



You Frackers Look What You've Done!

**American Rock Mechanics Association
Hydraulic Fracturing Seminar**

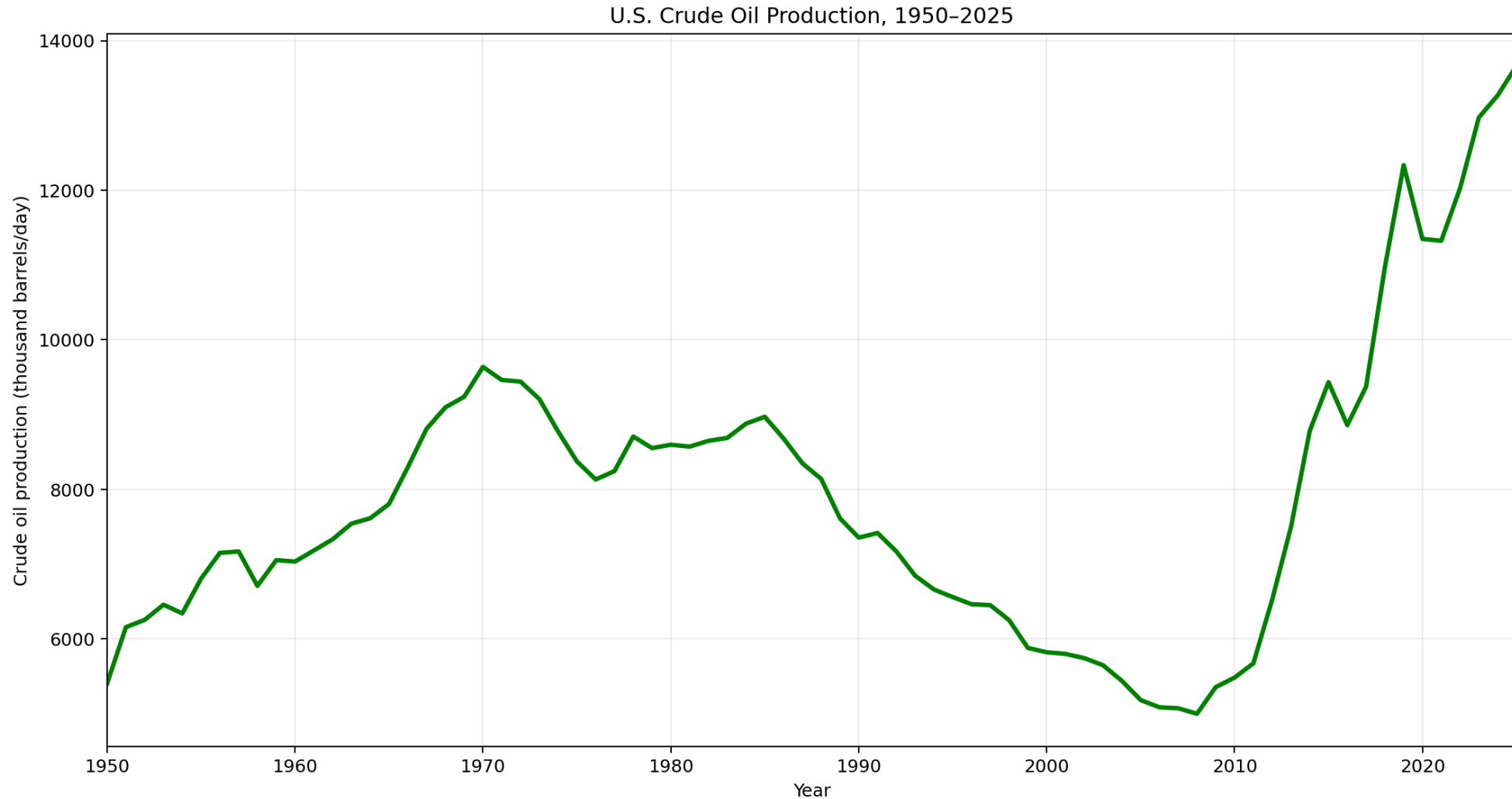
**Dr. C. Mark Pearson
September 17th 2026**



Outline

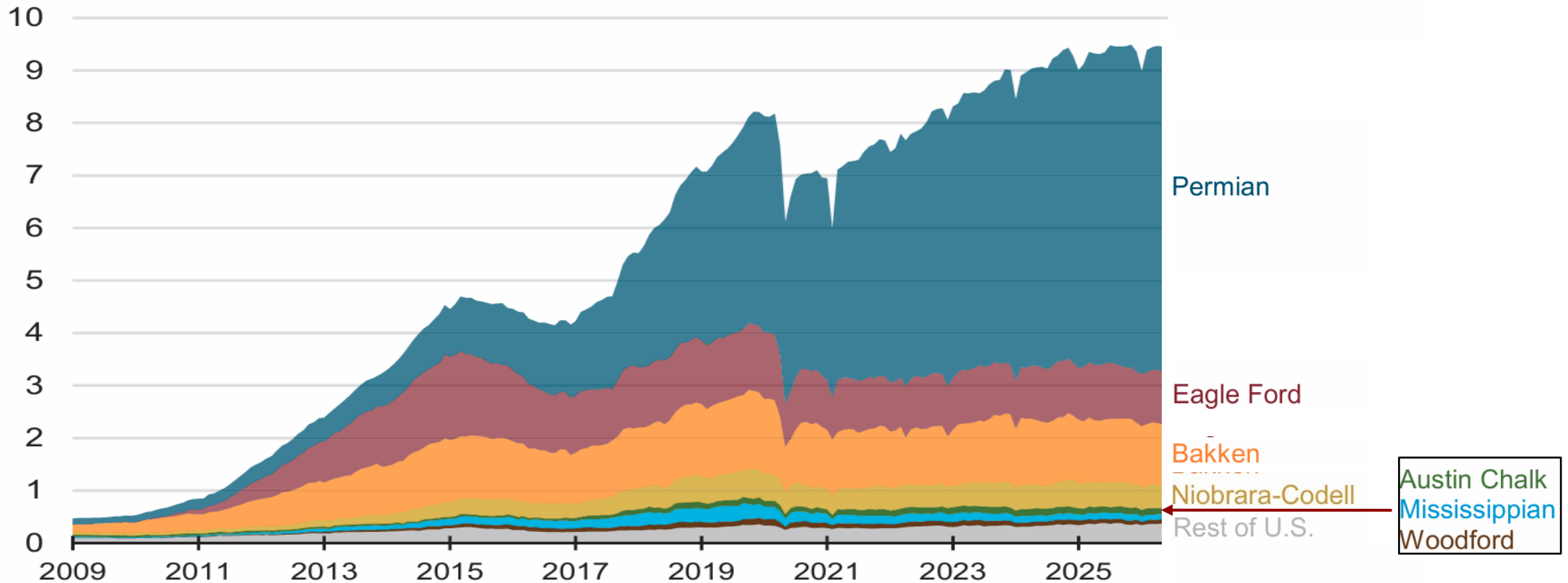
- **The Macro of US Oil & Gas Production / Development**
- **The Path to Becoming a Horizontal NAM Industry**
- **First Shale Developments**
 - **Gas (Barnett Shale)**
 - **Oil (Bakken)**
- **Environmental Advancements**
- **Where the \$ go ...**
- **Summary**

U.S. Crude Oil Production



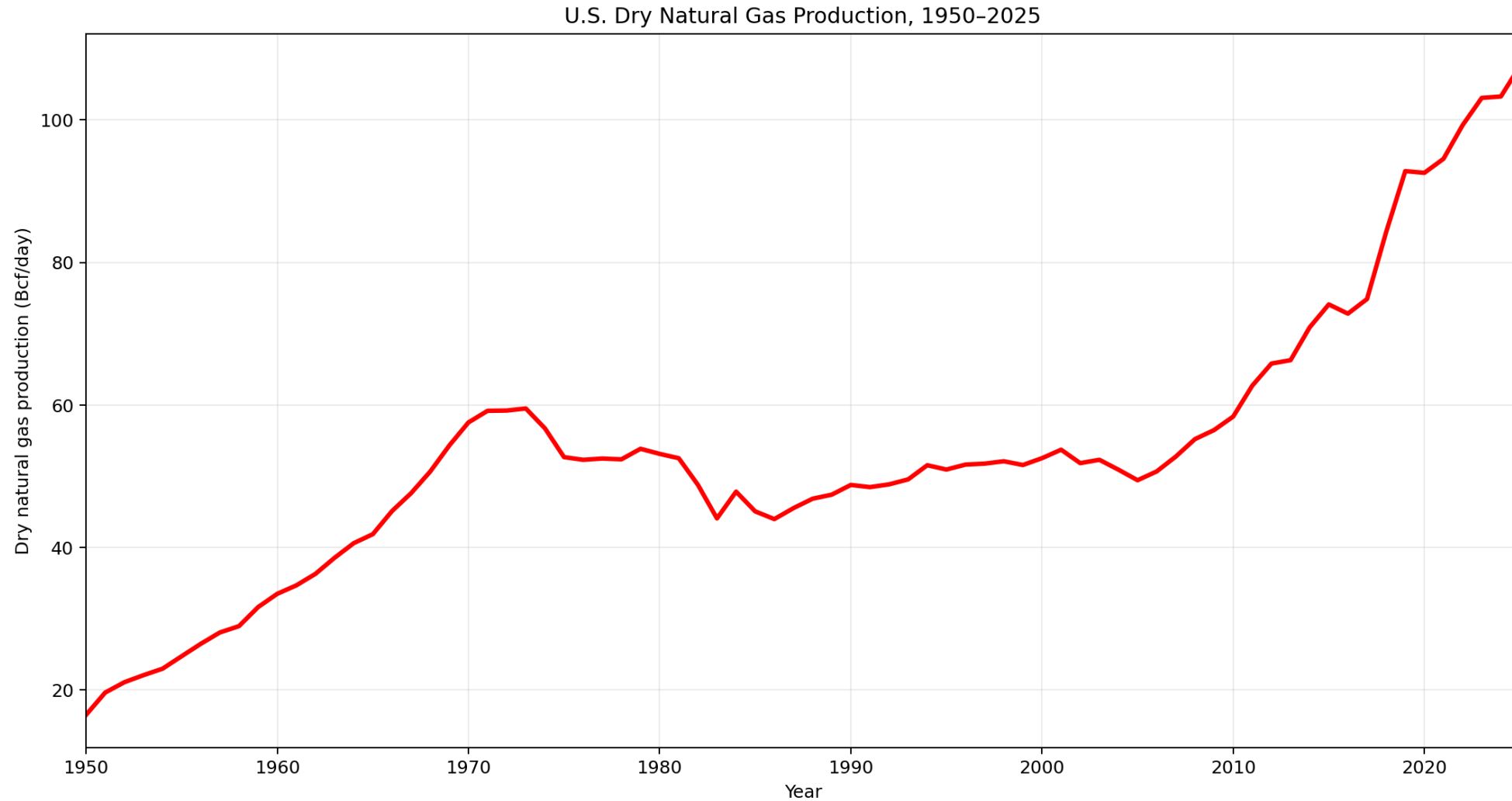
US Shale Oil Production

Monthly U.S. tight oil production by formation
million barrels per day



Data source: U.S. Energy Information Administration, Short-Term Energy Outlook, September 2026

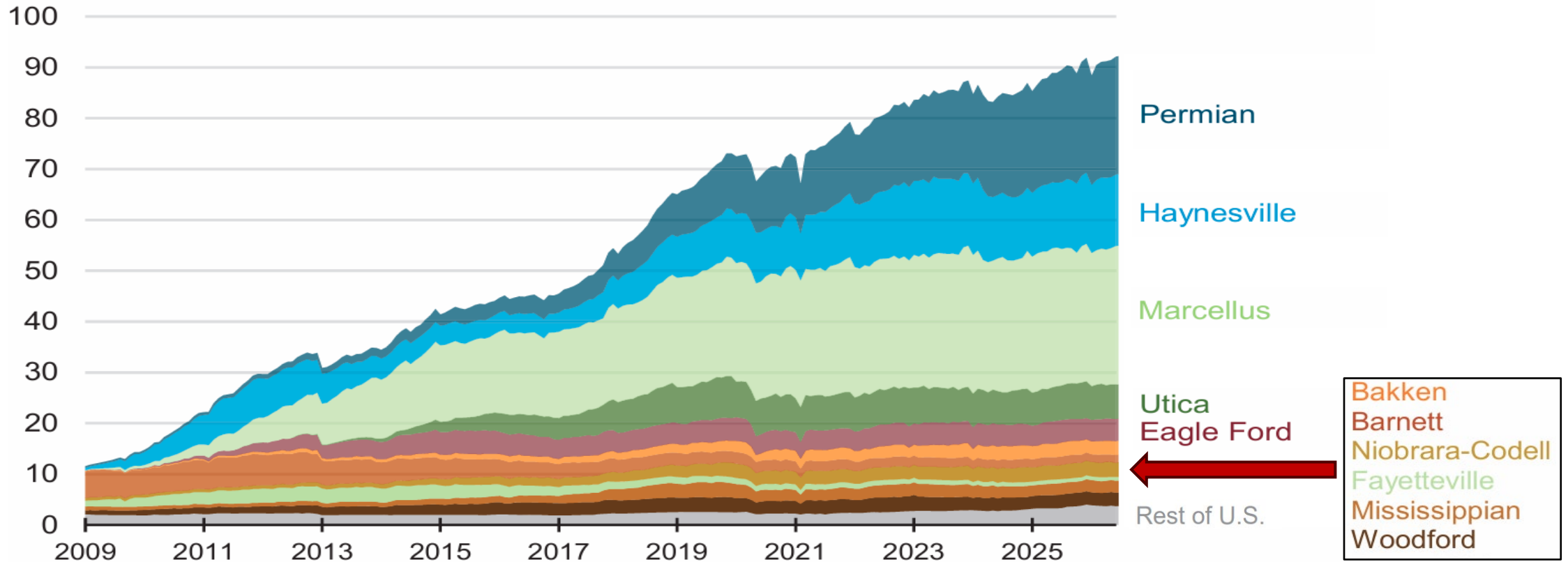
U.S. Natural Gas Production



U.S. Dry Gas Shale Natural Gas Production

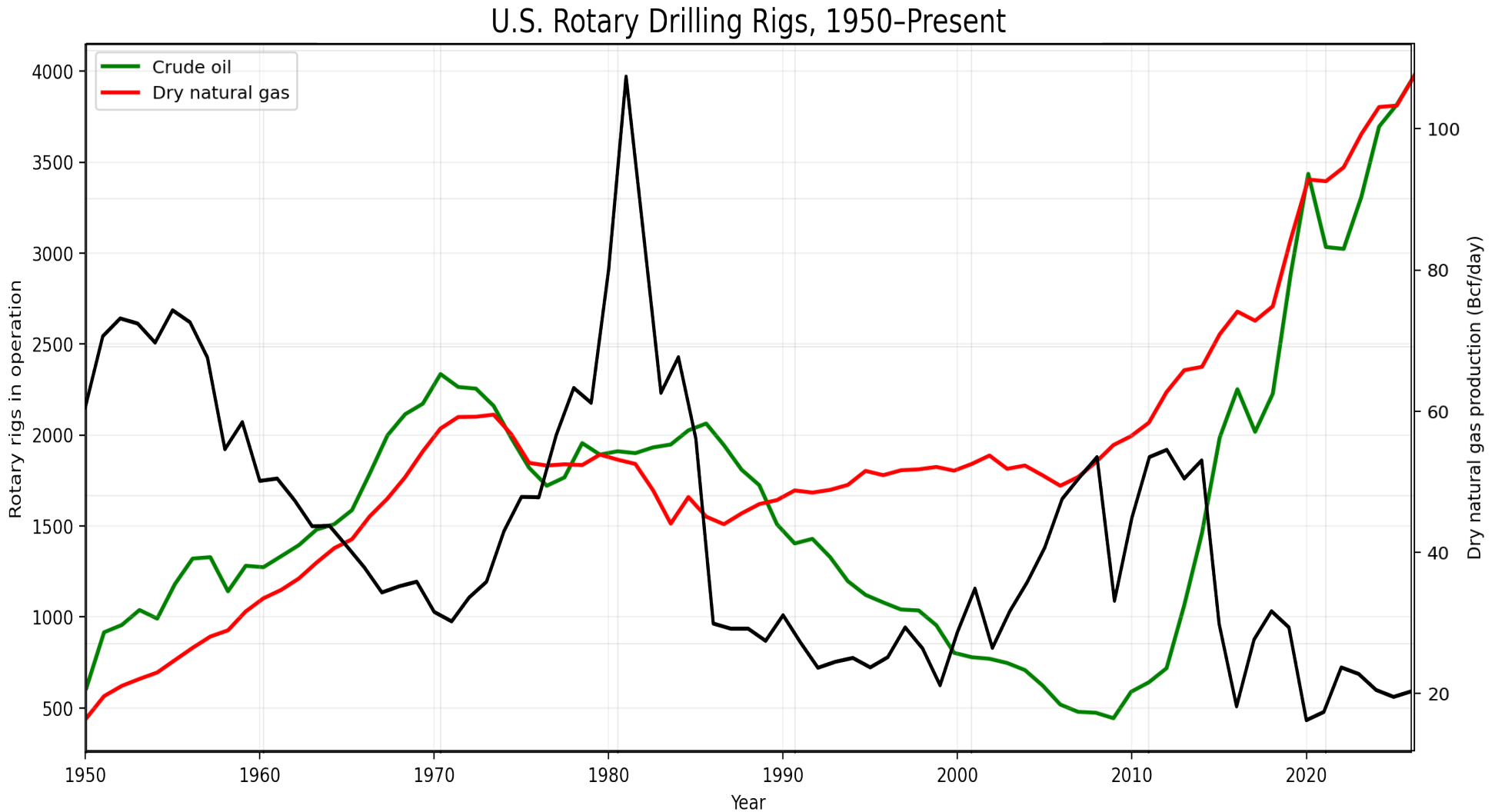


Monthly U.S. dry shale natural gas production by formation
billion cubic feet per day



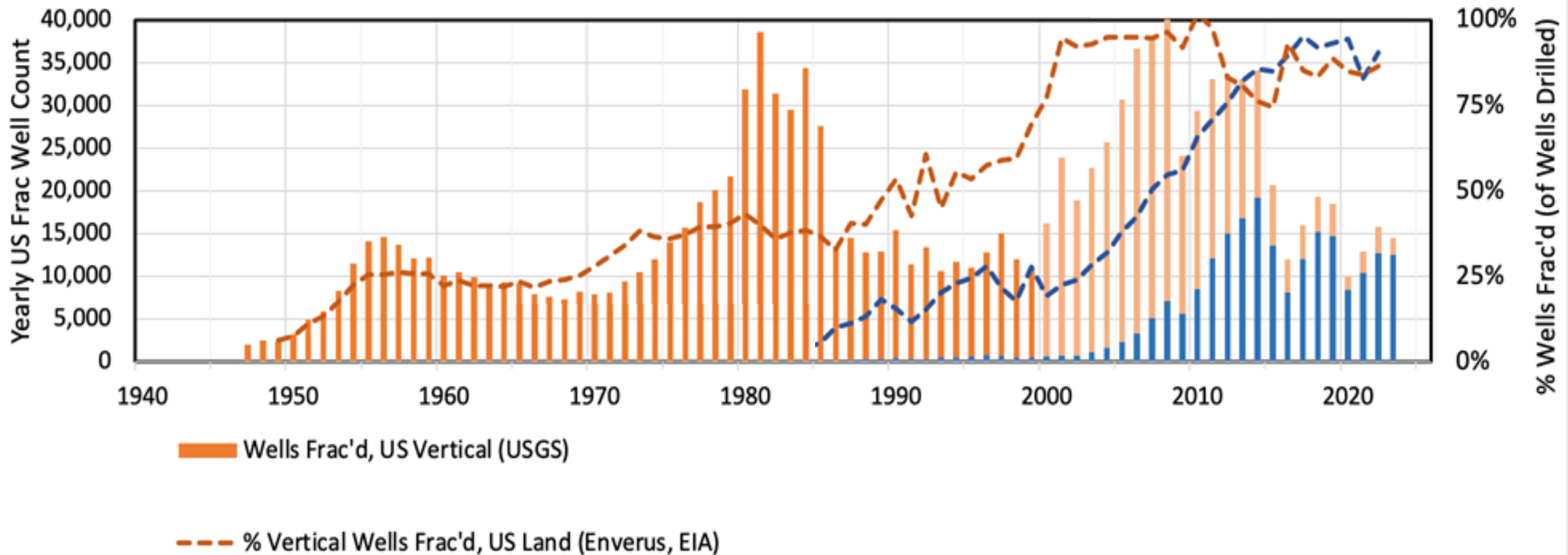
Data source: U.S. Energy Information Administration, Short-Term Energy Outlook, September 2026

U.S. Crude Oil Production



Historical US New Well Completions/Stimulation

Updated from Weijers et al, SPE Paper 194345 (2019)

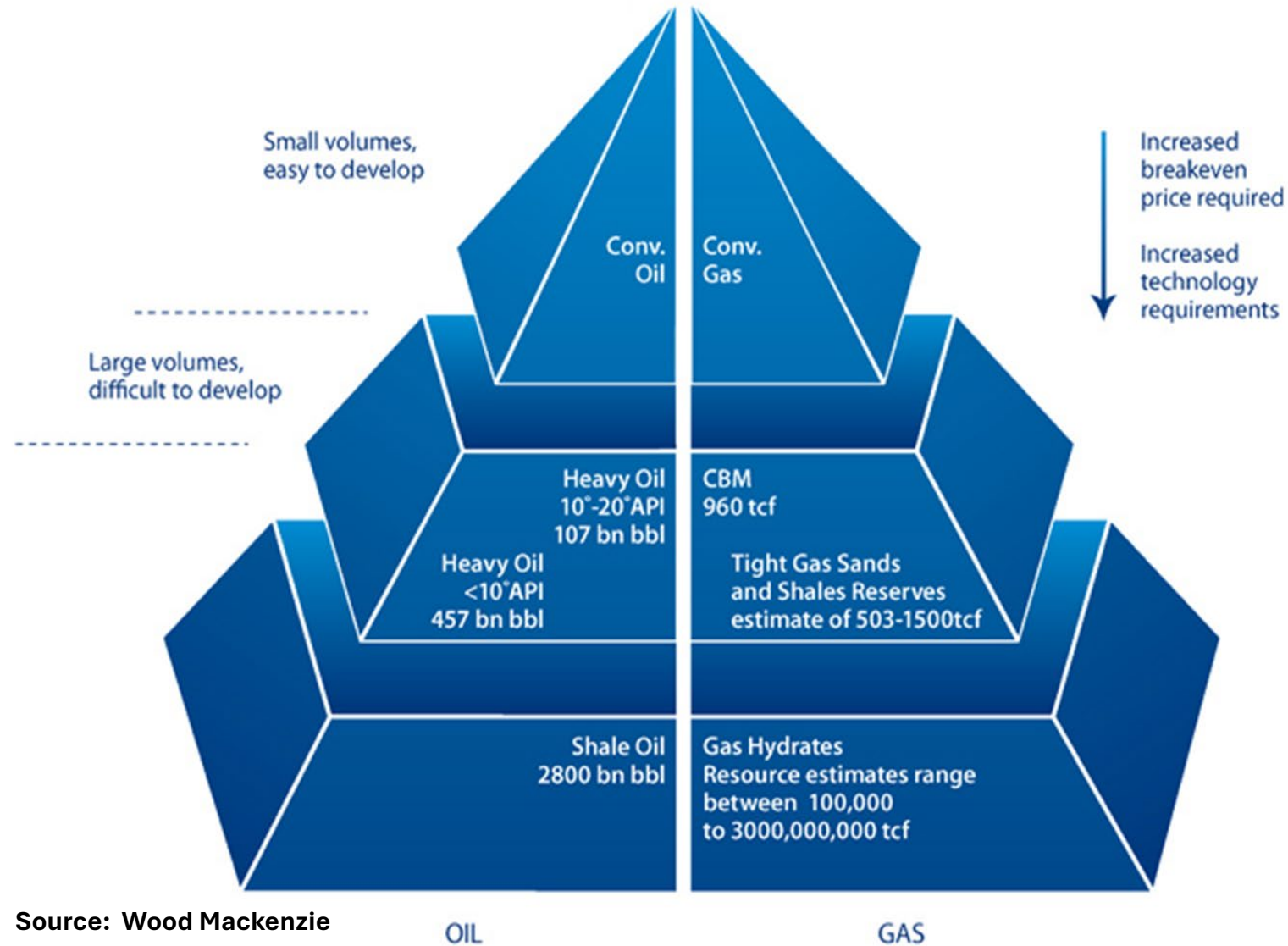


How Did We Get Here?

The three technologies that have most impacted our industry in the past 40 years:

- **3-D Seismic** (+ advanced reservoir characterization)
- **Horizontal Drilling** (+ rotary steerable / geosteering)
- **Hydraulic Fracturing** (+ multi-stage completions)

The Oil & Gas Resource Triangle

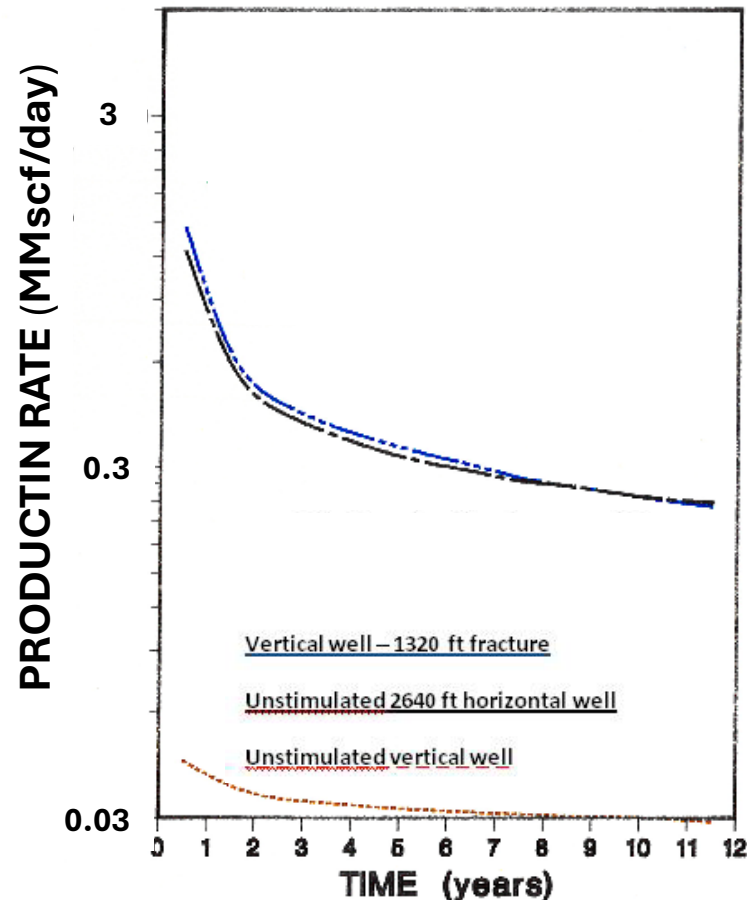


Early Horizontal Well Drilling & Applications

- The first recorded horizontal well was in Texon, Texas in 1929 and another in the Franklin Heavy Oil Field, Pennsylvania in 1944.
- Short radius wells were tested by:
 - ARCO in 1979-1982 in the Empire Abo Field, New Mexico; and
 - Exxon in 1984 (Ehleret #7 well) in the Giddings Field, Texas (285 ft. lateral).
- First Medium Radius Horizontal Well was drilled in the Austin Chalk in May 1985 by ARCO – the John G. Hubbard #1 in Rockwall, Texas; a 1500ft lateral with a 20°/100ft build rate.
- Late-1980's Applications:
 - To handle reservoir issues in some developments that were already using deviated wells – gas coning problems; thin sands development.
 - Tests in low permeability reservoirs that required hydraulic fracturing
 - Opportunity to more effectively develop naturally fractured reservoirs – e.g. the Austin Chalk, North Sea chalk reservoirs
- Modern horizontal well drilling came of age at the end of the 1980's: 257 horizontal well permits issued in the US in 1989; over 1000 in 1990.
- In 1991, the American Petroleum Institute started tracking Horizontal Wells as a separate well classification

1983 Gulf R&D Cotton Valley HWPS Study (Horizontal Well Production System)

HWPS PRODUCTION PROFILES
640 acre, 60 ft pay, 8000 ft depth



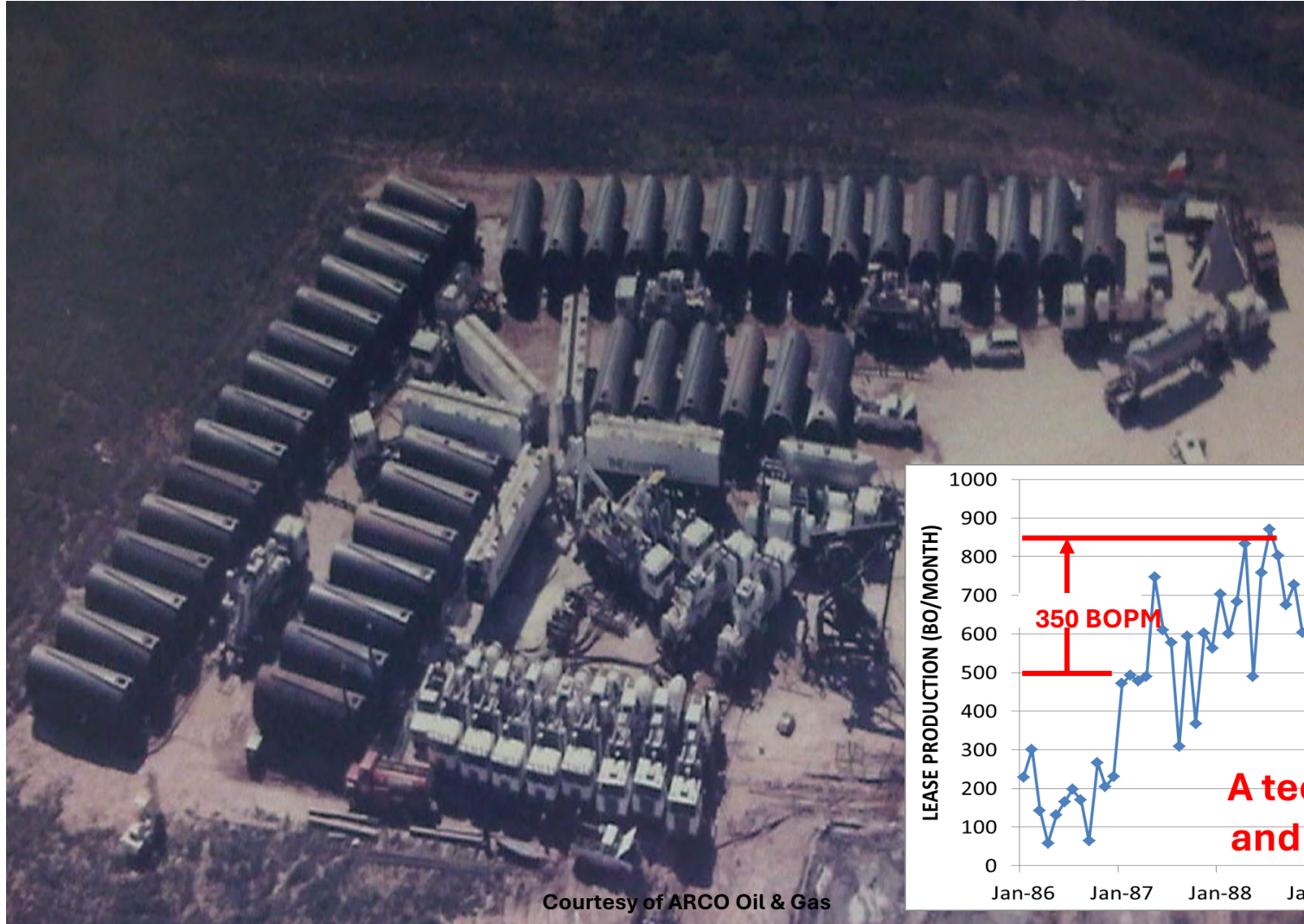
- Significant potential for increasing production rates and EUR by fracture stimulating a horizontal well in a tight gas sand
- Completion Problems:
 - Casing Centralization
 - Cement Displacement
- Stimulation Issues:
 - Fracture Re-Orientation
 - Fracture Extension/Growth

Big Rock Block Experiments

Terratek & SLB-Rosharon Work

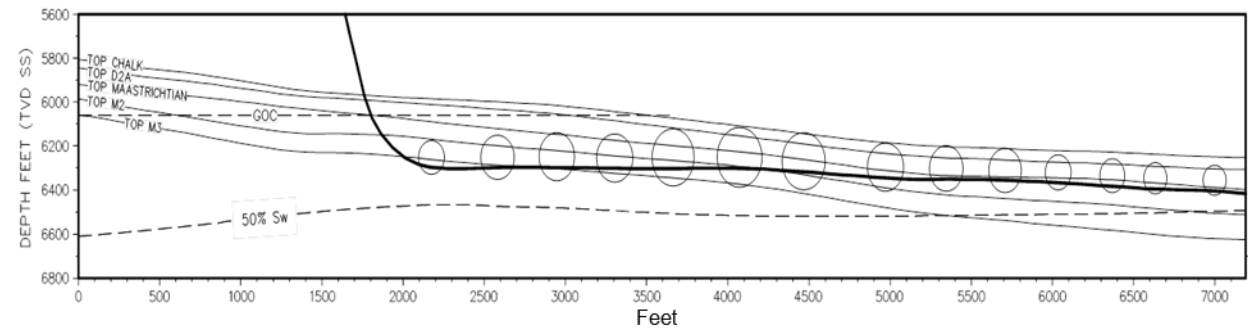
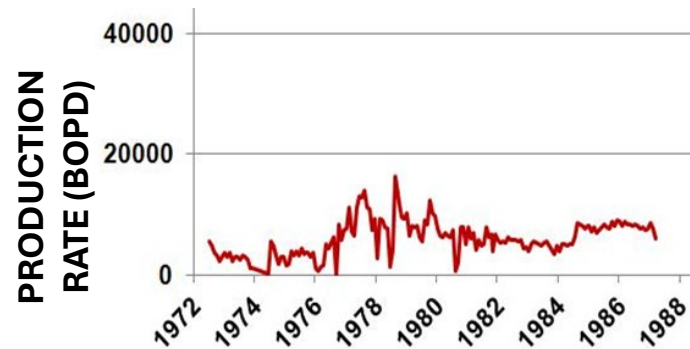
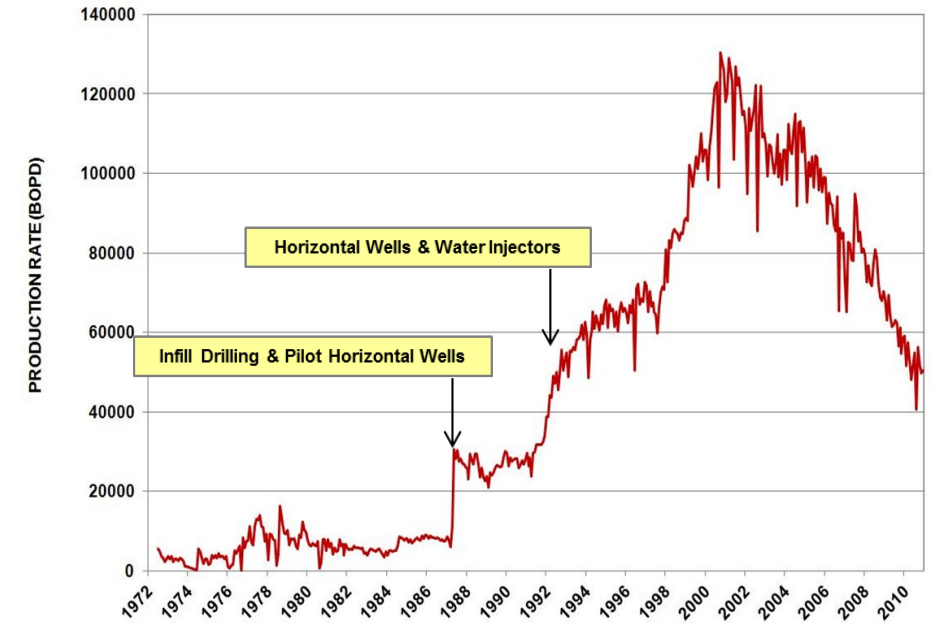
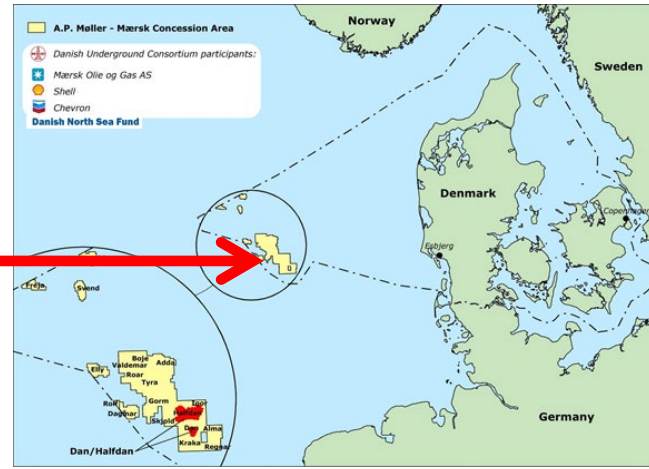


Early Multi-Stage Hydraulic Fractured Well



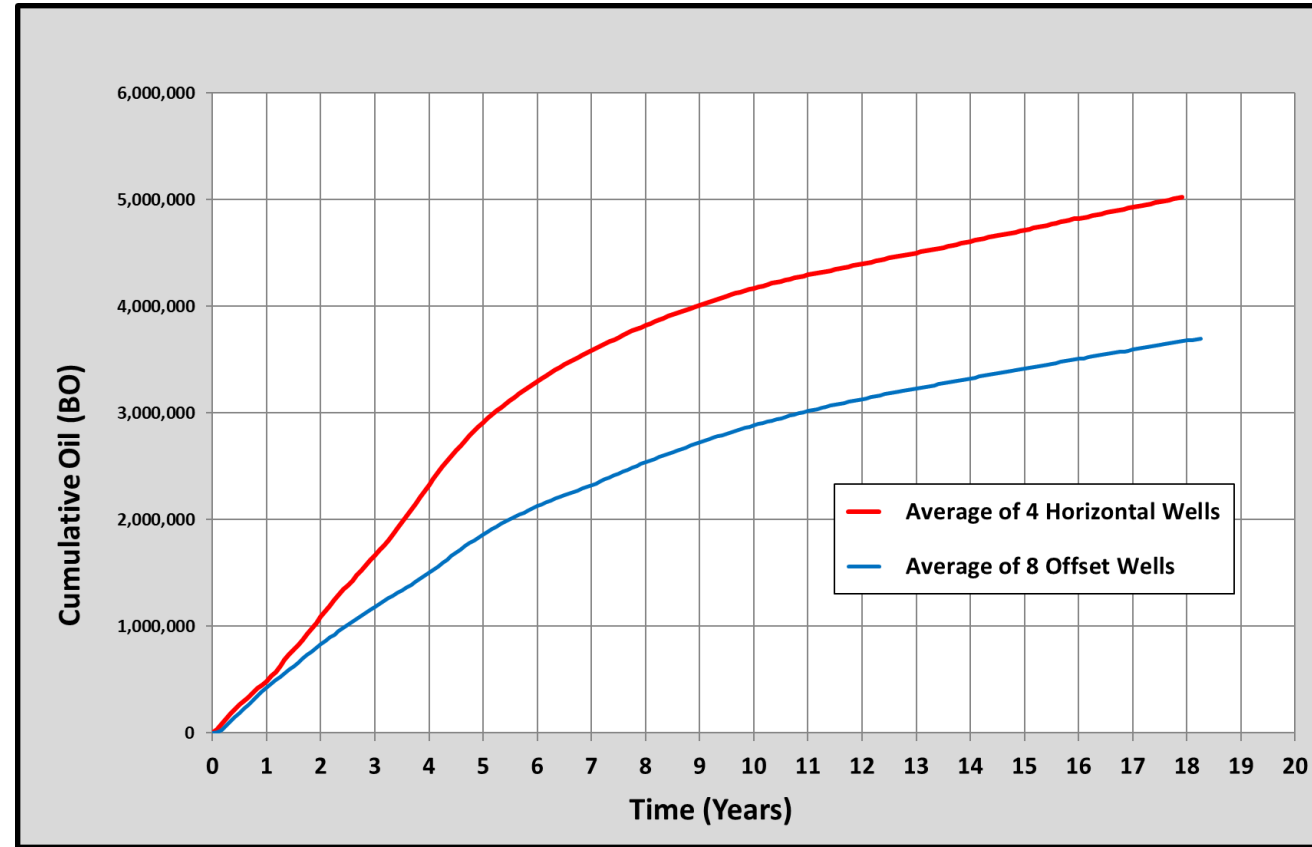
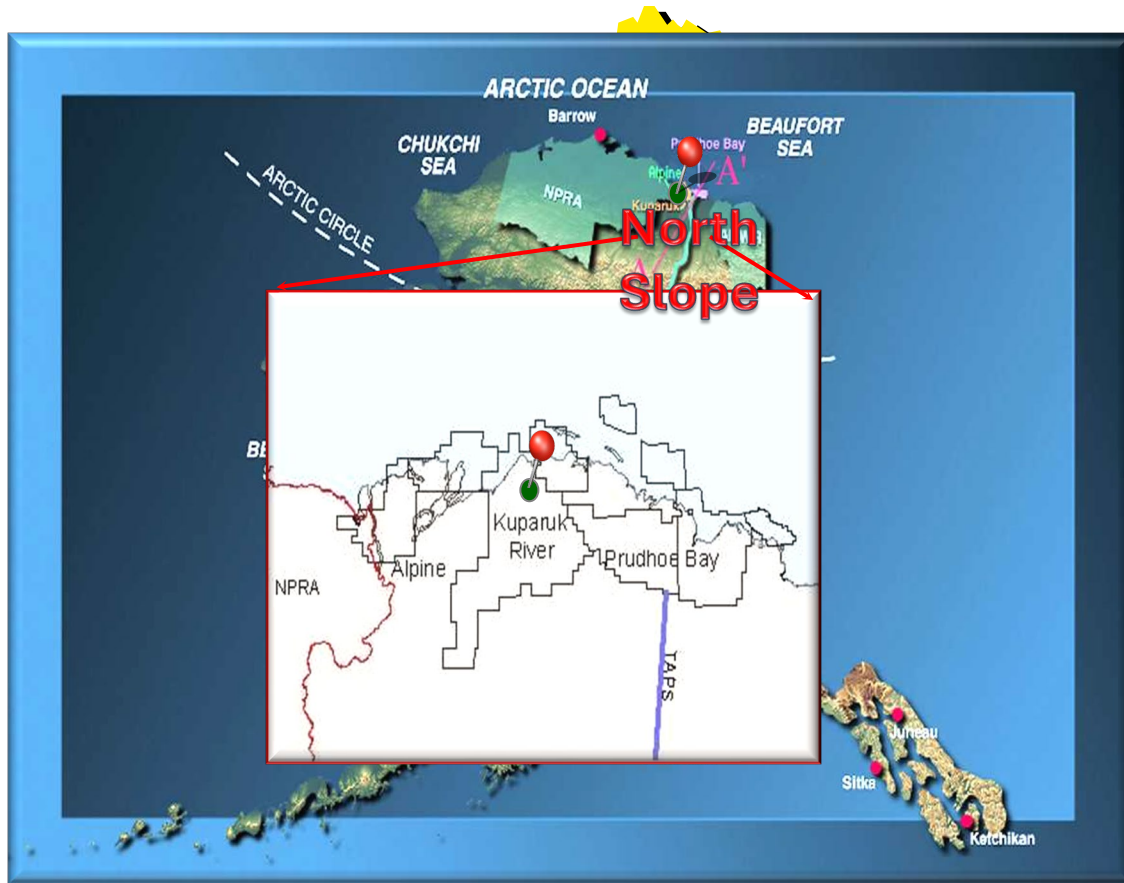
Late 1980's/90's – Dan Field Redevelopment

Danish North Sea; SPE 25049 (1992)



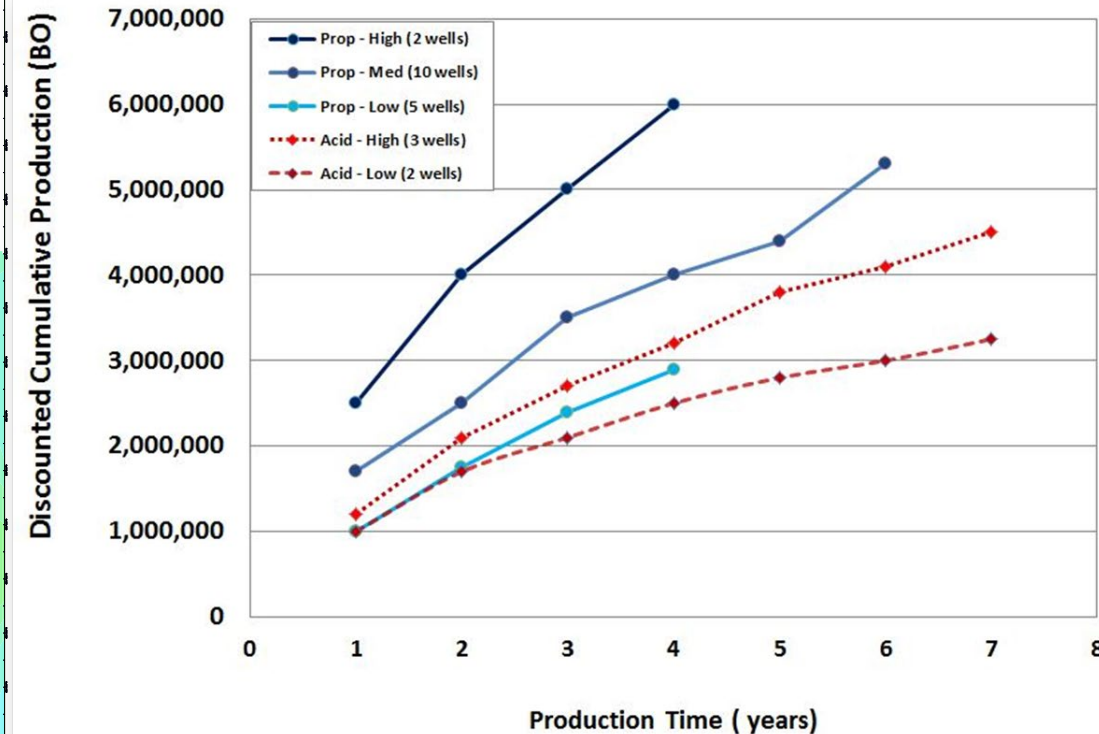
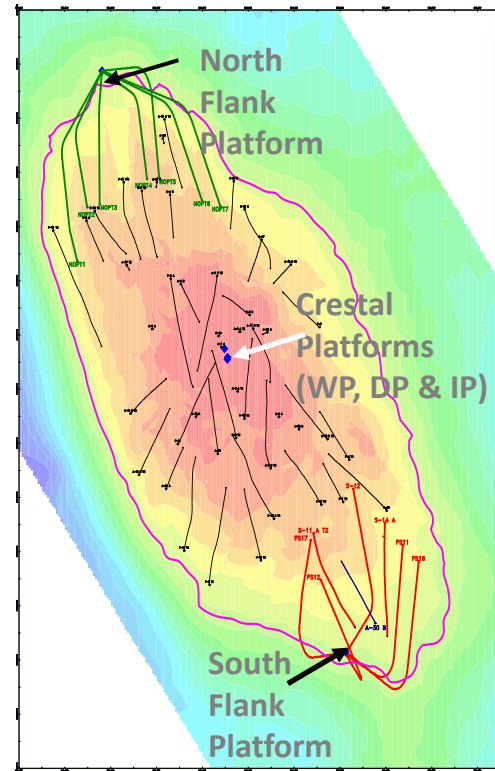
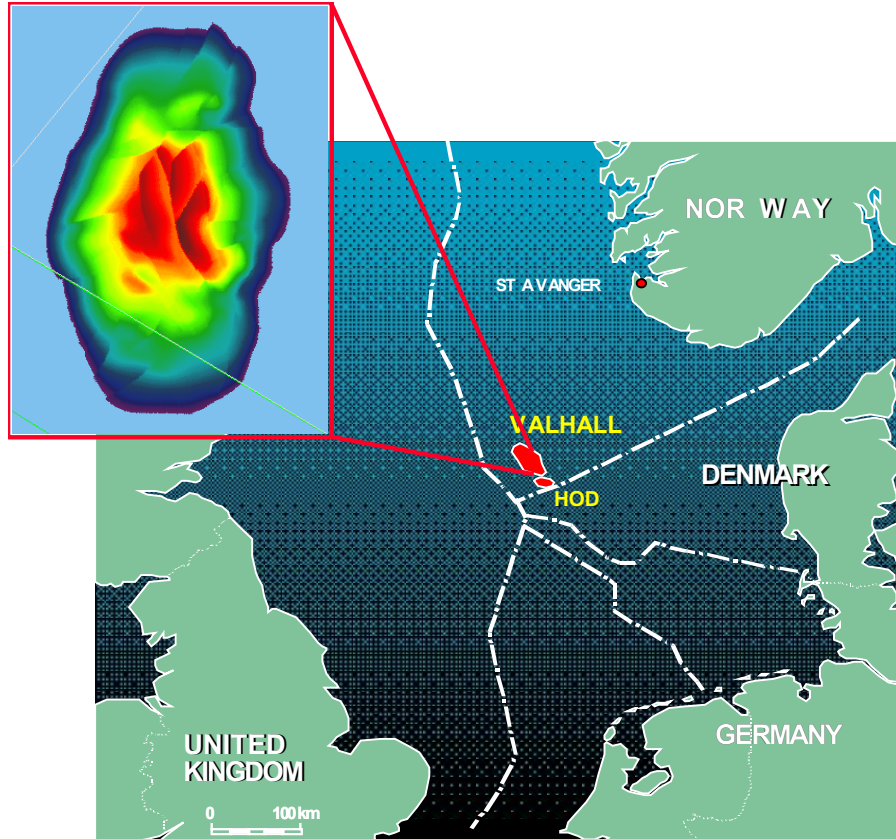
Kuparuk River Field: North Slope of Alaska

Use of 2640 ft. Longitudinally Fractured Wells; SPE 36454 (1996)



Valhall Field Development: Norwegian North Sea

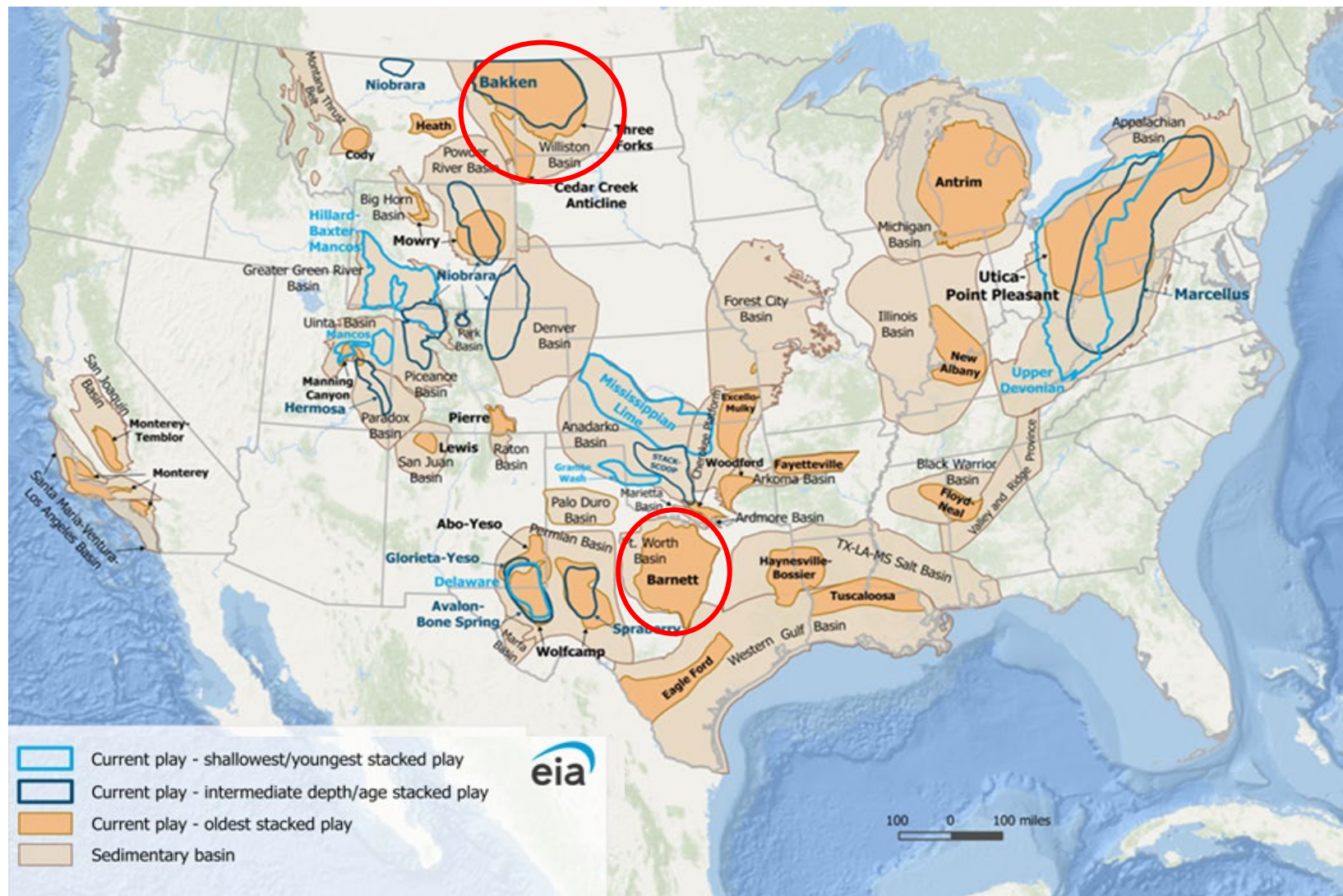
Comparison of Acid and Proppant Fracturing, SPE 84392 (2003)



An AI Summary of Horizontal Well Development

<u>Period</u>	<u>Technology milestone</u>	<u>Why it mattered</u>
1920s–30s	Directional drilling	Allowed wells to intentionally deviate from vertical and reach targets laterally or around obstacles.
1930s–50s	Downhole motors & improved surveying	Made controlled deviation increasingly practical.
1950s–60s	Hydraulic fracturing becomes commercial	Created artificial fractures to increase formation productivity.
1960s–70s	Offshore directional drilling	Wells could be drilled from one platform to multiple subsurface targets.
1970s–80s	MWD + PDC bits + mud motors	Provided much better directional control while drilling.
1980s–90s	Horizontal drilling	Long wellbore exposure to a reservoir became economically feasible.
1990s	Slickwater fracturing + horizontal wells	The critical combination behind unconventional/shale development.
2000s	Multi-stage fracturing	Turned long horizontal wells into multiple productive reservoir sections.
2010s–20s	Factory-style shale drilling	Pad drilling, longer laterals, high-density frac stages, automation and real-time geosteering dramatically increased productivity.

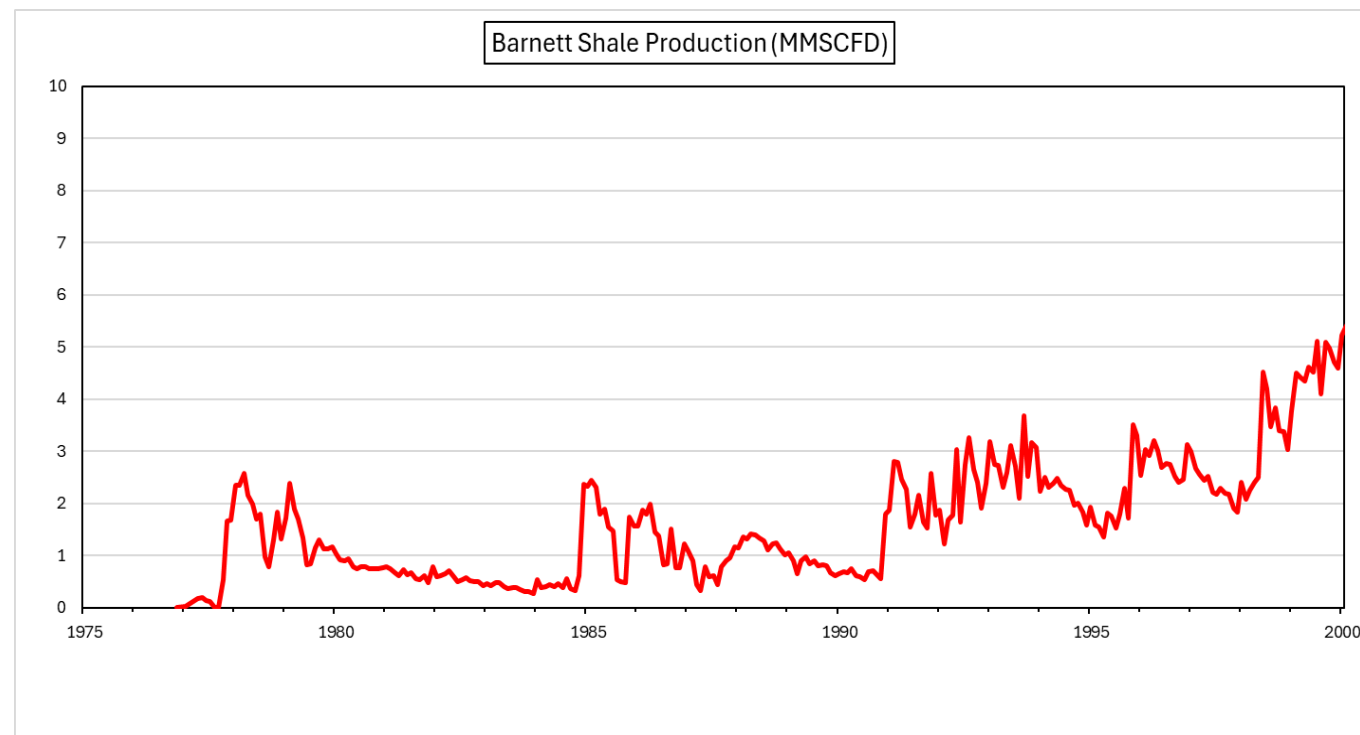
US Shale Basins



Barnett Shale: Texas, USA

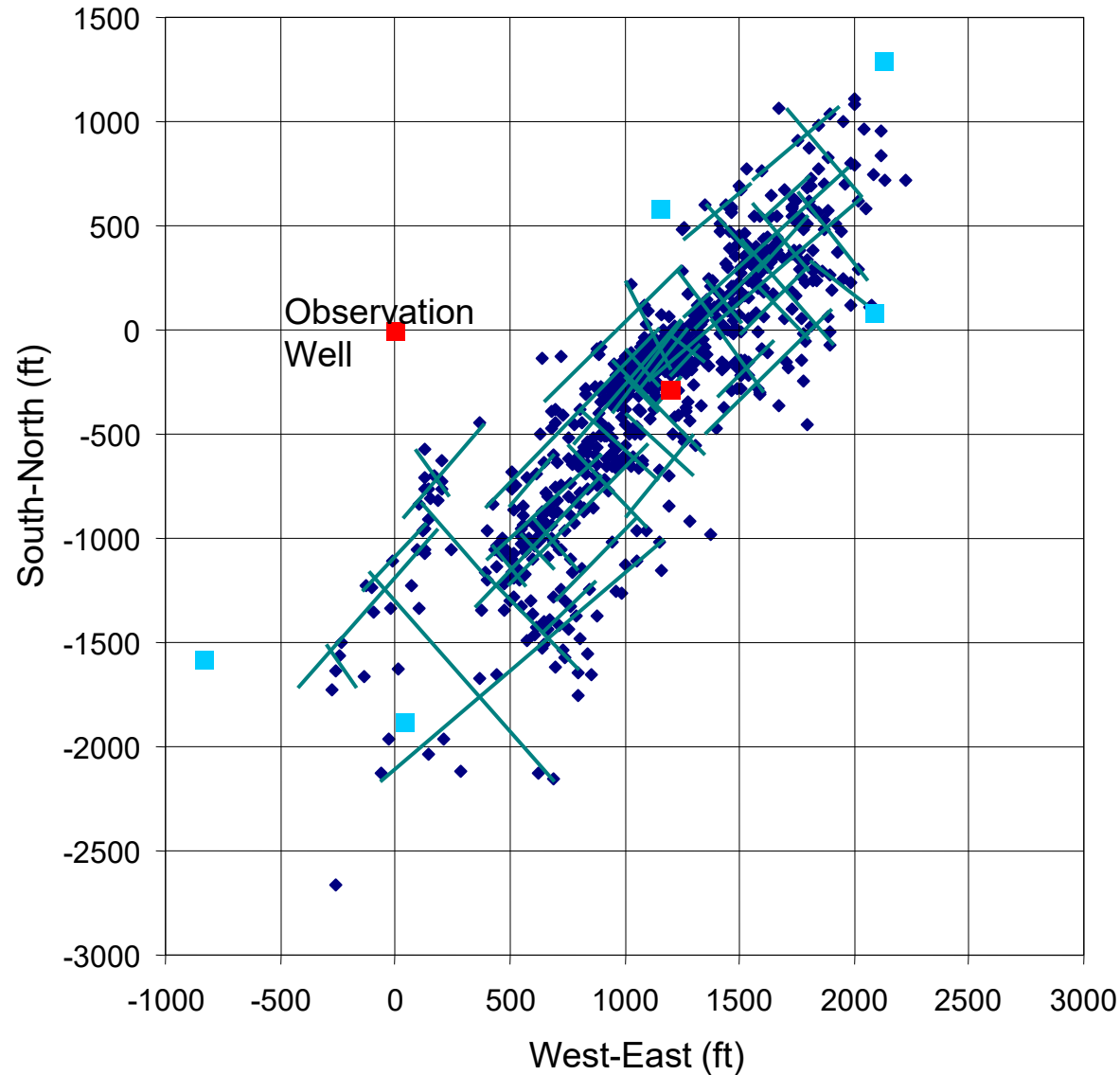


Courtesy Dan B. Steward



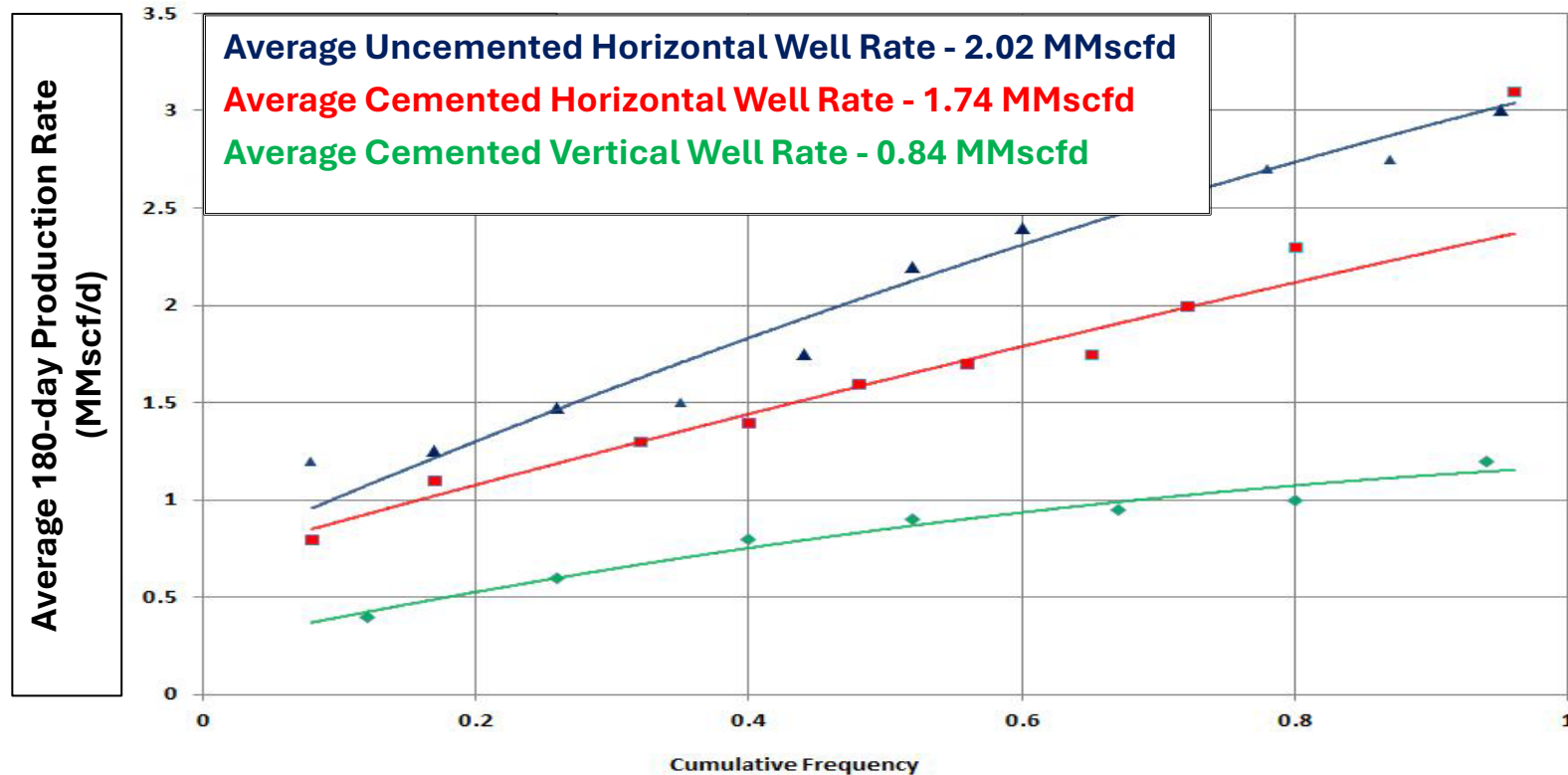
First Vertical Well with a Slickwater Frac/Completion

Fisher et al, SPE Paper 77441 (2002)

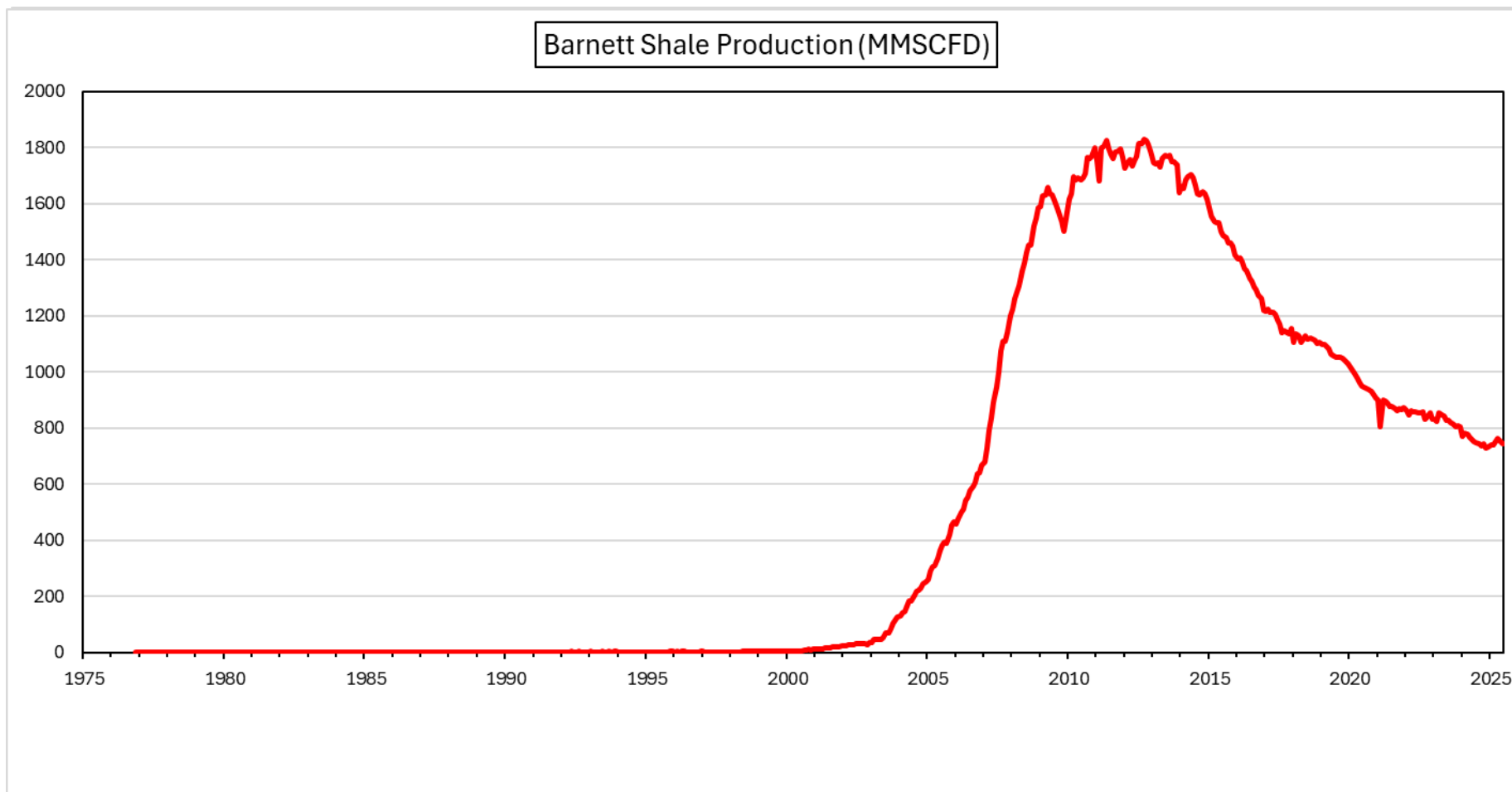


Barnett Shale: Texas, USA

Horizontal (Single Stage Frac) Well Pilot; Fisher et al, SPE Paper 90051 (2004)



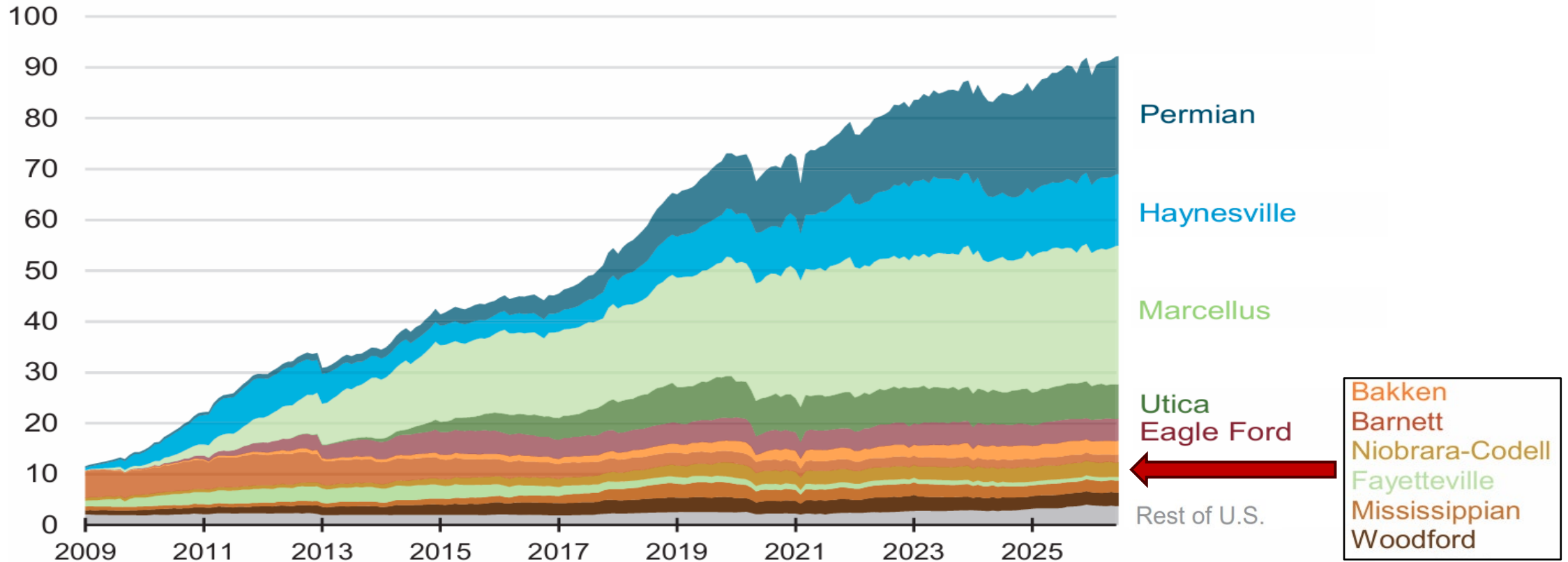
Barnett Shale Production



U.S. Dry Gas Shale Natural Gas Production



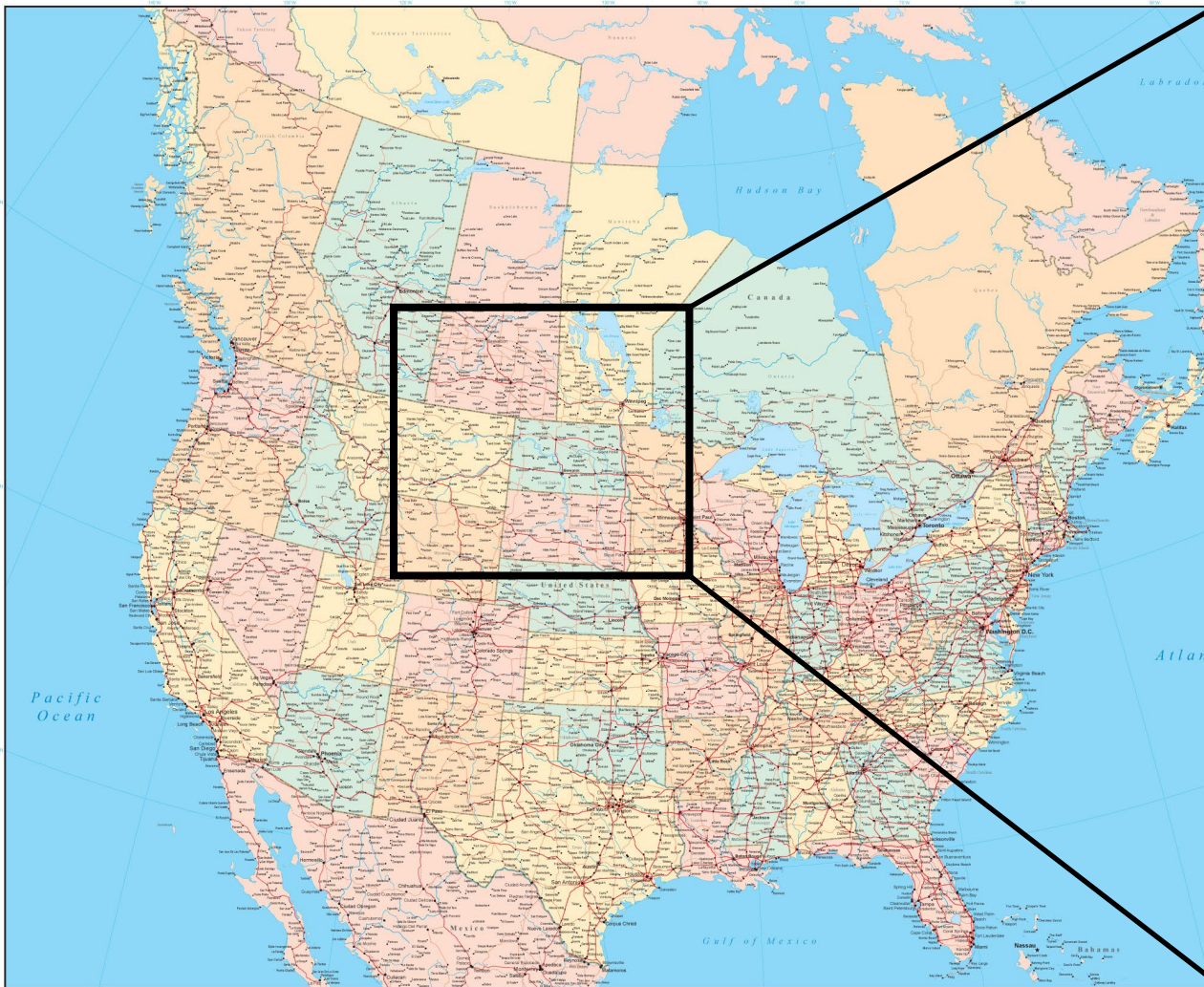
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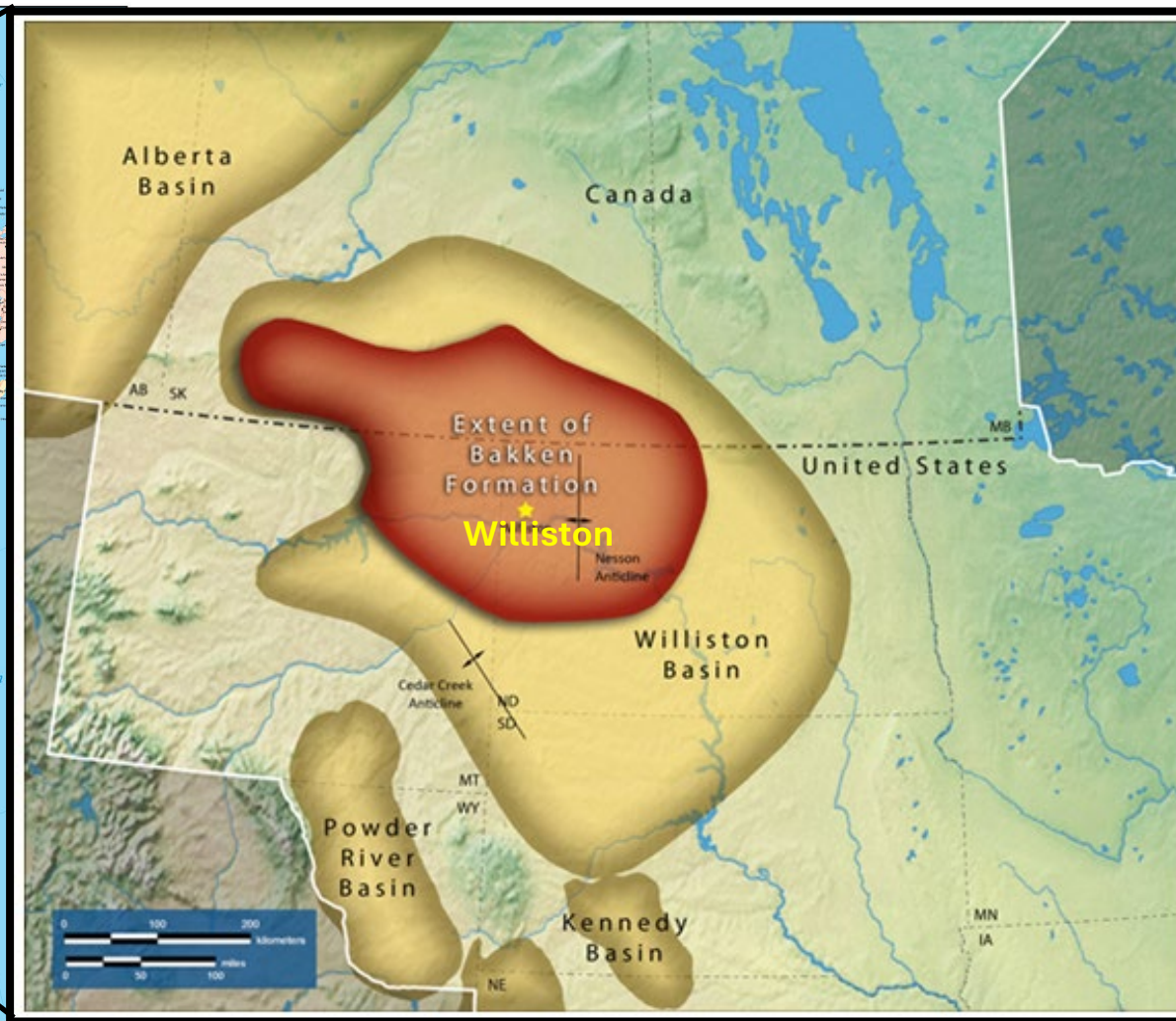
Data source: U.S. Energy Information Administration, Short-Term Energy Outlook, September 2026

Williston Basin

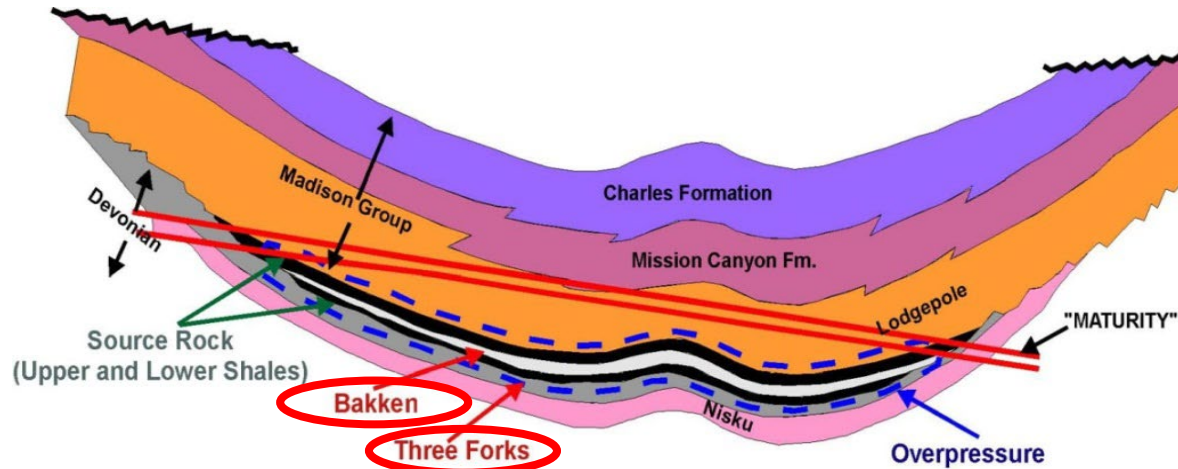
Locator Map



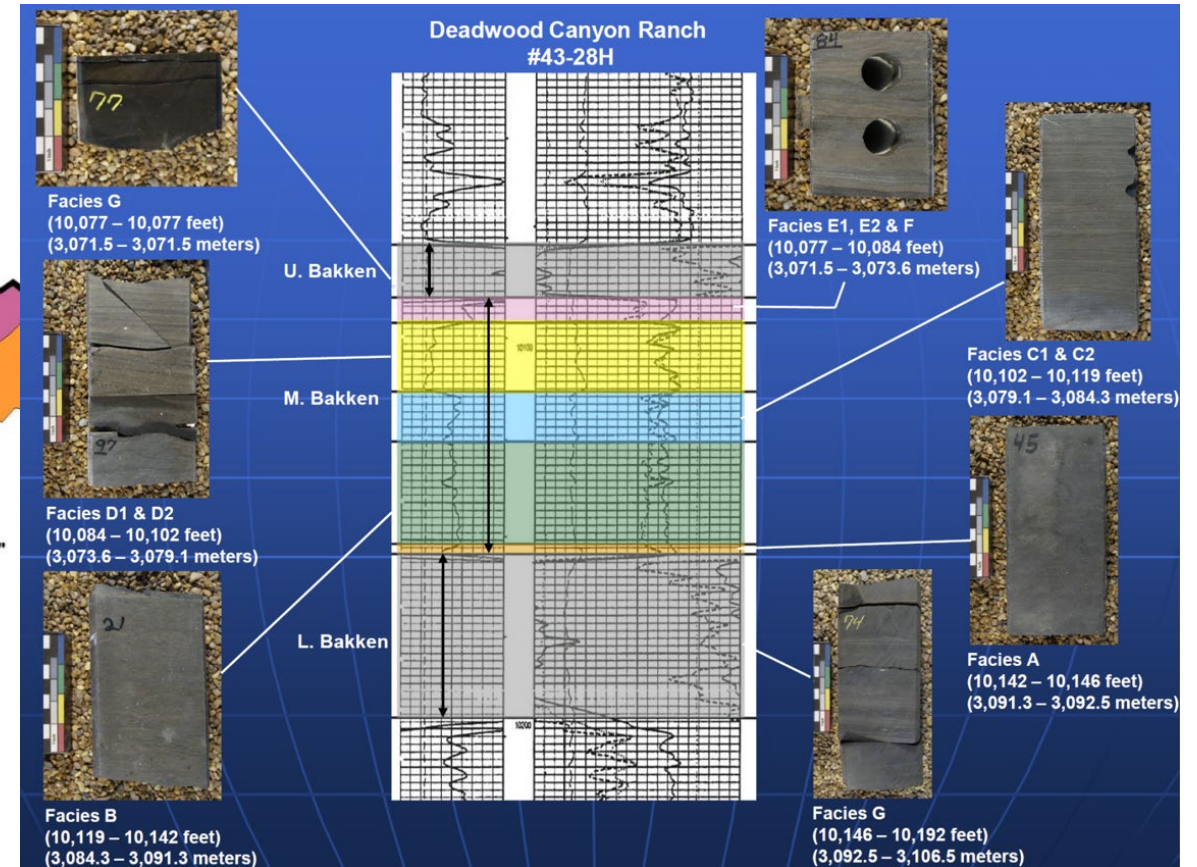
Williston Basin



Williston Basin Cross-Section & Bakken Lithofacies

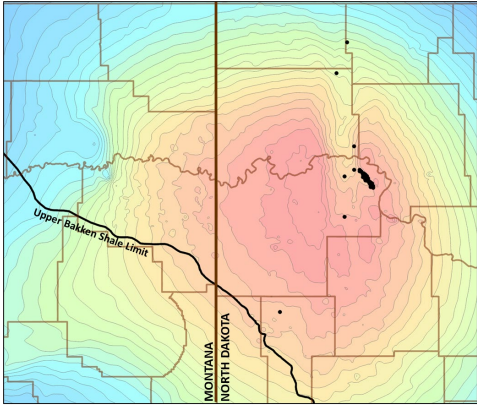


Simenson, 2010

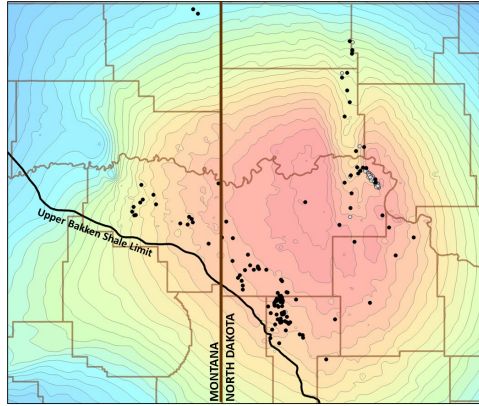


Early Bakken Development

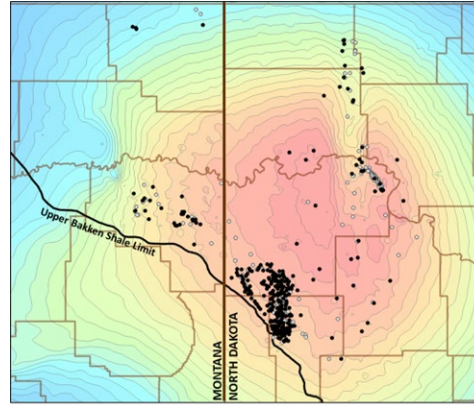
Pearson et al, SPE Paper 215644 (2023)



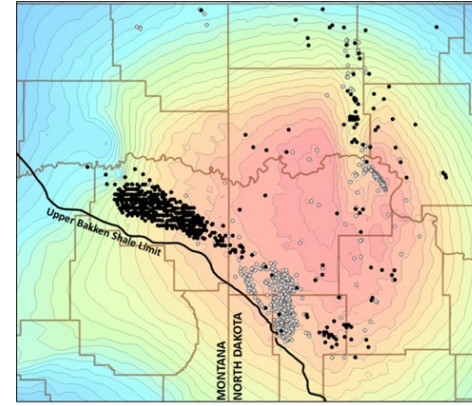
Phase 1: Early Development (1953-1970)
– 50 wells, ~3 wells/year



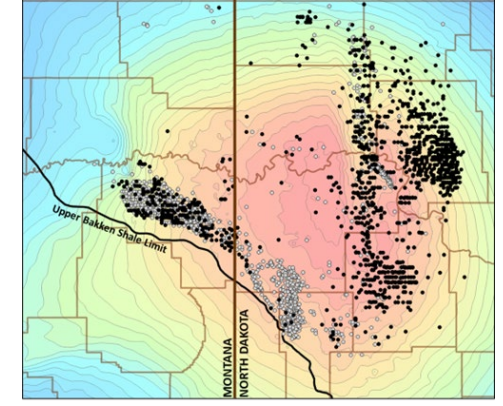
Phase 2: Vertical Well Development (1971-1986)
– 126 wells, ~8 wells/year



Phase 3: Horizontal Well Development (1987-2000)
– 306 wells, ~22 wells/year



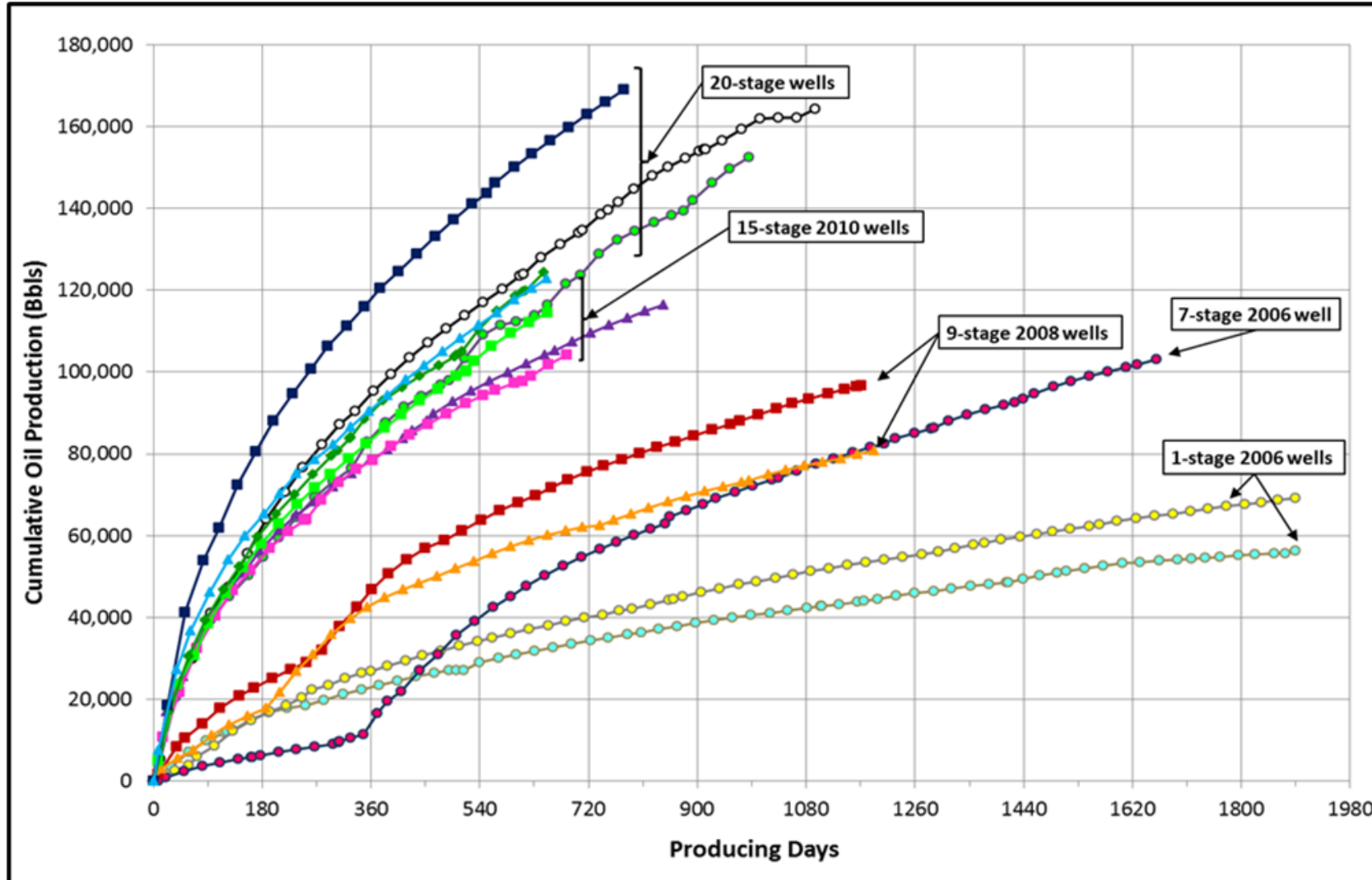
Phase 4: Elm Coulee Development (2001-2006)
– 587 wells, ~98 wells/year



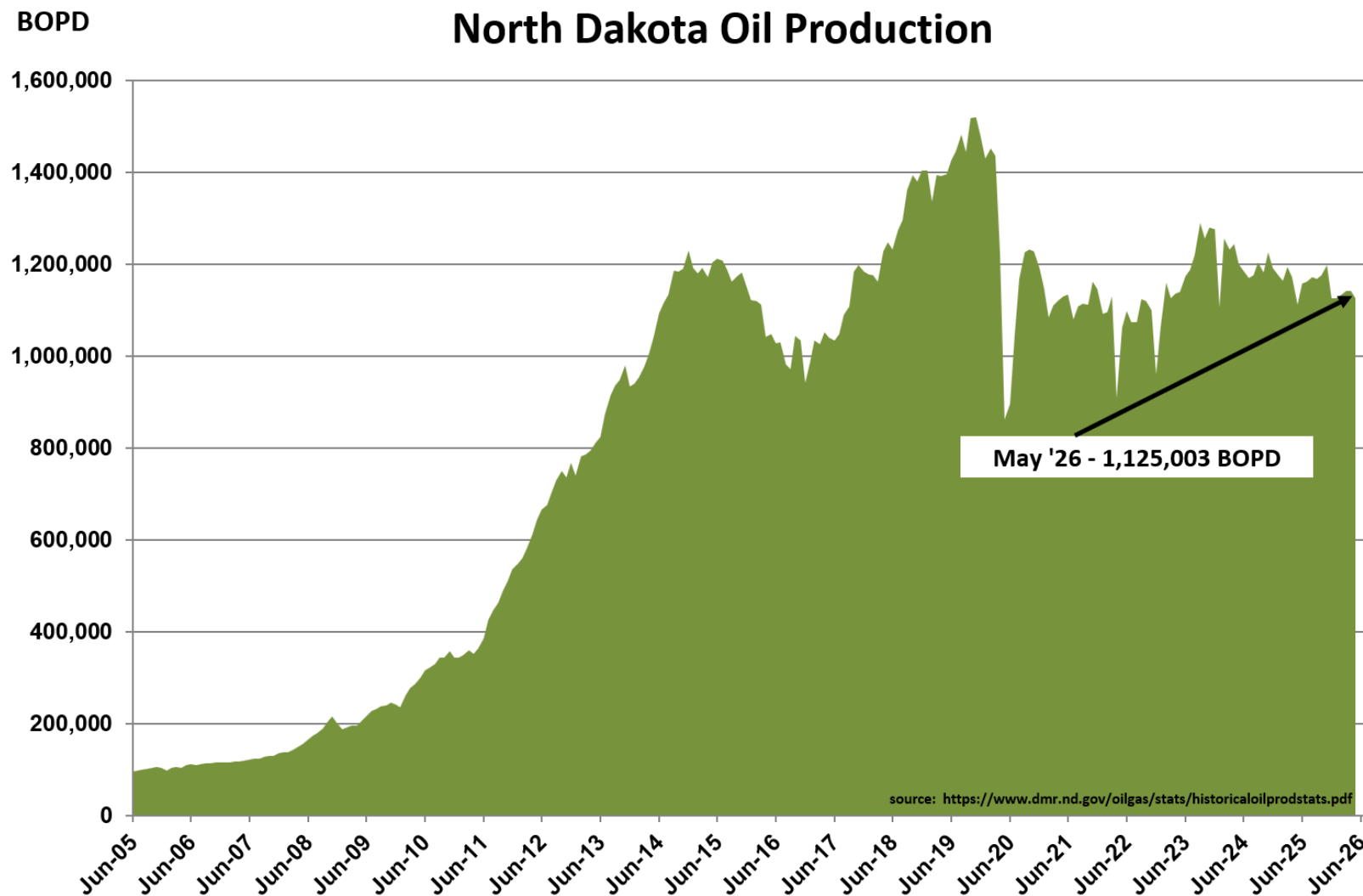
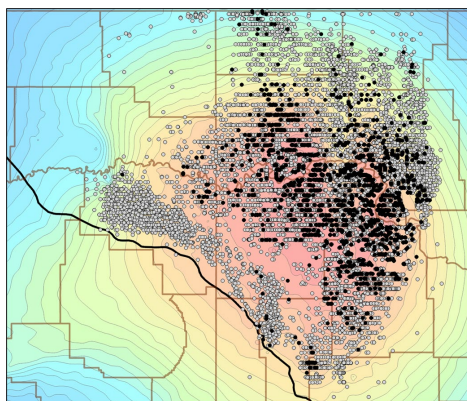
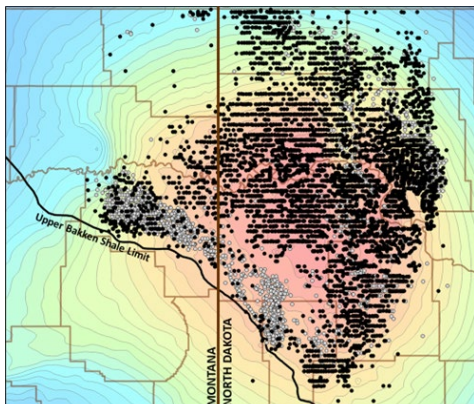
Phase 5: Eastern Basin Development (2007-2009)
– 1297 wells, 432 wells/year

Early Bakken Development: North Dakota, USA;

Increasing Stage Count in 2006-2010 Central Basin Wells; Pearson et al, SPE 163827 (2013)

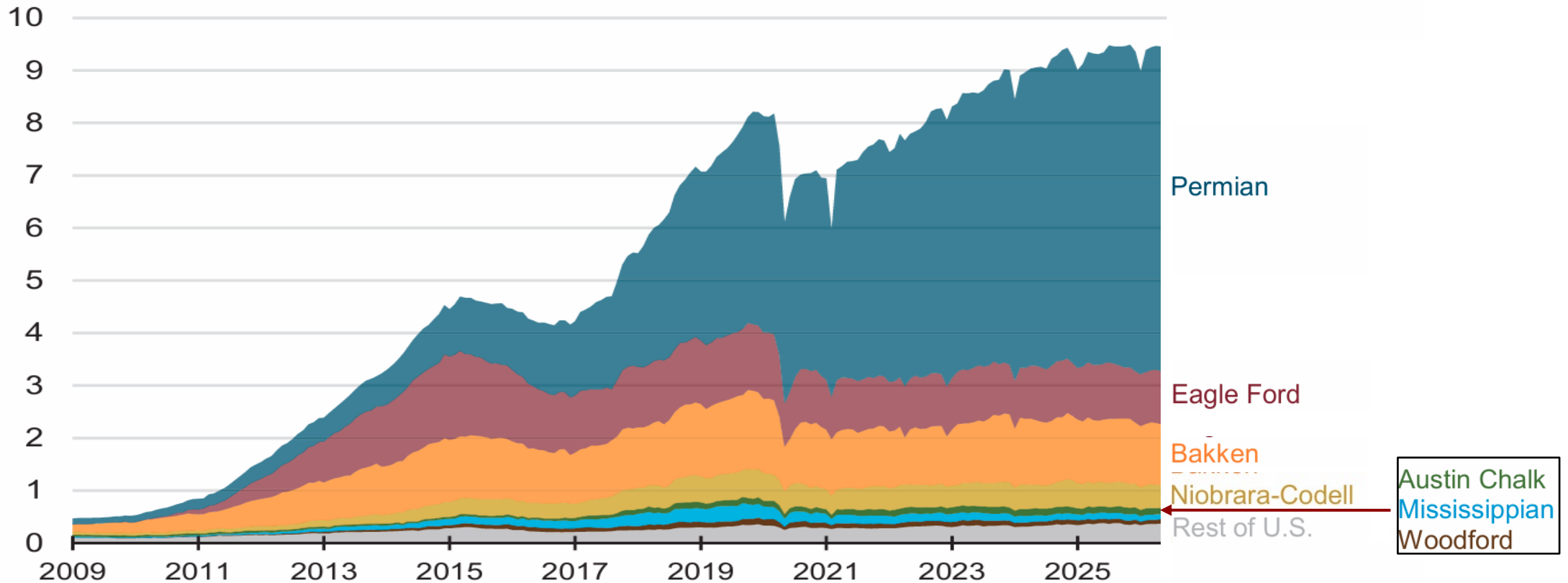


Bakken Development: North Dakota, USA



US Shale Oil Production

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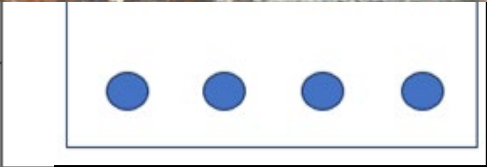
Environmental Advancements

- Reduced Surface Land Use
- Reduction in Noise and Traffic
- Reduced Emissions

Surface Location / Our “Footprint”

1970/80's Vertical Well Development



Flying Out of  Airport

2010/20's Horizontal Well Development



Flying Out of Denver, Colorado Airport

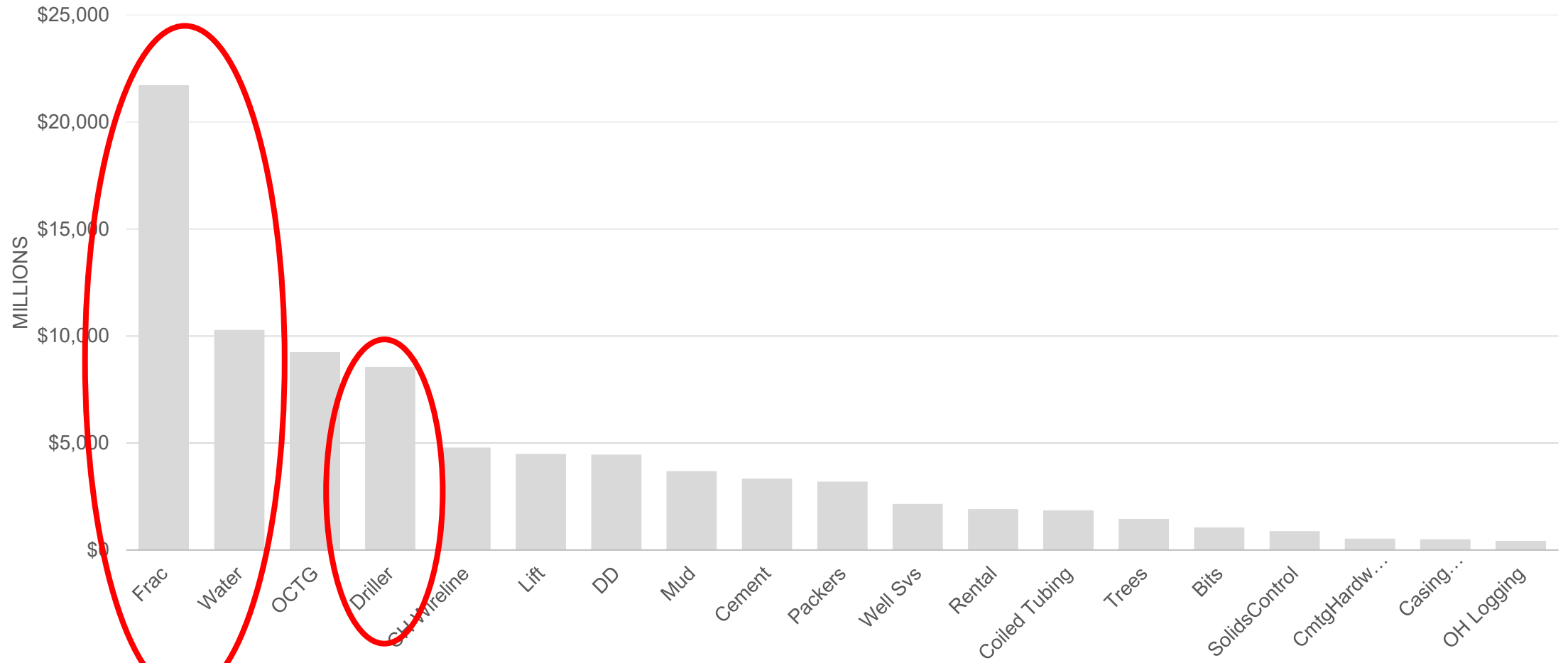
Anatomy of Funding Development – the Well AFE

WELL COSTS	BAKKEN COSTS
Storsul AFE (2024 1280 Lateral):	
Drilling	2.50
Completion	2.84
Production (downhole)	0.16
Pad & Facilities	1.86
TOTAL	7.36

~40%

<15%

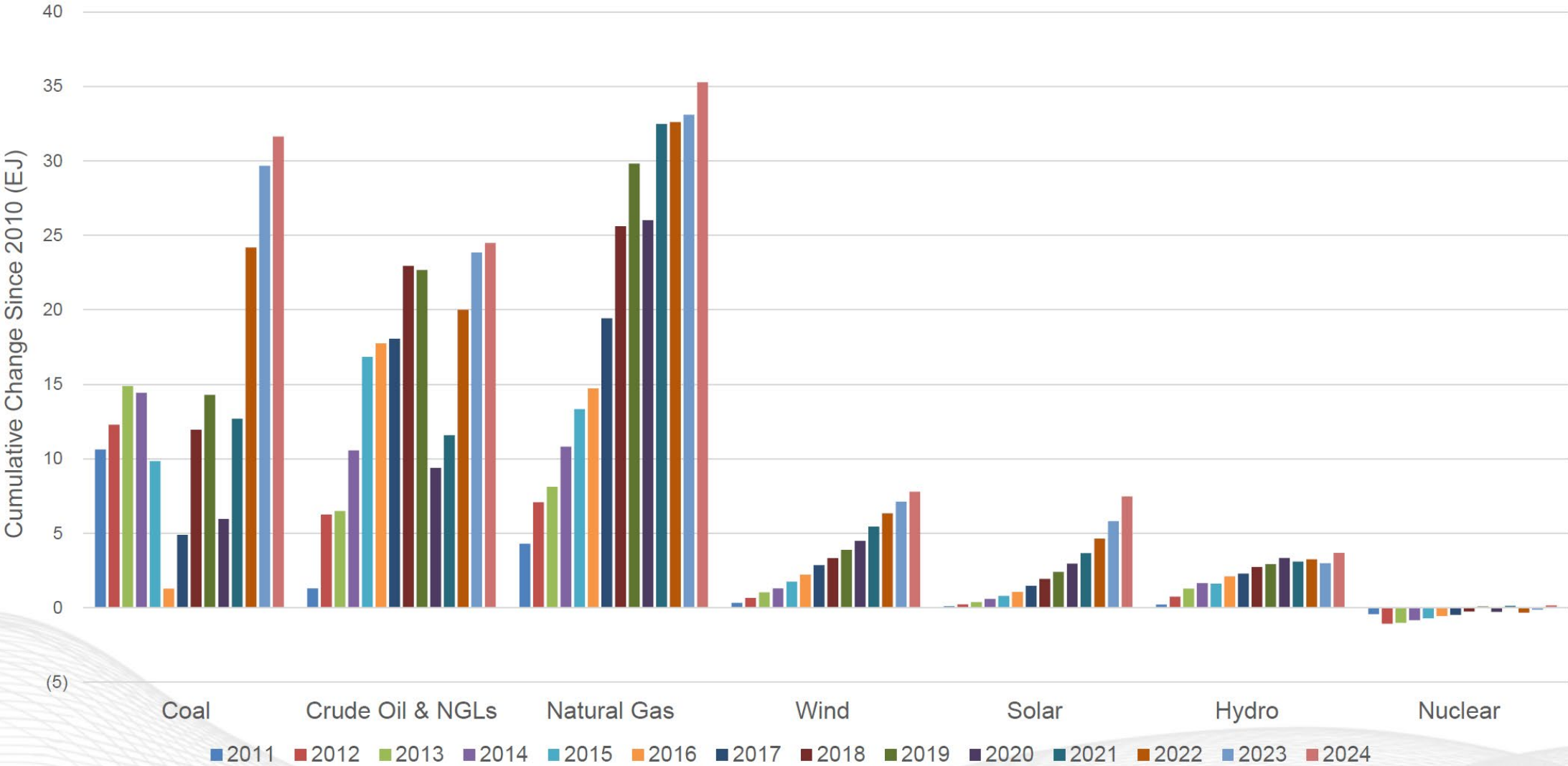
D&C Spending in the USA (2023)



Spears & Associates

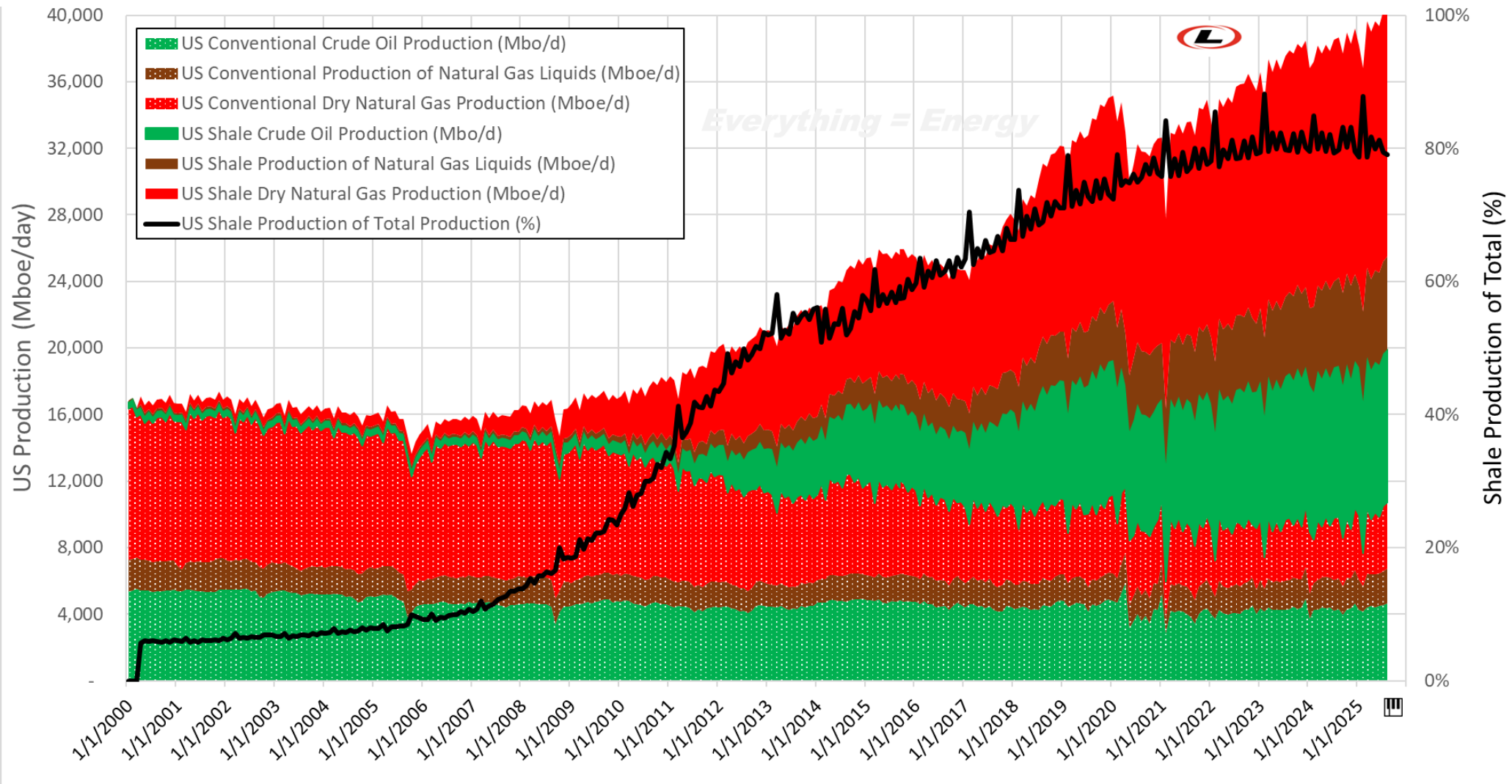
Global Energy (Production) Additions Since 2010

Source: Energy Institute & Liberty Energy



US Production of Oil, NGLs, and Natural Gas

In Conventional and Shale Reservoirs



Summary

Today's Unconventional Oil & Gas industry

- Is dominated by Horizontal Drilling and Multi-Stage Fracturing
- Accounting for ~80% of US production

This has resulted in the USA becoming an Energy Powerhouse producing more oil and gas than any other country

- With some of the cleanest environmental standards in the world
- And an industry that is committed to continuous environmental improvement
- And no longer dependent on Middle East oil coming through the Strait of Hormuz

Thank you “You Frackers – Look What You’ve Done”

Application of Horizontal Fractured Wells - 2025 Papers

- SPE 223561-MS: “Conventional & Unconventional Development **Part I: What Applies, Where and Why?**”; M. Rylance, C. M. Pearson, G. Fowler, & M. McClure.
- SPE 223562-MS: “Conventional & Unconventional Development **Part II: Extrapolation of Unconventional** Horizontal Development to Low Permeability Reservoirs”; C. M. Pearson, G. Fowler, M. McClure, & M. Rylance.
- SPE 226612-MS: “Conventional & Unconventional Development **Part III: Extrapolation of Conventional** Horizontal Fractured Well Development to Lower Permeability Reservoirs”; C. M. Pearson, G. Fowler, M. McClure, & M. Rylance.

References:



SPE Horizontal References

Thank You

References:



SPE Horizontal References