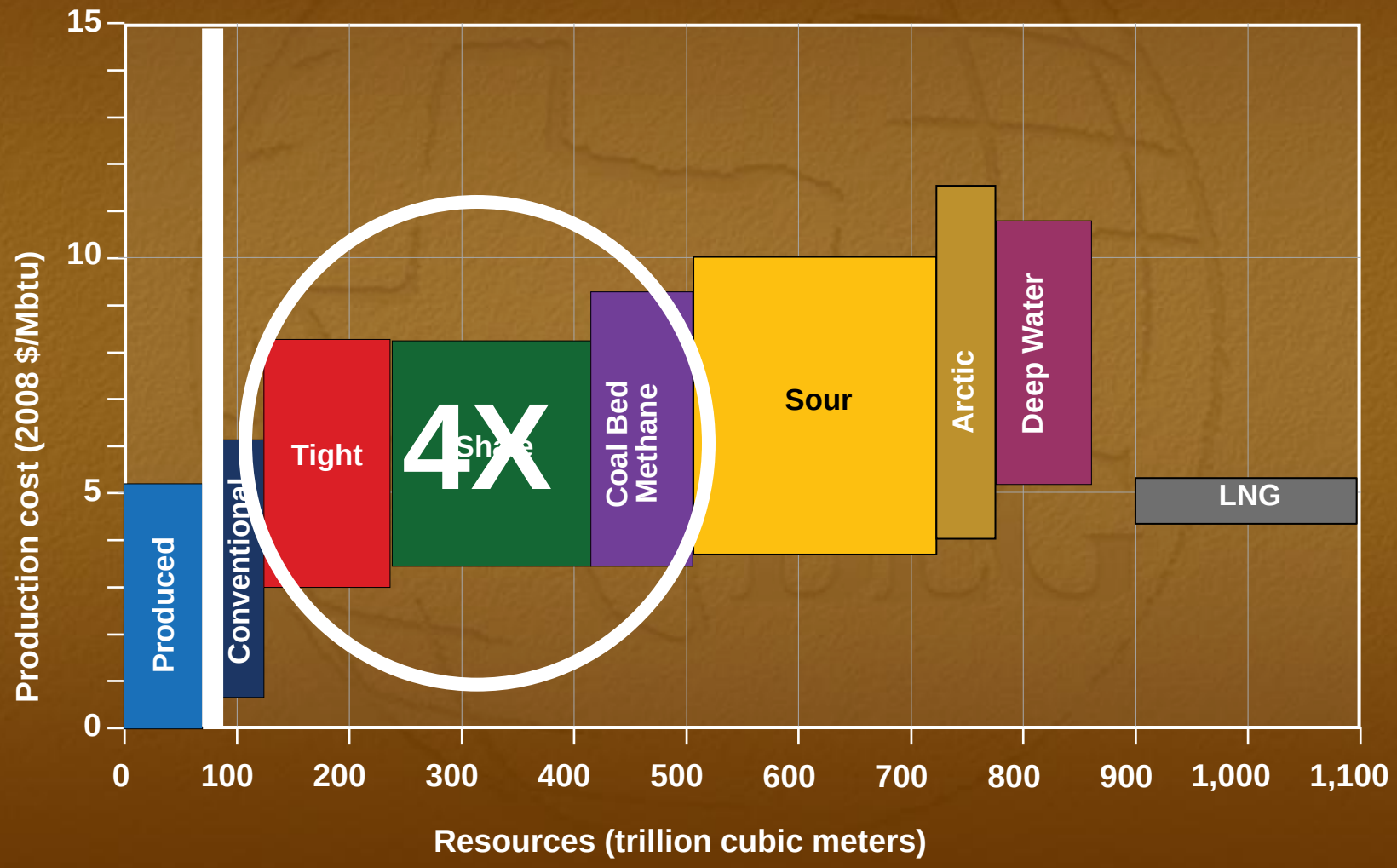
Natural Gas Supply

Resources and Cost



Source: IEA World Energy Outlook (2009)

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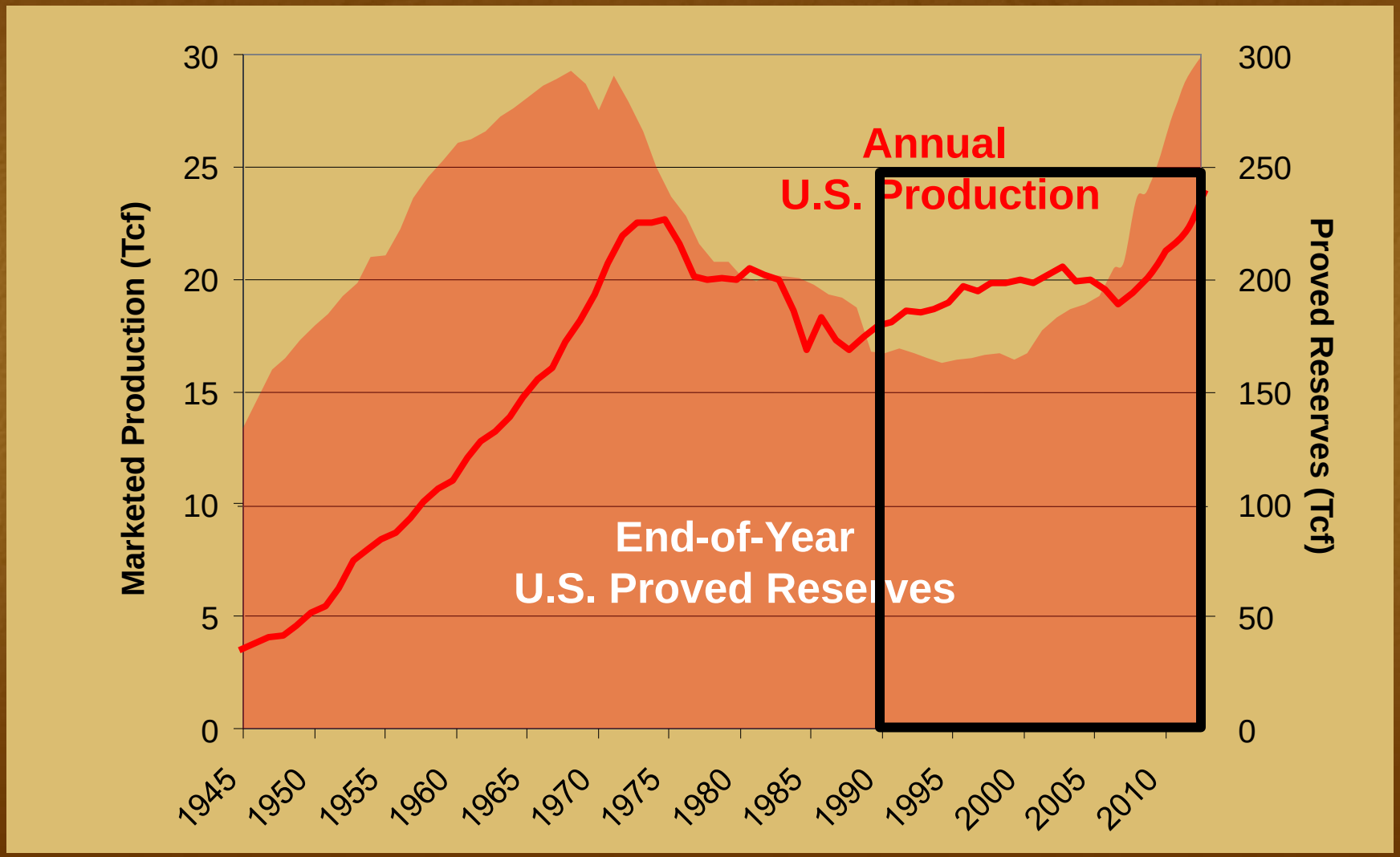
U.S. Natural Gas

Production and Reserves



Data: BP World Energy 2012

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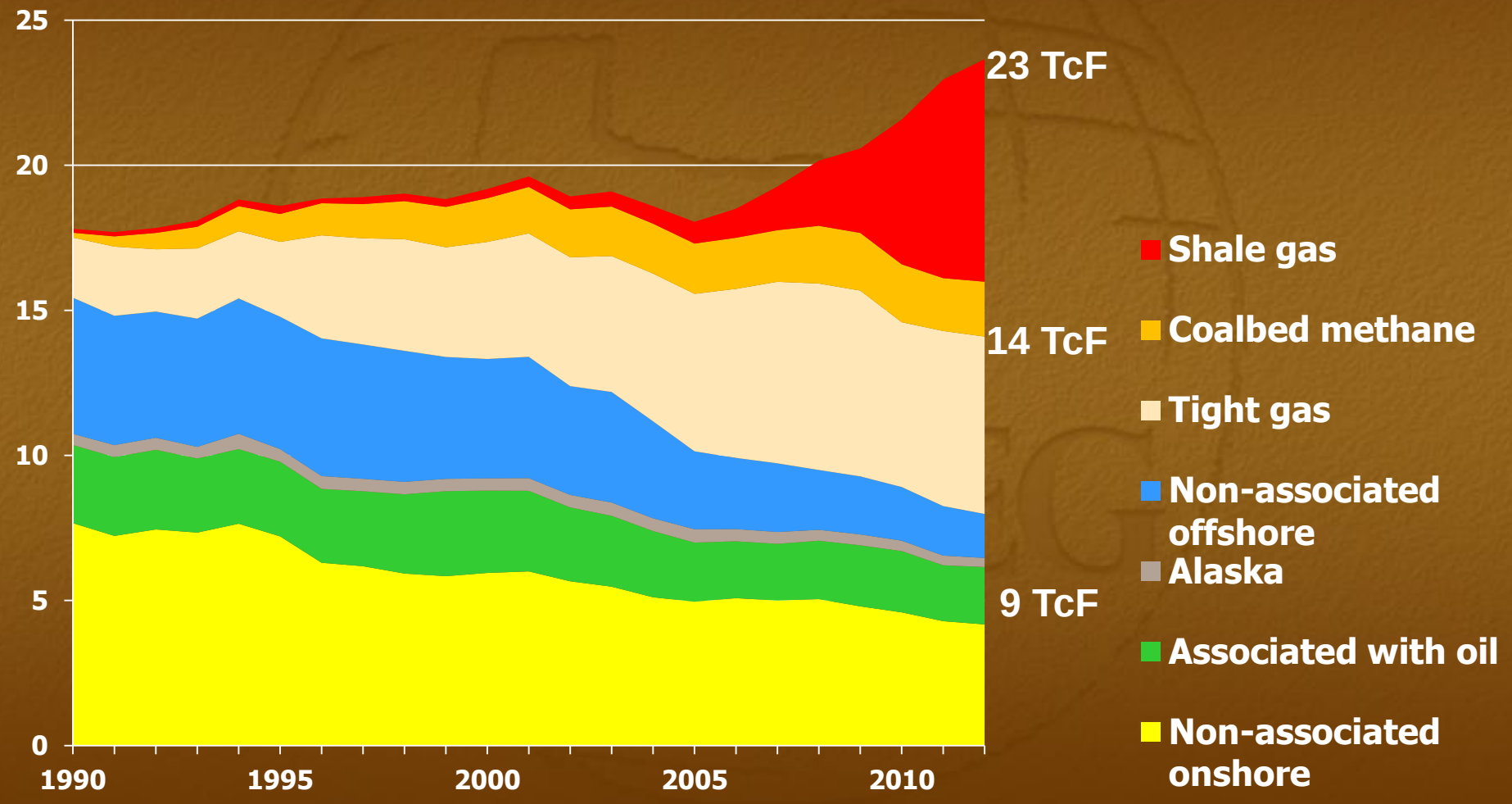
U.S. Natural Gas

Production (TcF)

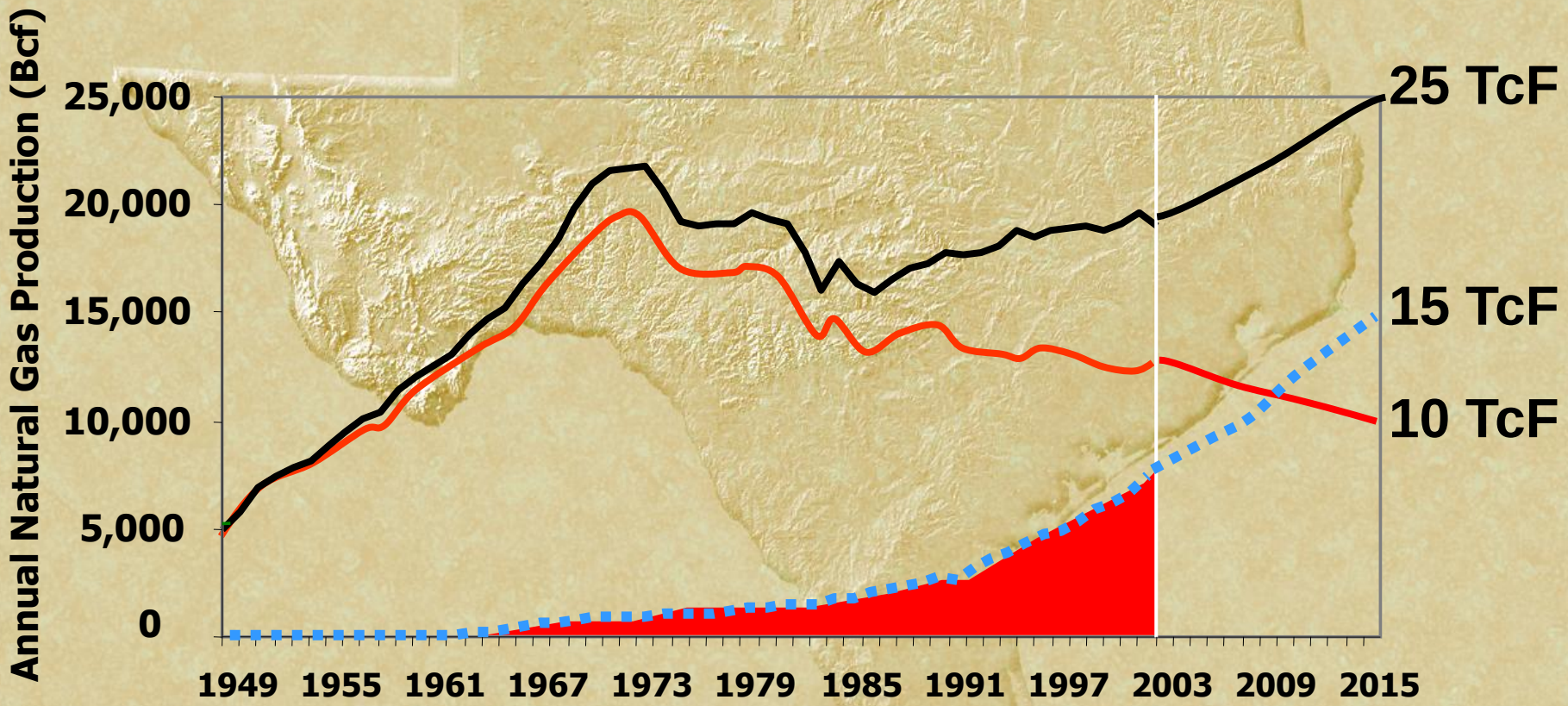


http://www.eia.gov/energy_in_brief/about_shale_gas.cfm

From a 2004 Tinker Talk to the IPAA

US Natural Gas 2004 forecast

An Anticipated Evolution



EIA (1949-1990) and NPC (1991-2015)

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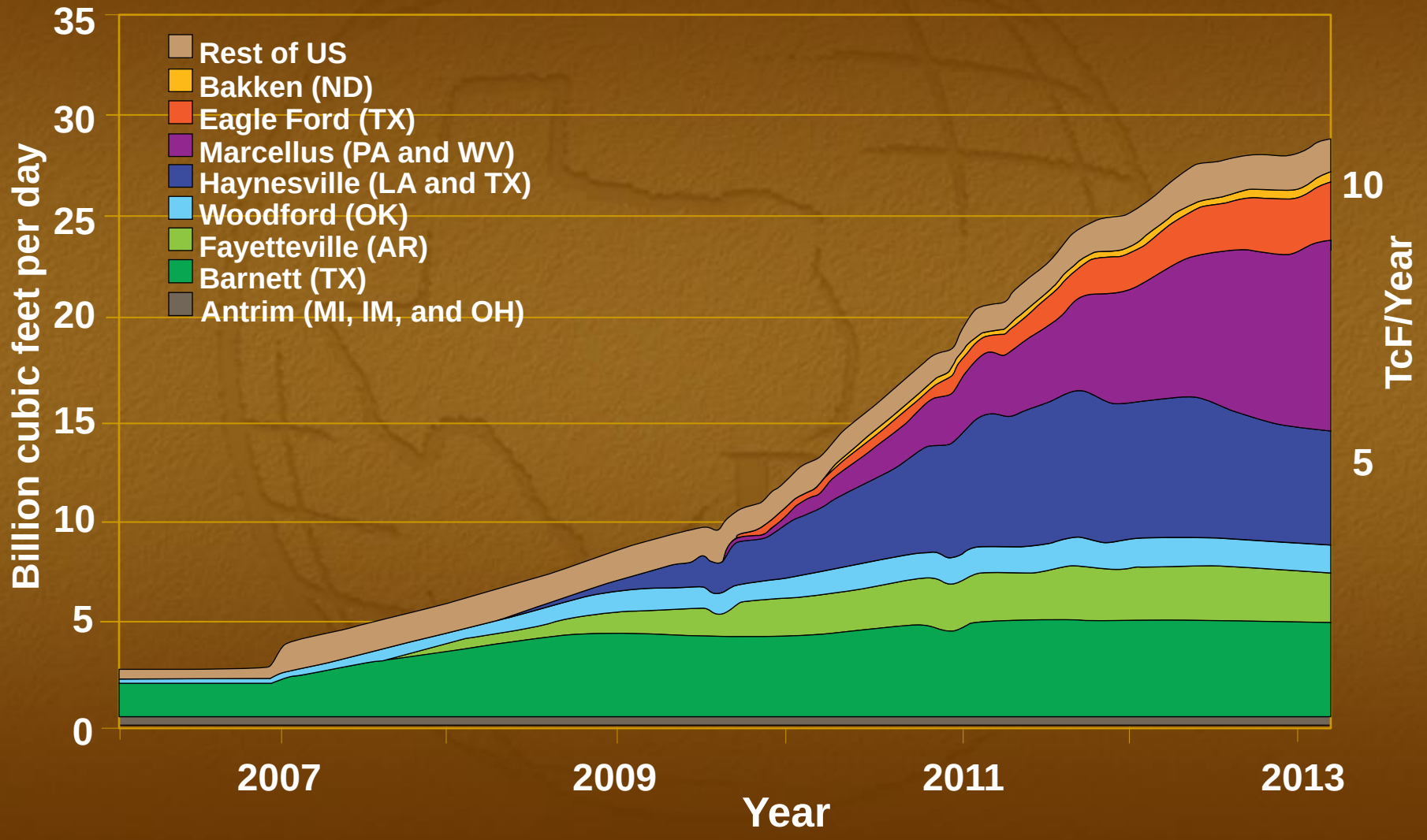
2013 Dry Shale Gas Production



Source: U.S. Energy Information Administration

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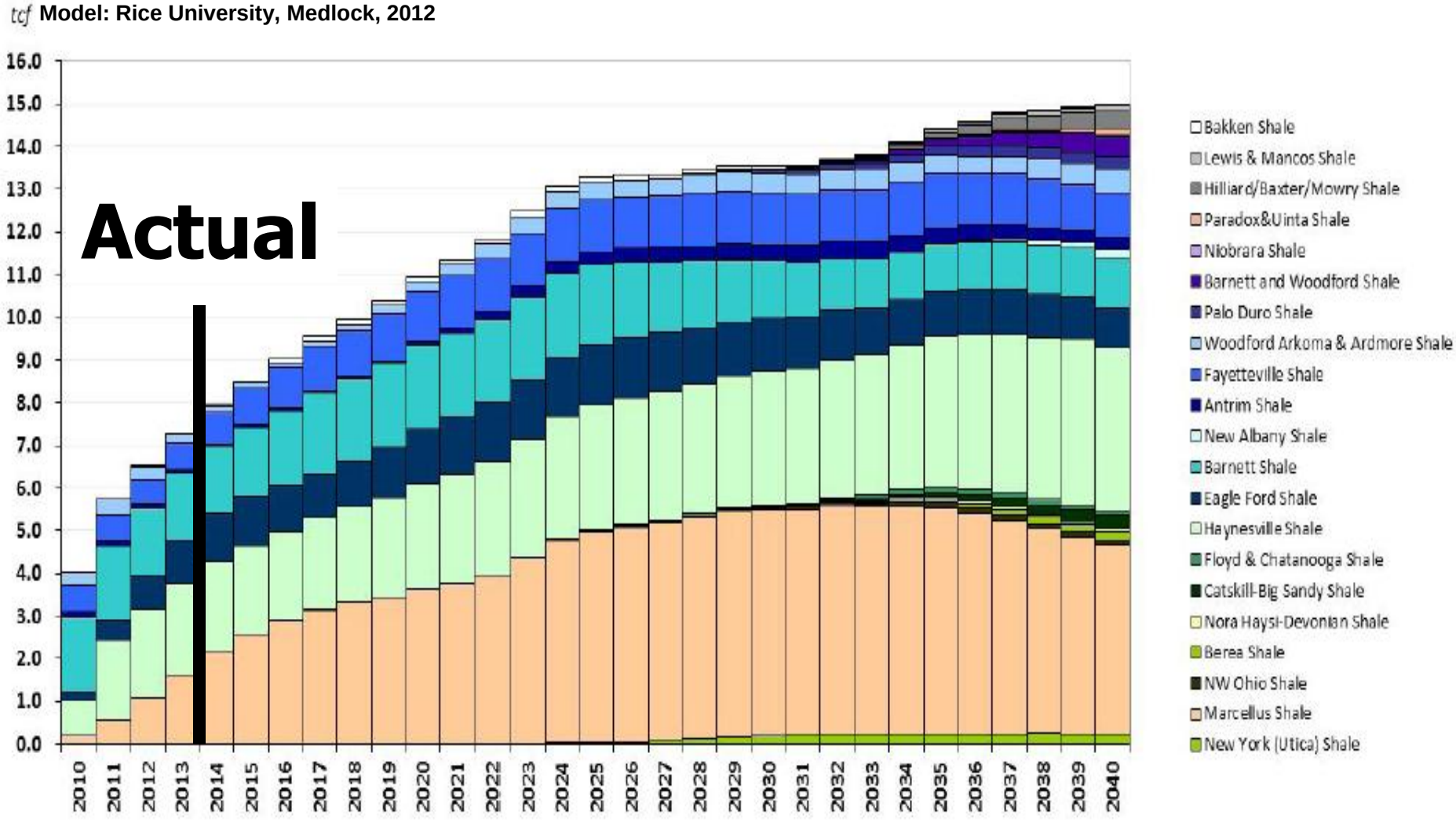
2013 Dry Shale Gas Production



Source: U.S. Energy Information Administration

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2013 Dry Shale Gas Production

2010 forecast is low to actual. Why?

In spite of continued popular prognostications about the poor economics of shale, the reality is that *parts* of several basins are economic, and technology and price allow for continued drilling and production.

Rigorous, integrated, bottom-up geologic, engineering and economic studies provide a realistic look at the future.

Outline

- The Role of Shale
- Reserves and Production Forecasting
- Implications and Considerations

Reserves and Production *Forecasting*

Bureau of Economic Geology Program

Goal: Contribute to the objective understanding of the capability of U.S. shale gas to contribute to natural gas supply for the next 20 years

- **3-year project, funded by the Alfred P. Sloan Foundation**
- **Multidisciplinary team of geoscientists, engineers, and economists.**
- **Four plays: Barnett, Fayetteville, Haynesville, Marcellus**
- **Rapidly developing, some mature, others just starting**
- **Uncertainties about well performance and drivers**
- **Low price environment**

Framing Questions

- What is the resource base in place?
- What portion of that resource is recoverable?
- What pace of drilling activity will be necessary to sustain production at various levels?
- How achievable is this activity level, given advances in technology and prices?
- What impact will these levels of production have on infrastructure, roads, water, regulation, jobs, taxes…

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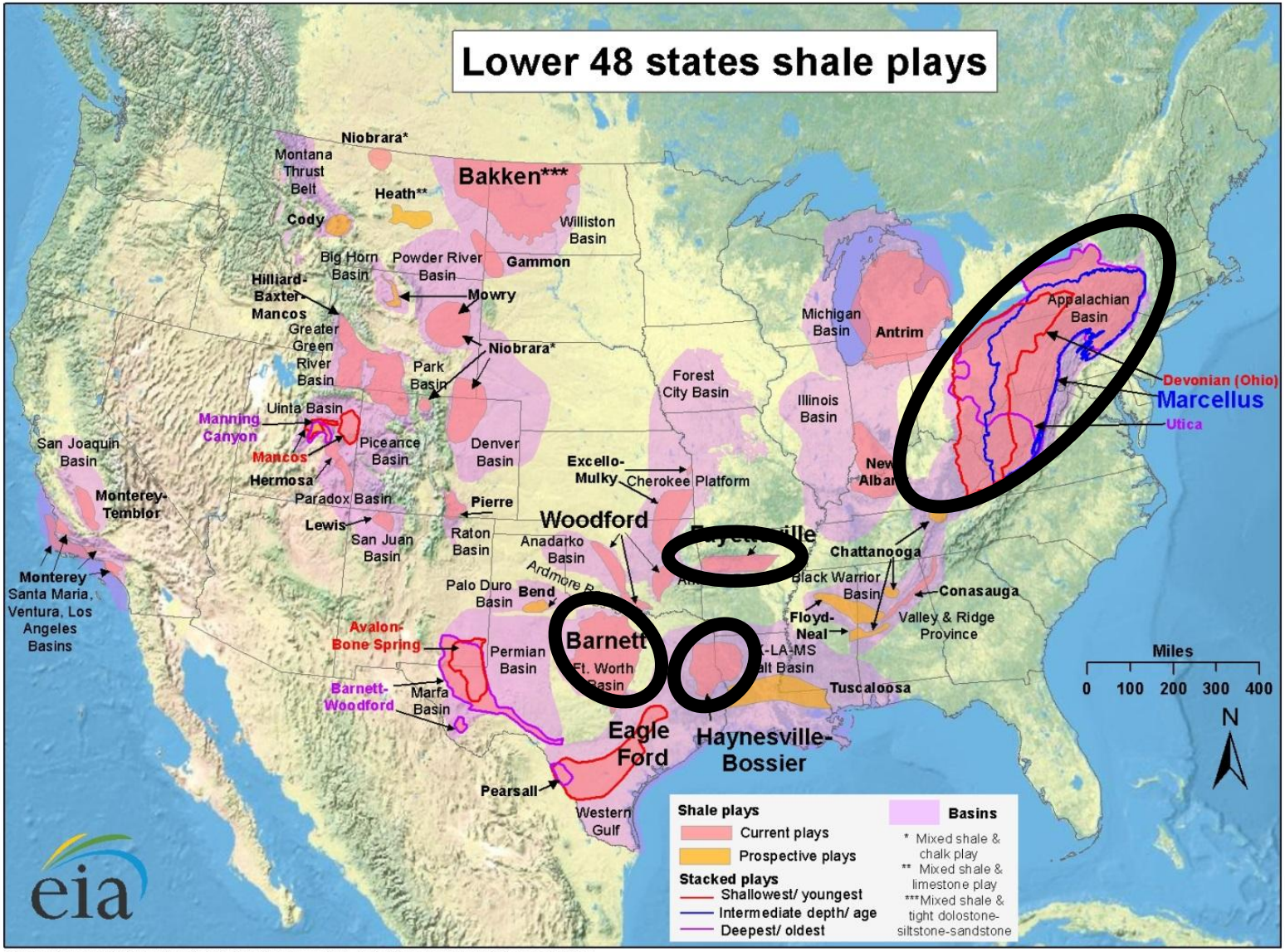
U.S. Shale Gas Plays



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

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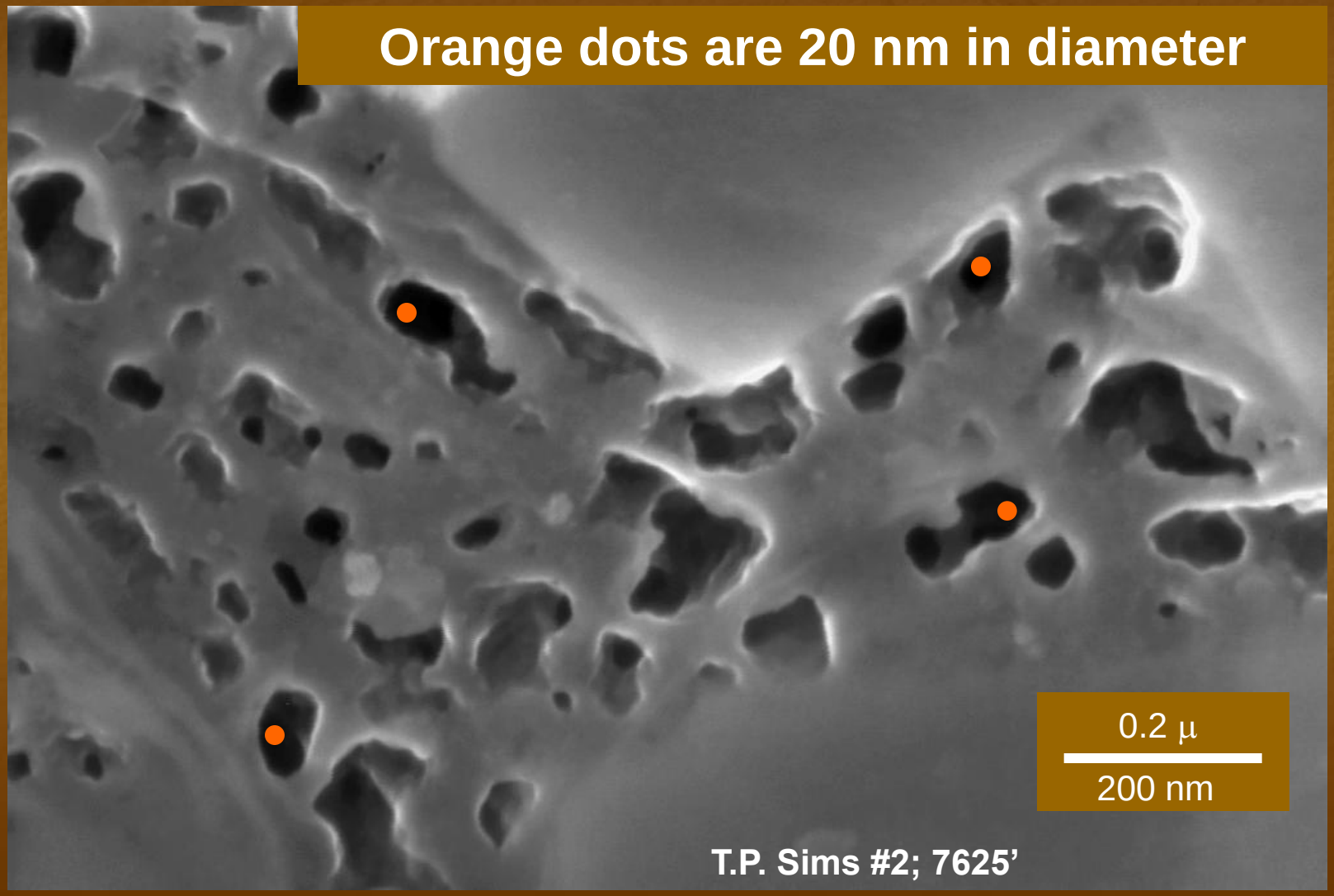
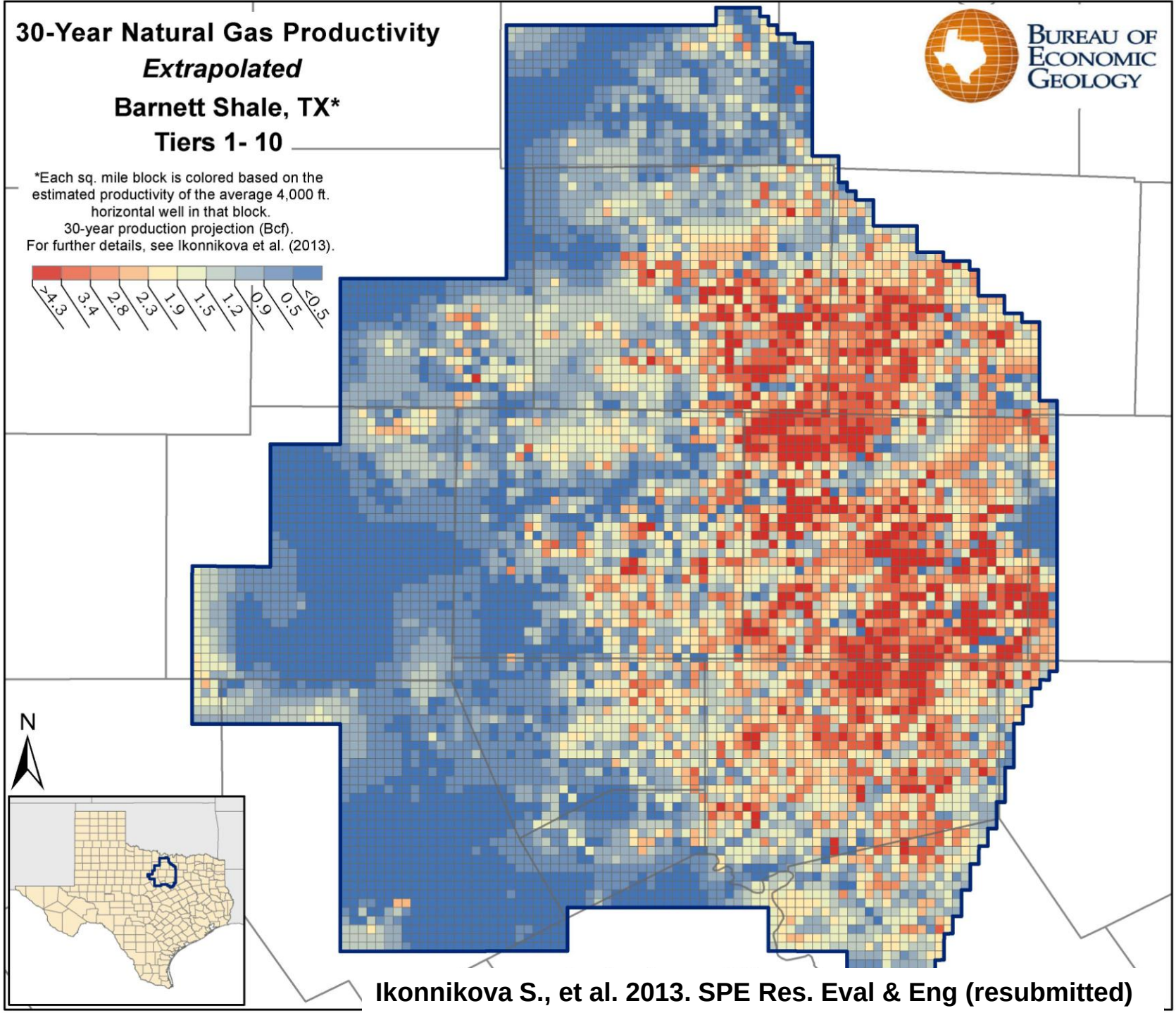
Barnett Shale

Nanopores in Organics



After Reed, BEG



Ikonnikova S., et al. 2013. SPE Res. Eval & Eng (resubmitted)

Barnett Production Outlook

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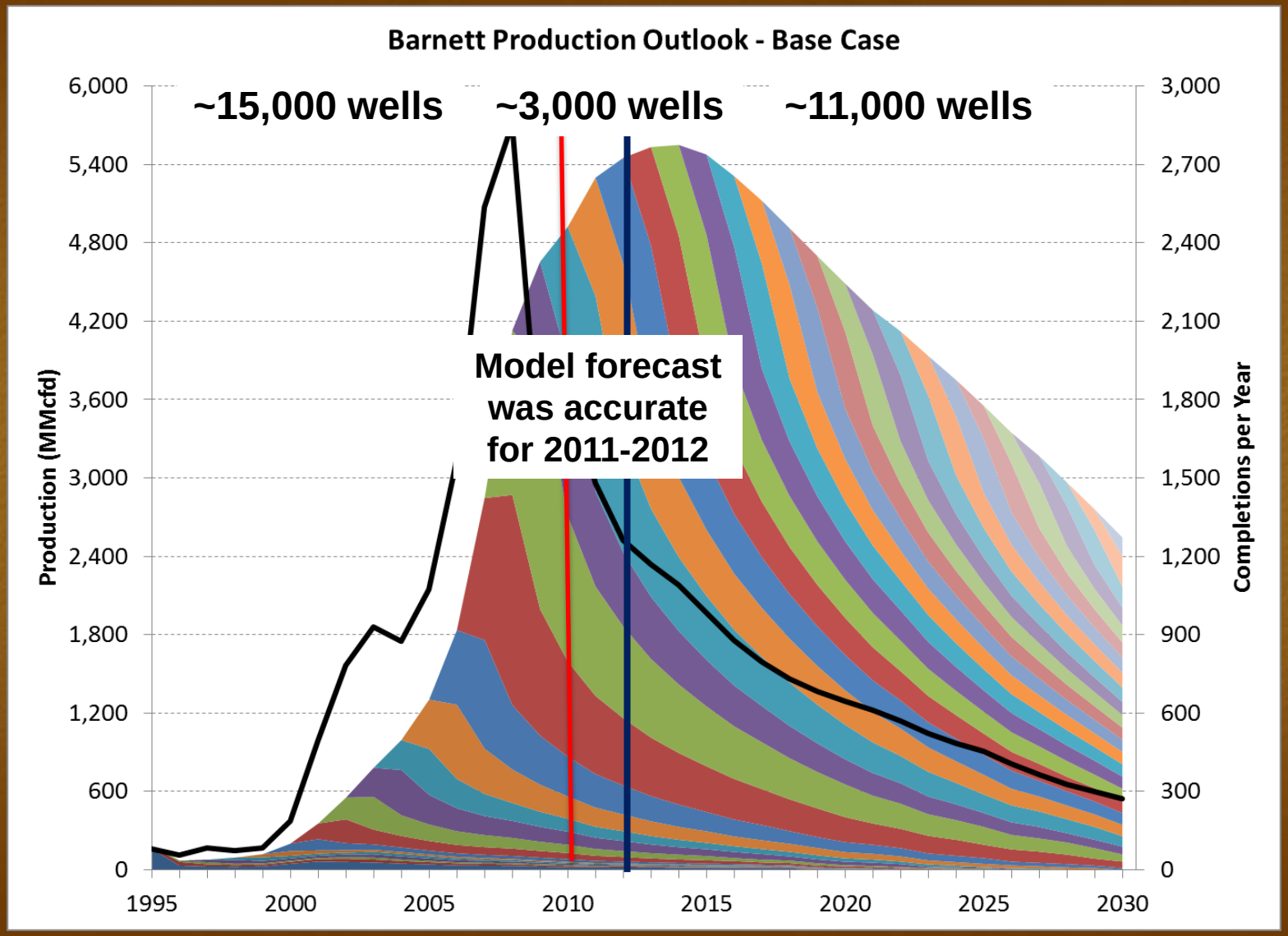

Browning, J. et al. 2013. SPE Econ & Mgmt

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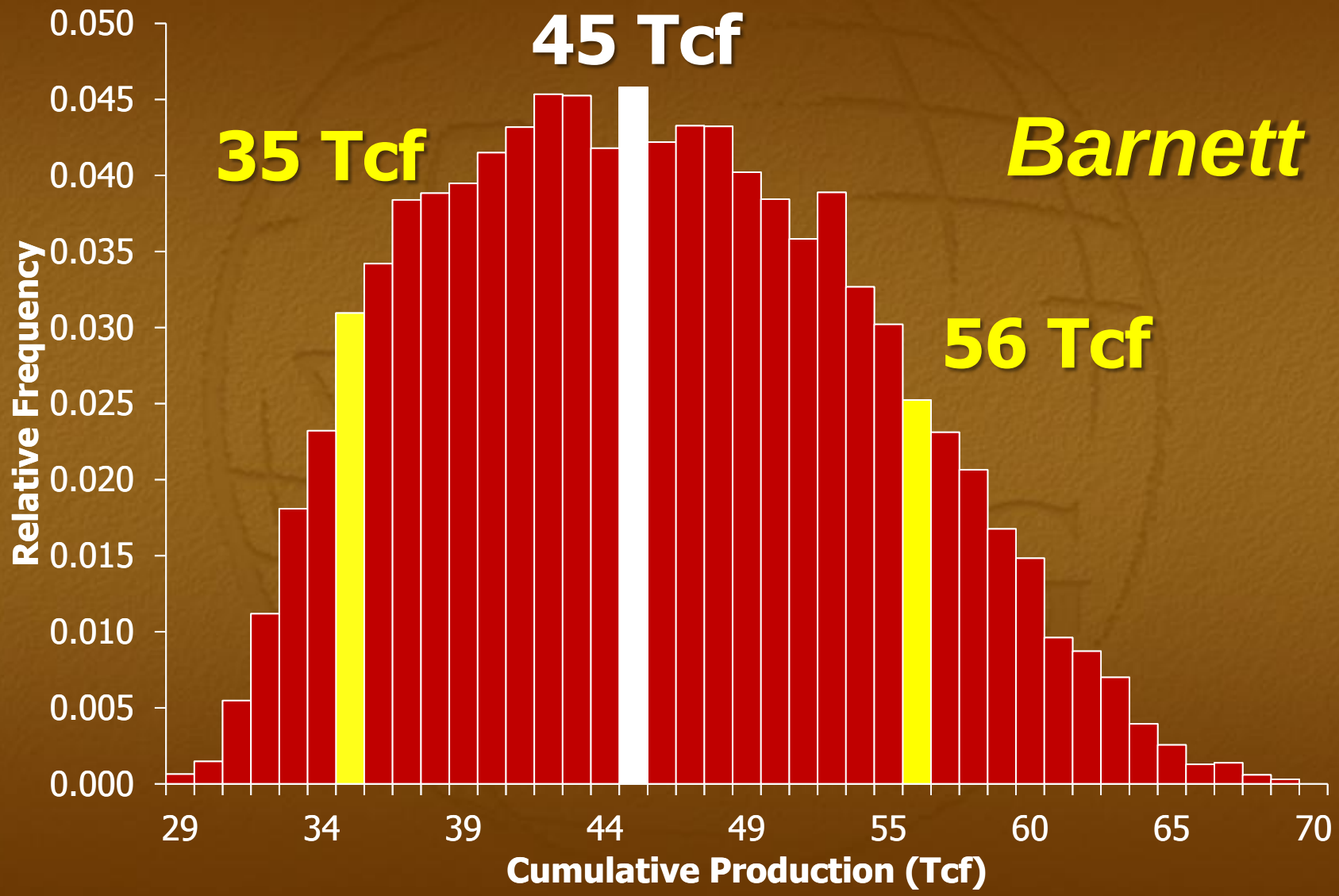
Economic Production Distribution



Browning, J. et al. 2013. SPE Econ & Mgmt

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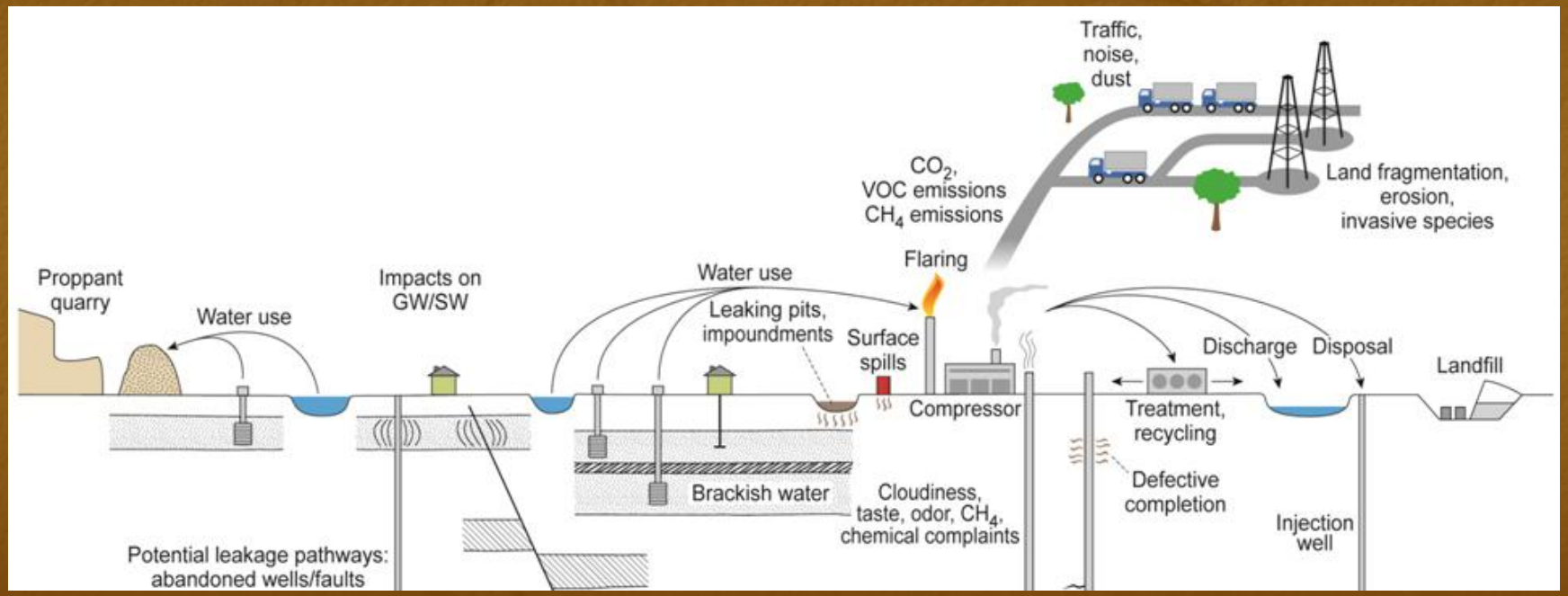
Unconventional Reservoirs



After Nicot and Wolaver, BEG, 2013

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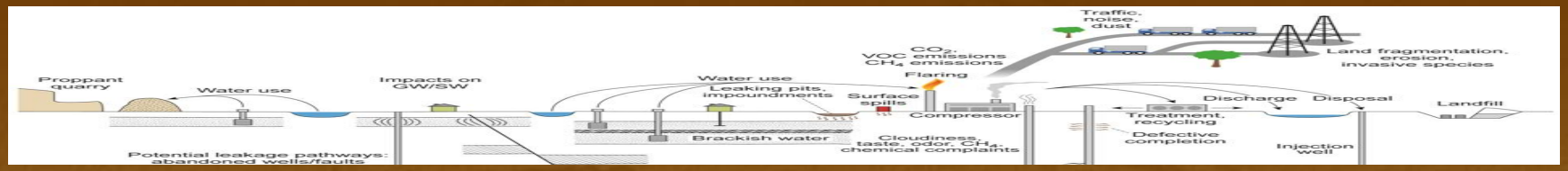
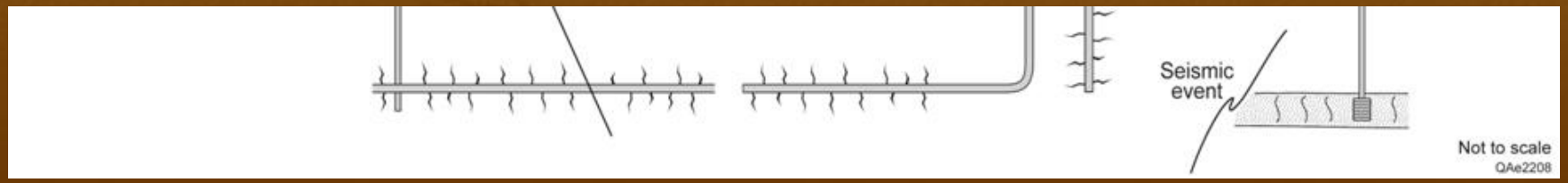
Unconventional Reservoirs



1000's of Feet of Rock



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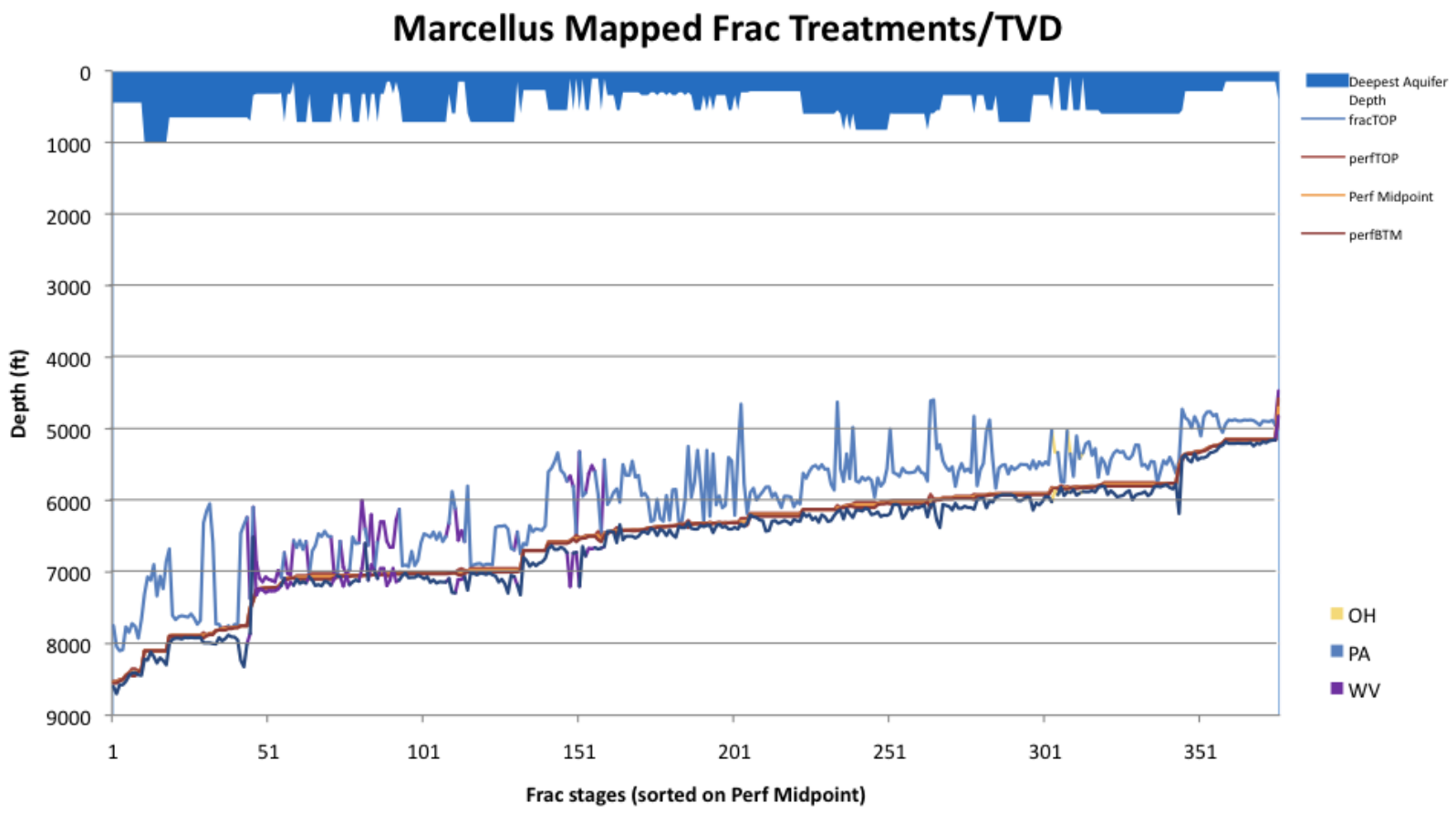
Unconventional Reservoirs



Pinnacle
A HALLIBURTON SERVICE

Emissions Considerations

- Infrared cameras and Organic/Toxic Vapor Analyzer to detect leaks
- Electric or CNG motors
- "Green completions"
- Well pad location to account for wind
- Capture gas and limit flaring/venting

After Nicot and Wolaver, BEG, 2013

Water Considerations

- Harvest rain water (impoundments)
- Re-use and recycle brackish, flowback and formation water
- Chemicals that perform with high TDS
- Biodegradable chemicals
- "Dry" fracturing

After Nicot and Wolaver, BEG, 2013

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Surface Considerations

- Location selection
- Noise control/sound barriers
- Mobile water tanks and centralized impoundments instead of pits
- Use of waste heat/stranded natural gas
- Well pad footprint
- Re-vegetate pad to limit erosion
- Multi-well pads

After Nicot and Wolaver, BEG, 2013

Subsurface Considerations

- Cement all gas producing zones
- Subsurface characterization for disposal
- Disclosure of all chemicals
- Baseline data ahead of drilling
  - Thermal
  - Chemical
  - Conductive
  - Hydro
  - Seismic

After Nicot and Wolaver, BEG, 2013

Unconventional Summary "Trade Offs"

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- Environmental Risks and Impacts
  - Traffic/noise/light
  - Surface
  - Groundwater
  - Quakes
  - Local and atmospheric emissions
- Energy Security and Economic Benefits
  - Available
  - Affordable
  - Reliable
  - Atmospheric emissions
  - Jobs and Taxes

These are not mutually exclusive!

Unconventional Reservoirs

Implications

- **Balance of Trade**
  - ✓ **Exports: Natural gas, liquids, products**
  - ✓ **Imports: Oil**
- **Regulation and Planning**
  - ✓ **Infrastructure**
  - ✓ **Resources**
  - ✓ **Permitting**
- **Emissions**
- **Energy Security**