USGS
science for a changing world

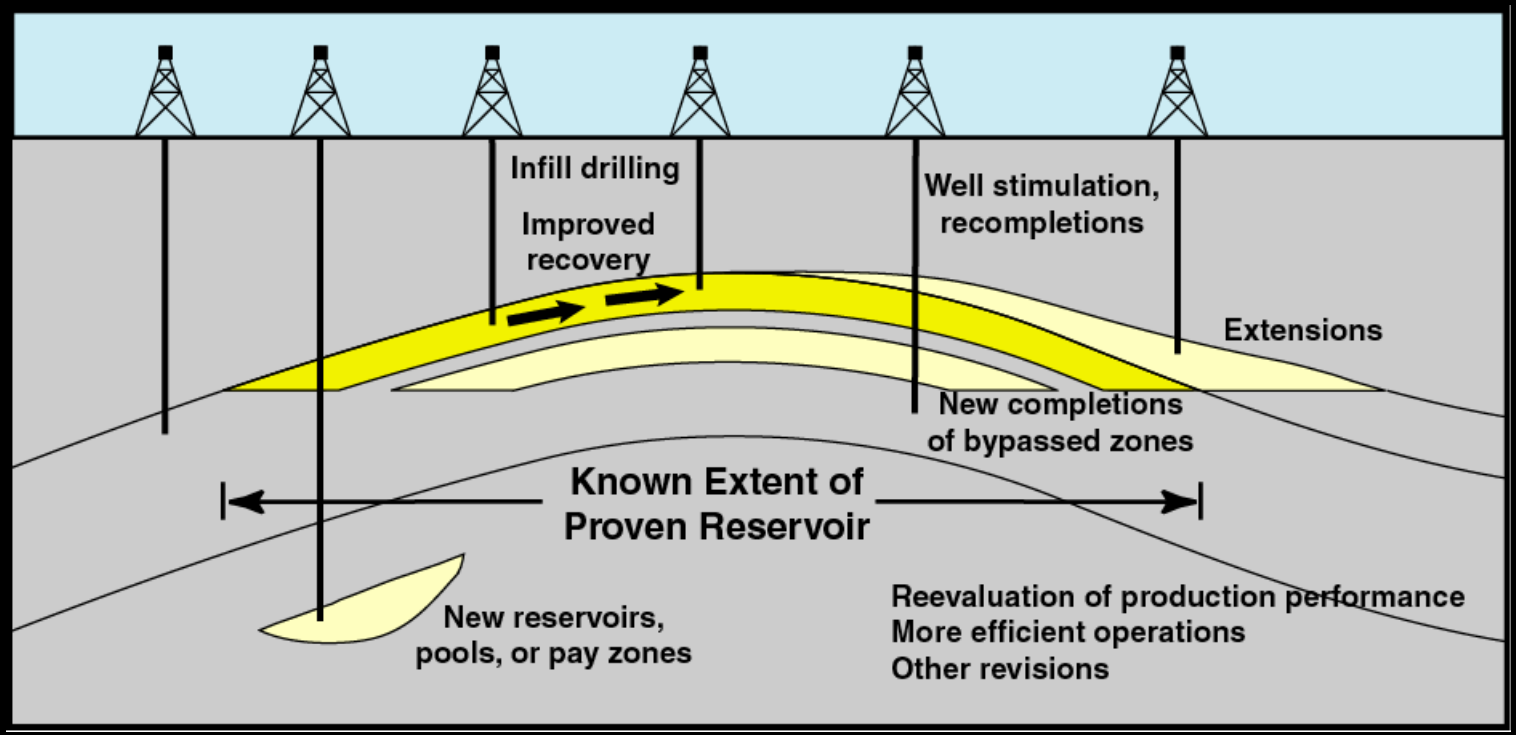
Global Significance of Reserve Growth

Don Gautier
Tim Klett
Brenda Pierce

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

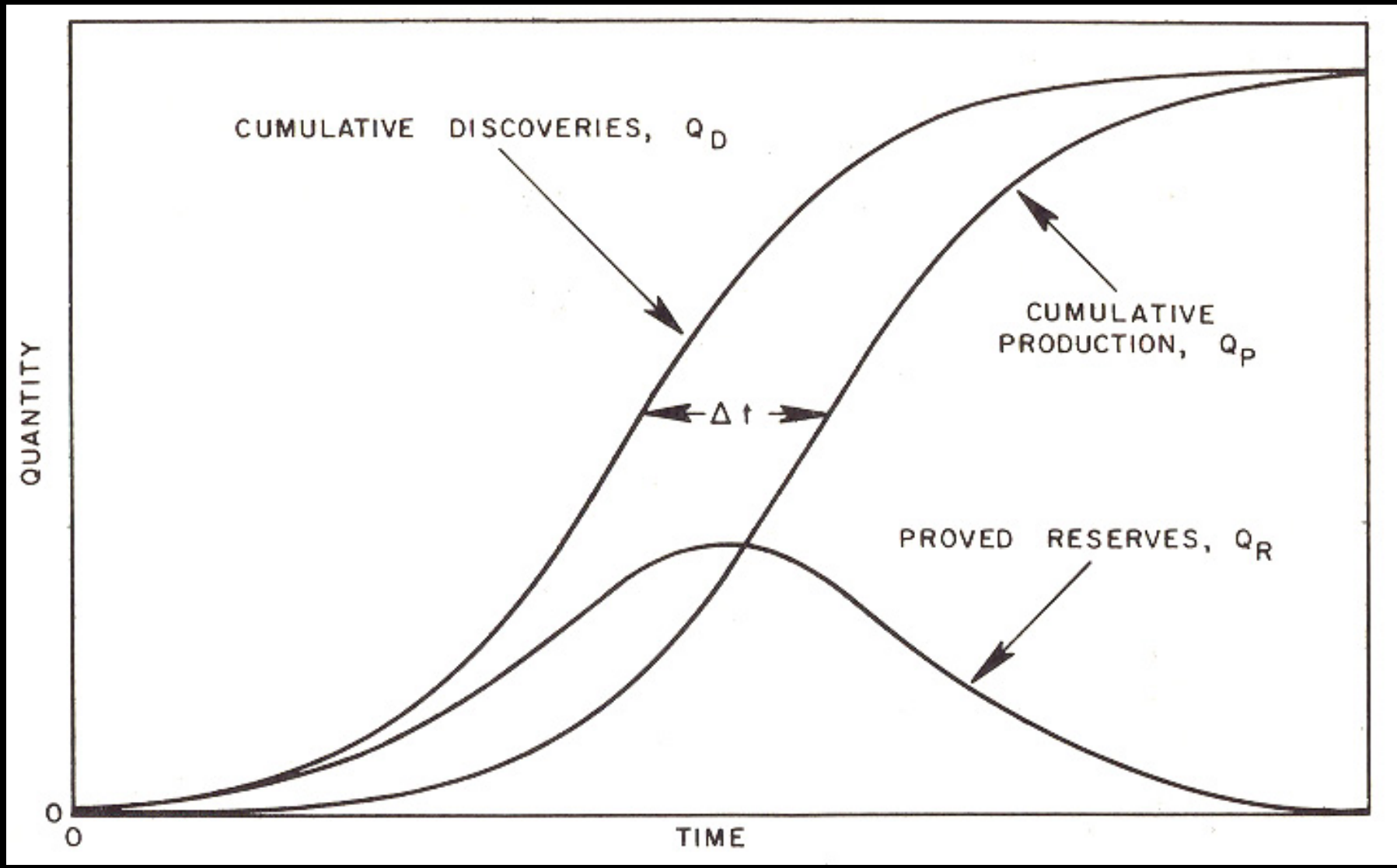
Reserve Growth

Definition



Increases in successive estimates of recoverable volumes of crude oil, natural gas, and natural gas liquids in discovered fields

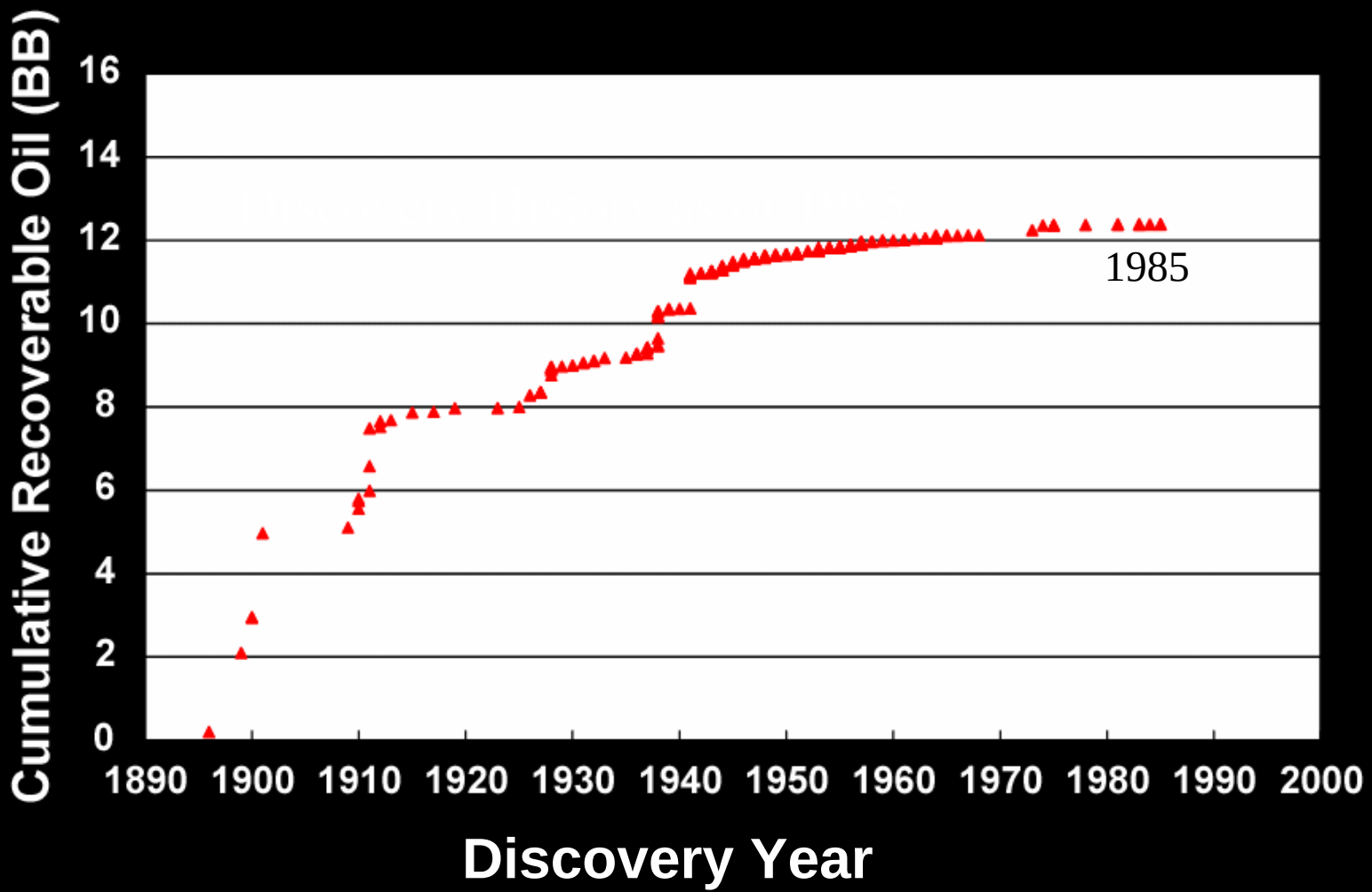
- Delineation of additional in-place volumes (geological)
- Increases in recovery efficiency (technological)
- Recalculation of viable reserves in changing conditions (definitional)
  - Economic, operating, and political/regulatory



USGS

From Hubbert (1974)

San Joaquin Basin, Oil in Oil Accumulations



USGS

Data from NRG Associates (2002)

San Joaquin Basin circa 1965

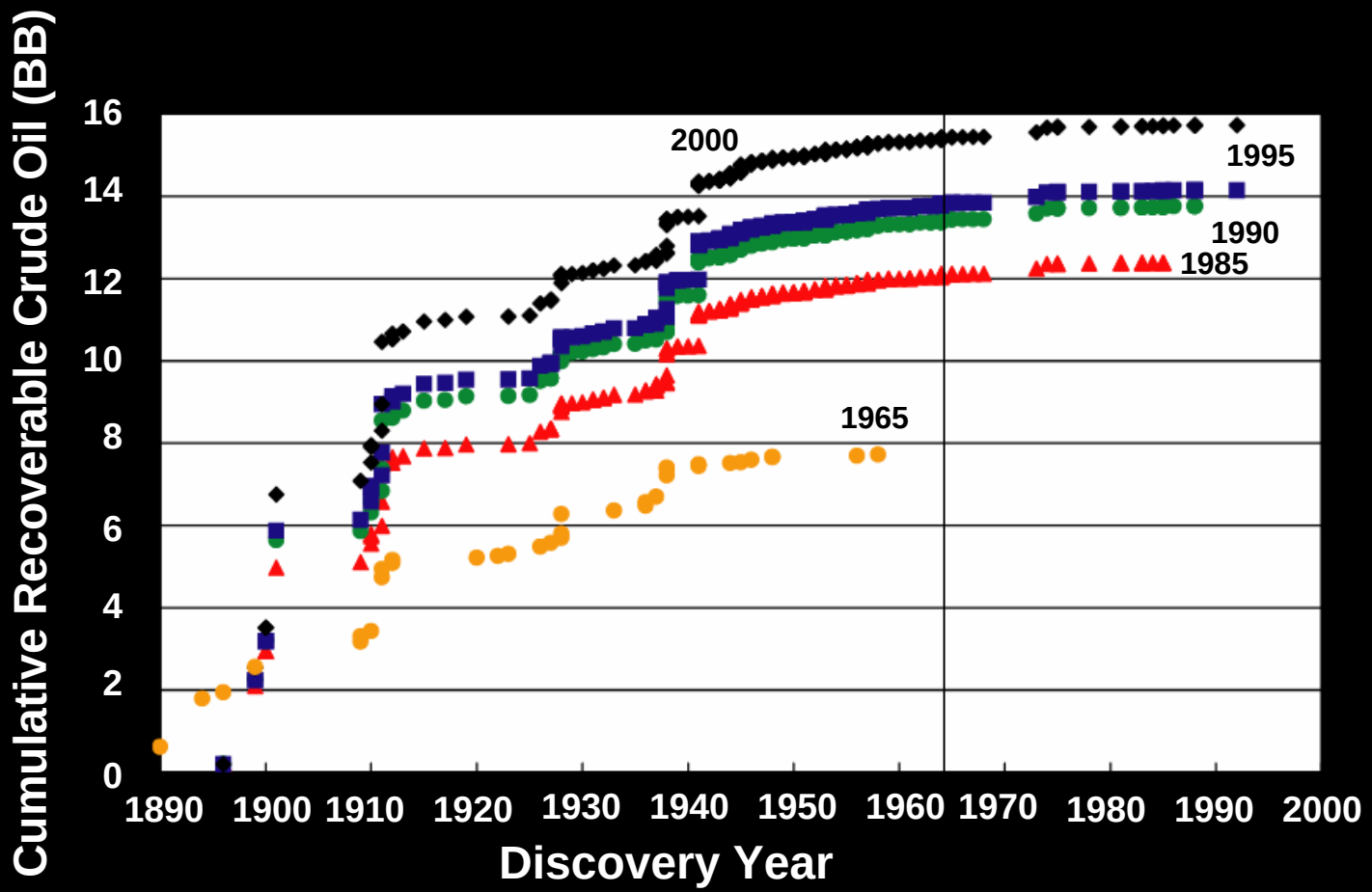
- 20,000+ wells
- Midway-Sunset Field

  ~ 1 BBO est. recoverable
- Cumulative production ~2 BBO
- Remaining ~ 6 BBO
- Steam was new technology

Midway-Sunset Field, California
Photograph courtesy of Ken Takahashi, USGS

USGS

San Joaquin Basin – Oil in Oil Accumulations



USGS

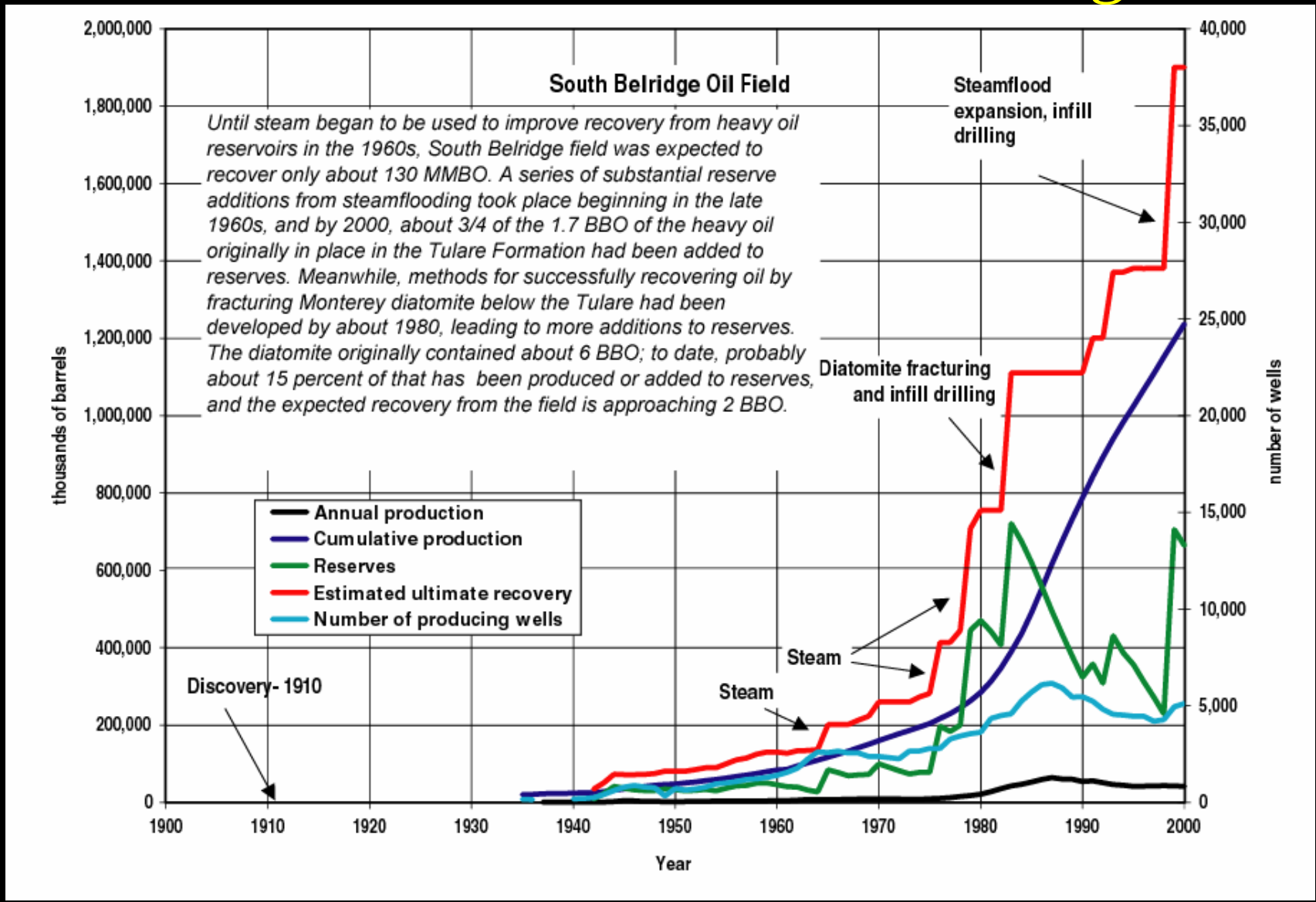
Data from NRG Associates (2002); Oil & Gas Journal (1966)

Causes of Reserve Growth

- **Conservative initial estimates**
- **Exploration technology (3-D, 4-D seismic)**
- **Geologic insights**
- **Improved drilling technology**
- **Production technology (enhanced oil recovery)**
- **Political and economic changes**

USGS

Reserve Growth at South Belridge



USGS

Data from various sources compiled by Tennyson (written communication, 2004)

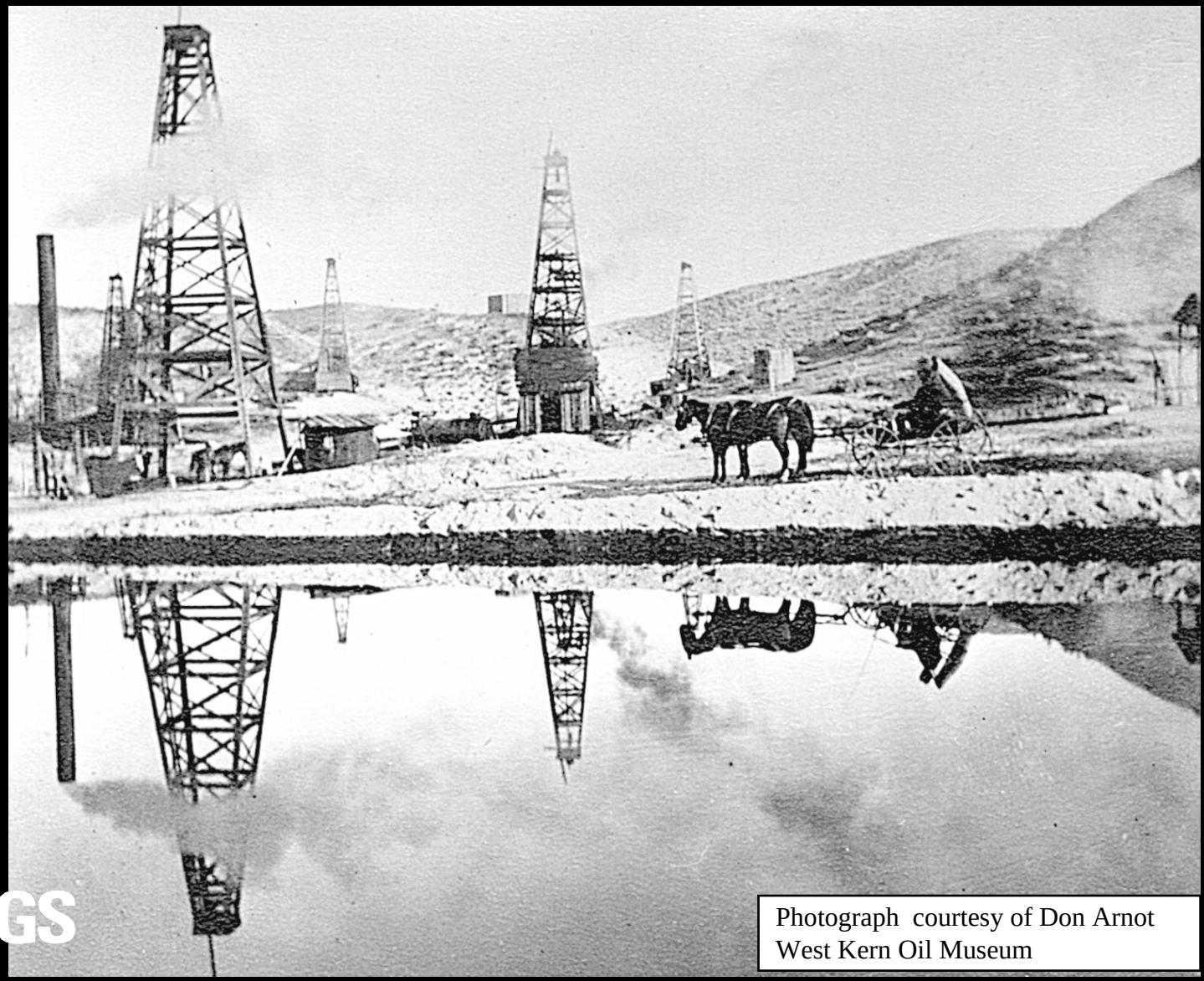
Current Recovery, San Joaquin Basin

Field	Discovery Year	Original Oil in Place, BB	Recovery Efficiency (%)
Buena Vista	1909	2.8	24
Coalinga	1890	4.5	22
Cymric	1909	1.6	32
Elk Hills	1911	4.1	33
Kern River	1899	4.1	51
Lost Hills	1910	3.3	13
McKittrick	1896	1.0	32
Mid-Sunset	1894	7.5	46
N. Belridge	1912	0.9	13
S. Belridge	1911	8.3	23

USGS

Data from various sources compiled by Tennyson (written communication, 2004)

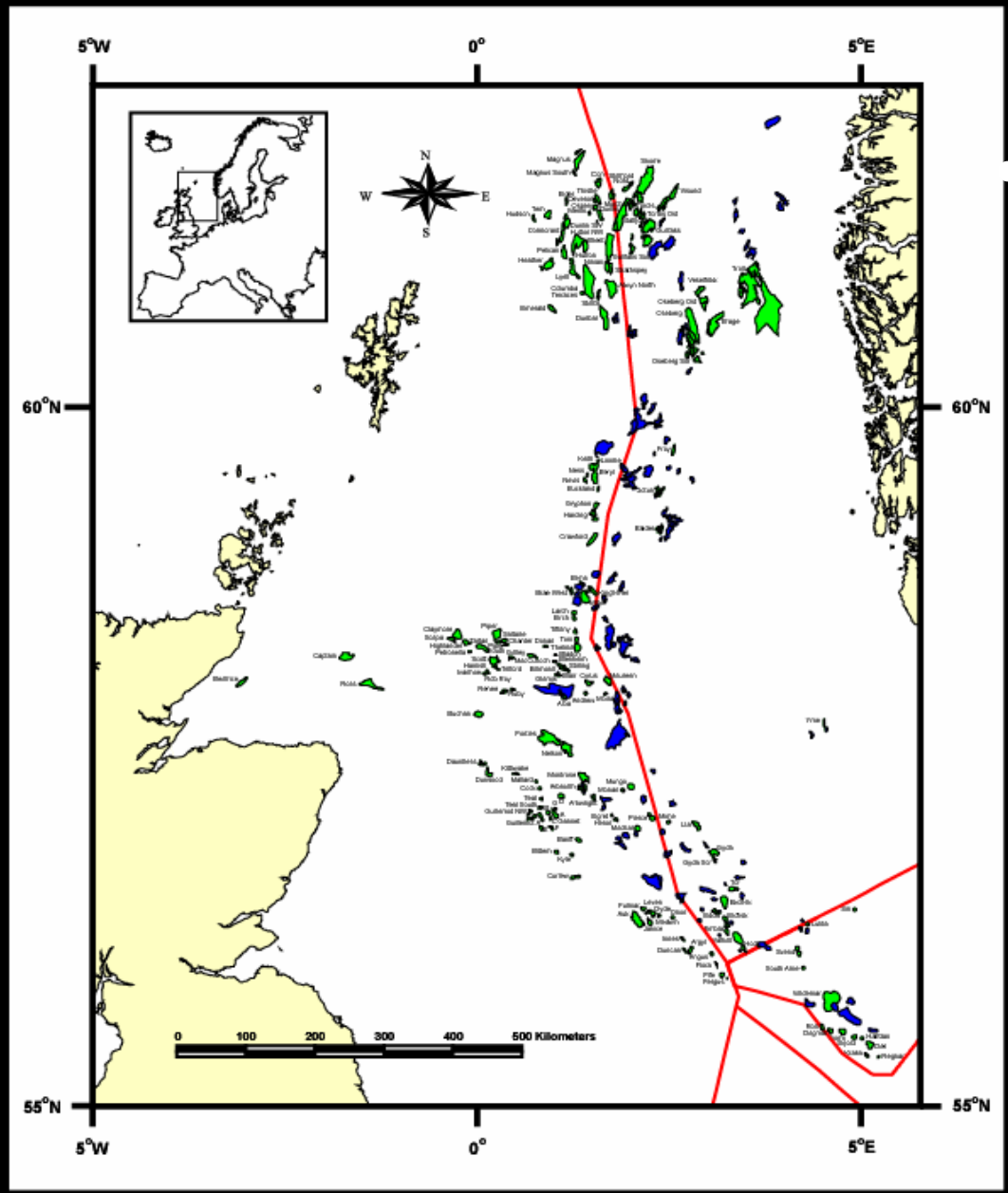
Is this magnitude of reserve growth unique to the San Joaquin Basin?



Photograph courtesy of Don Arnot
West Kern Oil Museum

USGS

Oil Fields in North and Central North Sea



- Mechanisms, characteristics, rates, and quantities of reserve growth
  - Capital investments
  - Advanced technologies
  - Careful data collection
  - Data well reported and publicly available

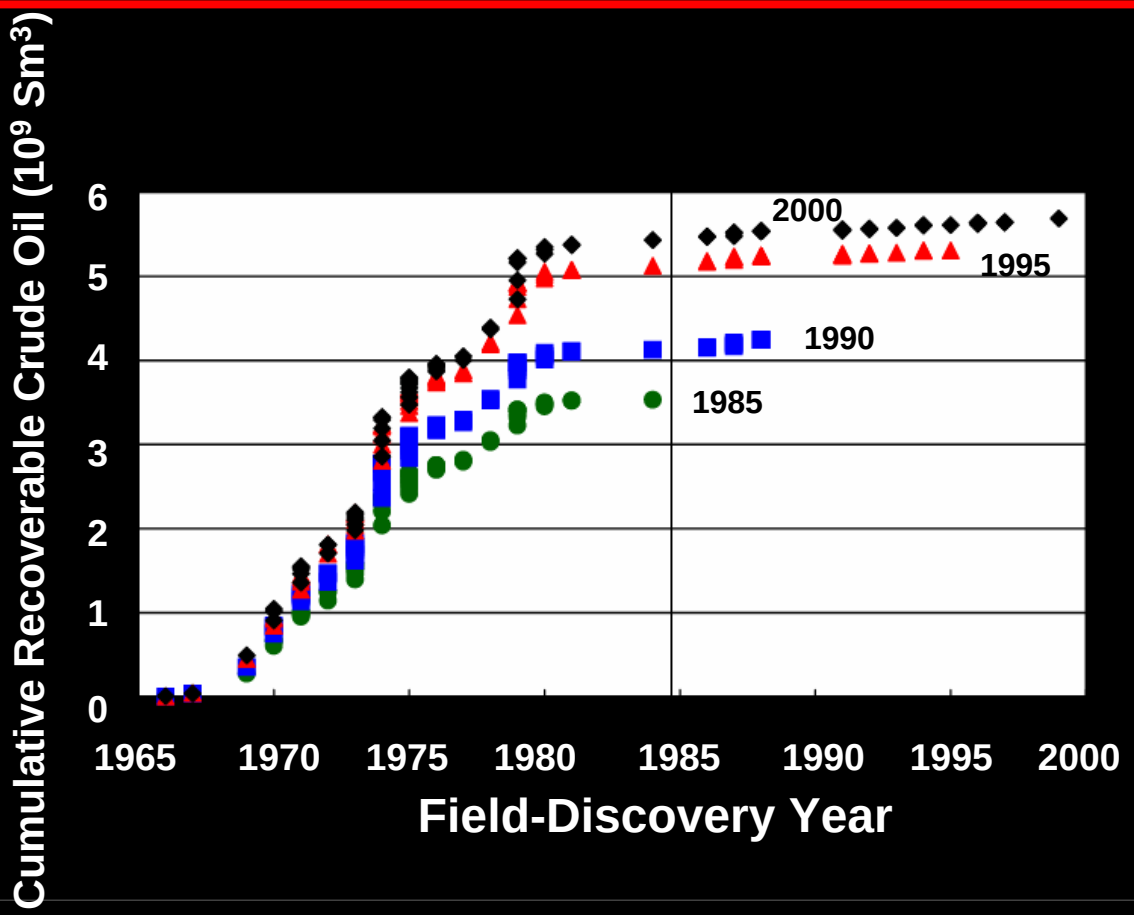
Red line represents offshore country boundaries

USGS

Map information from ESRI (1992), DTI (2001), NPD (2000), Brzozowska and others (2003)

Magnitude of Reserve Growth

North Sea Oil Fields – 1985 to 2000 (15 years)



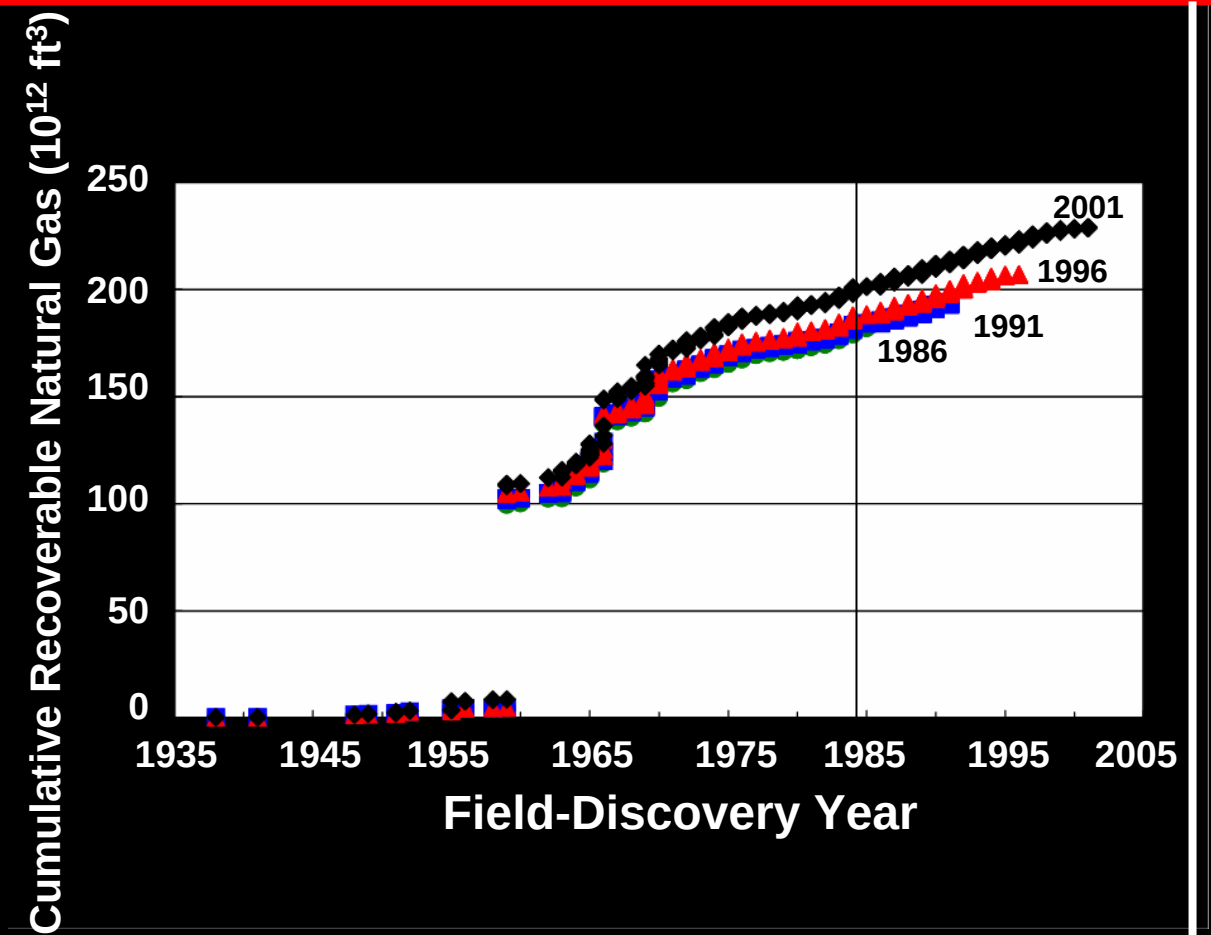
Data from DEA, DTI, NPD (1985 to 2001)

- Reserve growth
  - 1.9 X 10^9 Sm^3 (12 X 10^9 bbls) since 1985
  - 57 existing oil fields
- New-field discoveries
  - 0.3 X 10^9 Sm^3 (2 X 10^9 bbls) since 1985
  - at least 25 oil fields discovered after 1985

USGS

Magnitude of Reserve Growth

Southern North Sea Gas Basin Fields – 1986 to 2001 (15 years)

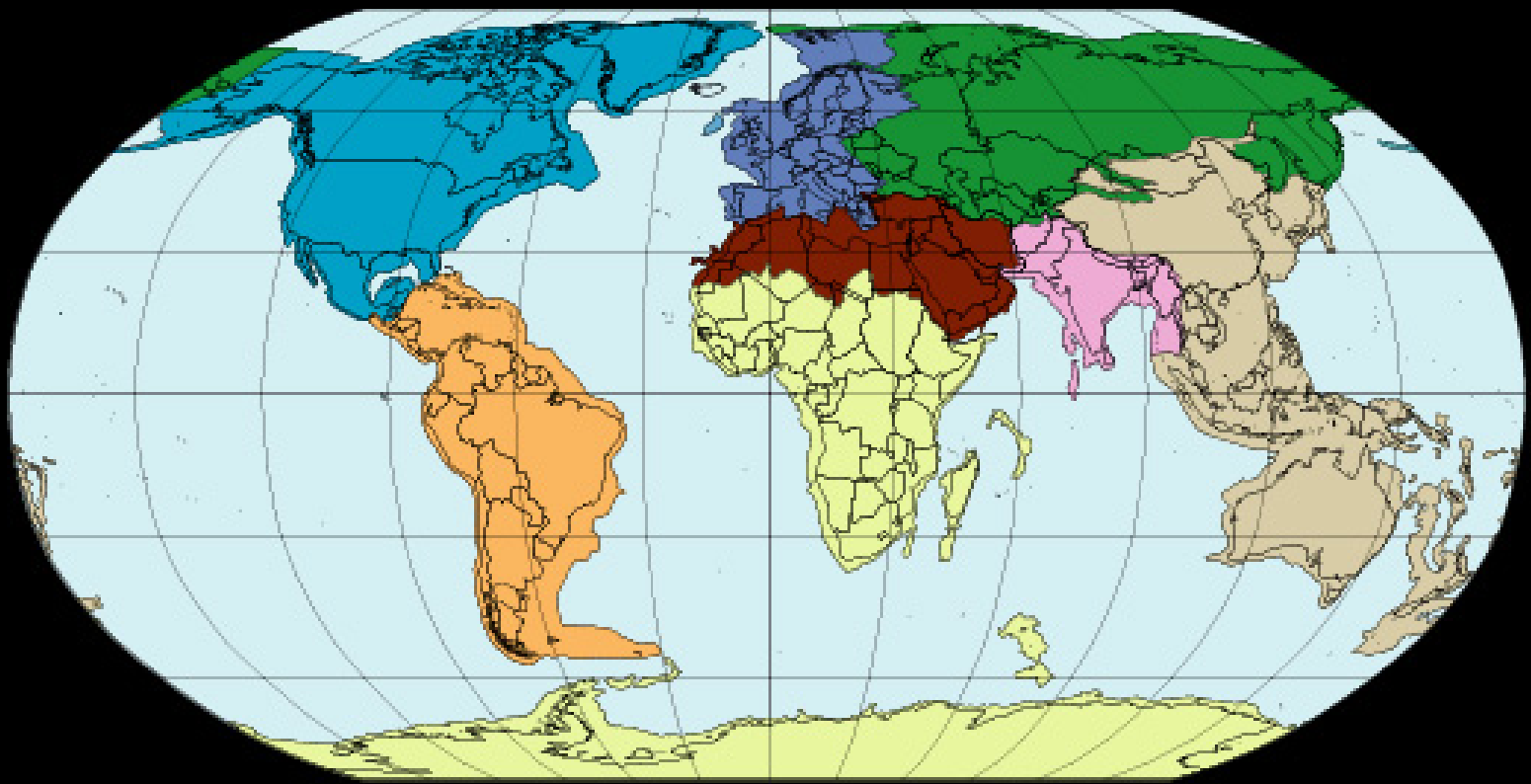


Data from IHS Energy (1986 to 2001)

- Reserve growth
  - 19 X 10^{12} ft^3 (0.5 X 10^{12} Sm^3) since 1986
  - 240 existing gas fields
- New-field discoveries
  - 28 X 10^{12} ft^3 (0.8 X 10^{12} Sm^3) since 1986
  - at least 259 gas fields discovered after 1986

USGS

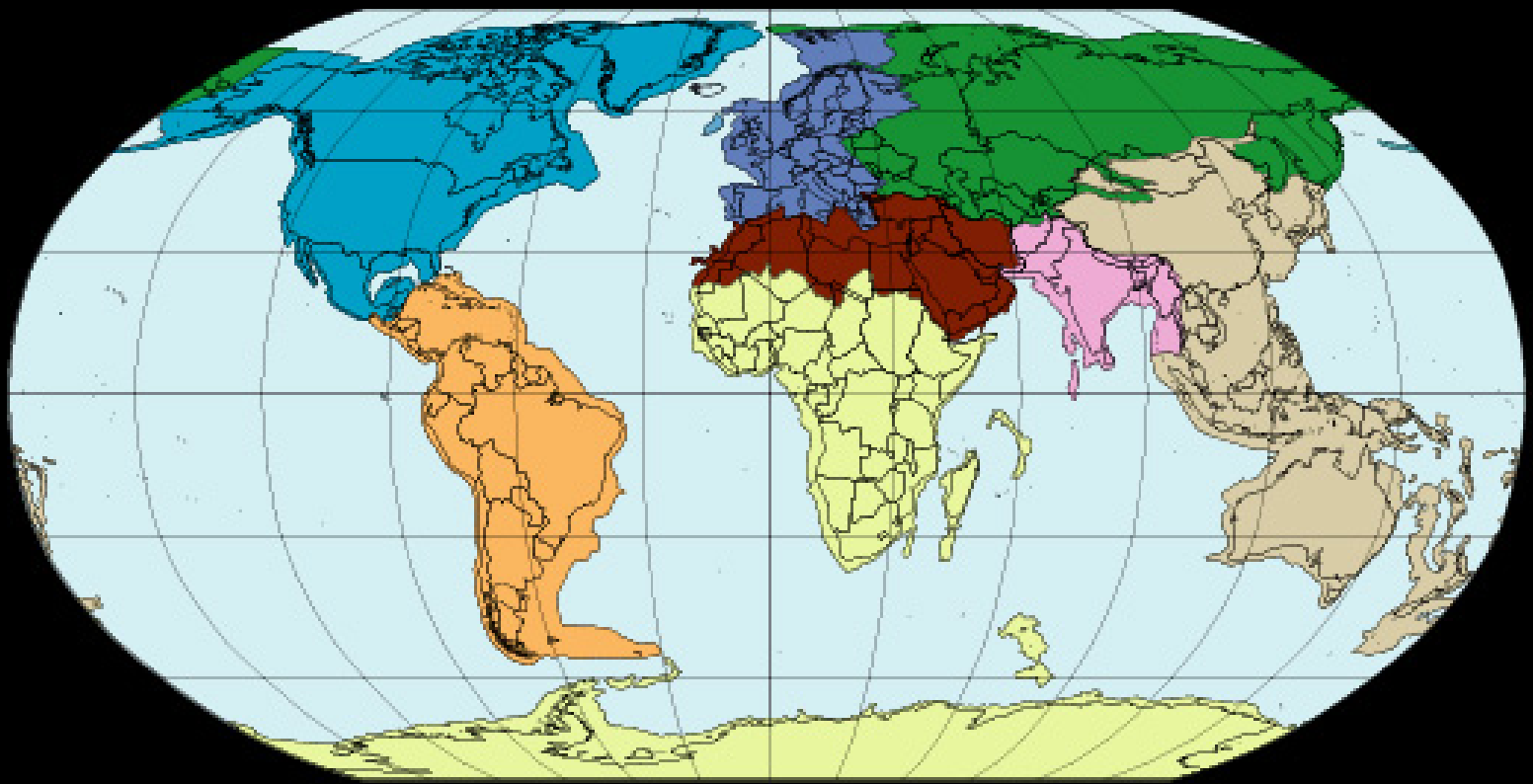
Consider the world . . .



USGS

From USGS (2000)

In 1996, USGS estimated that existing fields might grow by 600 BB of oil



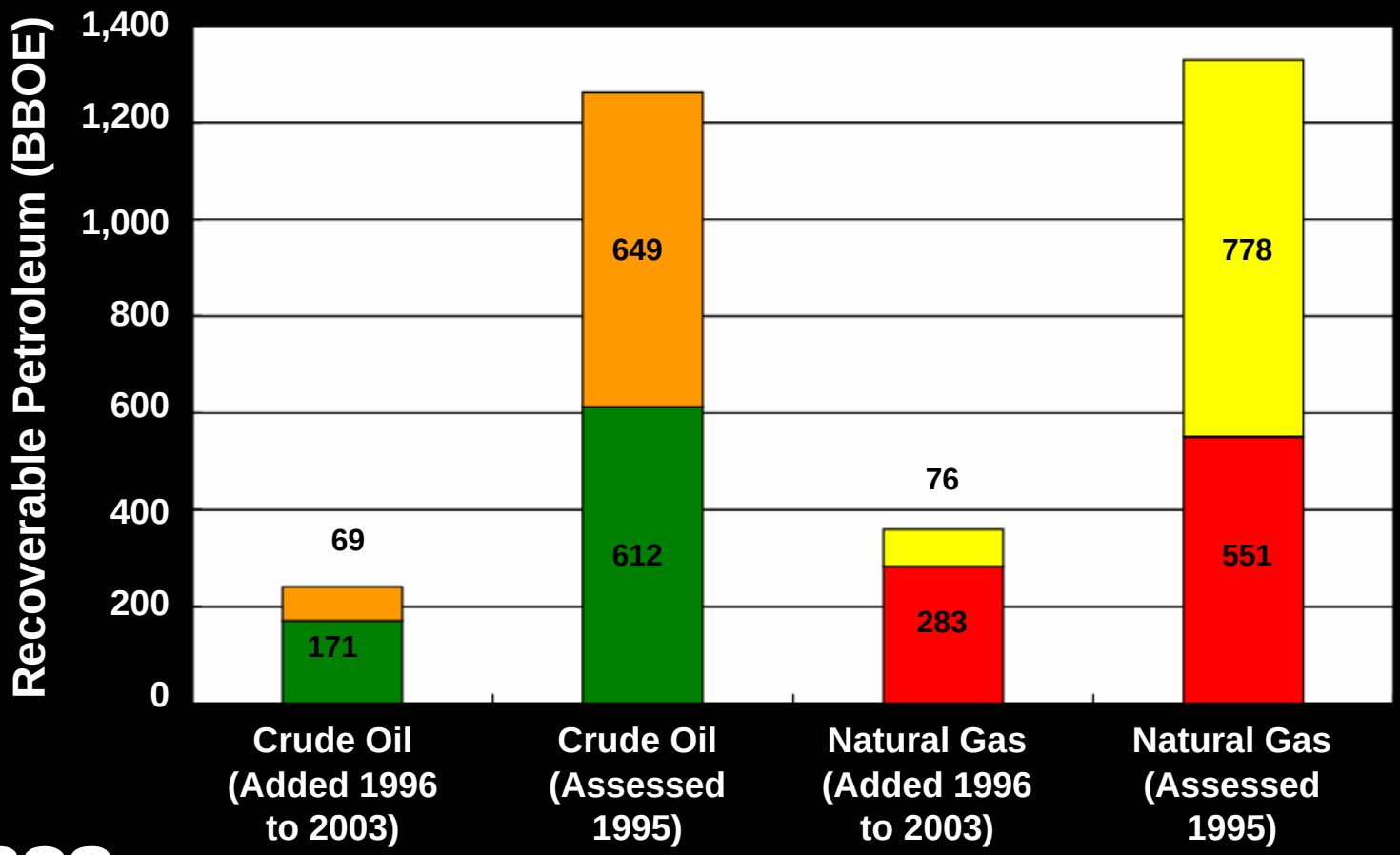
USGS

From USGS (2000)

Global Additions to Reserves 1996-2003

Orange: New oil field discoveries
Green: Reserve growth of existing oil fields

Yellow: New gas field discoveries
Red: Reserve growth of existing gas fields

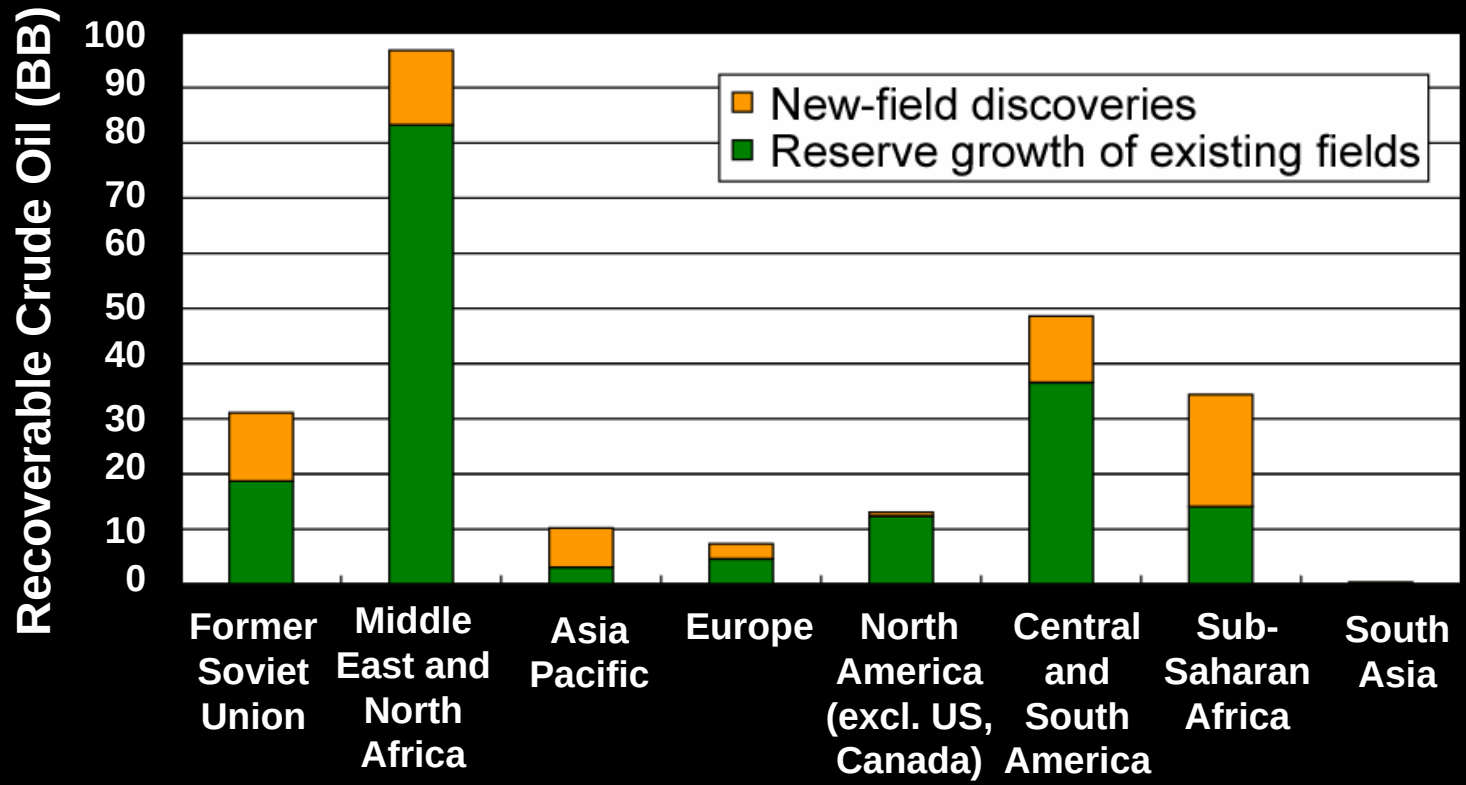


USGS

Data from IHS Energy (1986 to 2003); USGS (2000)

Global Additions to Oil Reserves 1996-2003

By Region

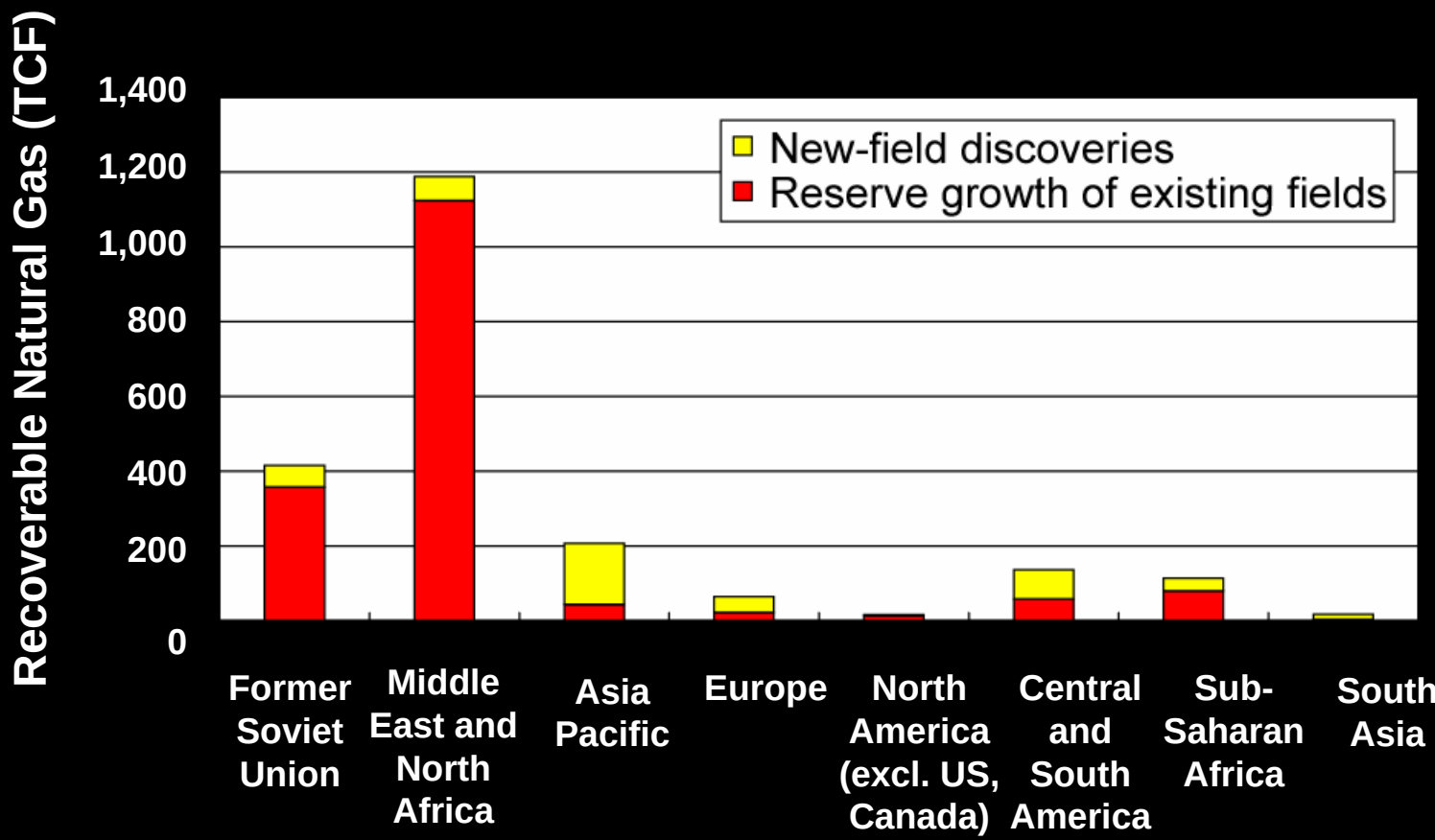


USGS

Data from IHS Energy (1996 to 2003)

Global Additions to Gas Reserves 1996-2003

By Region



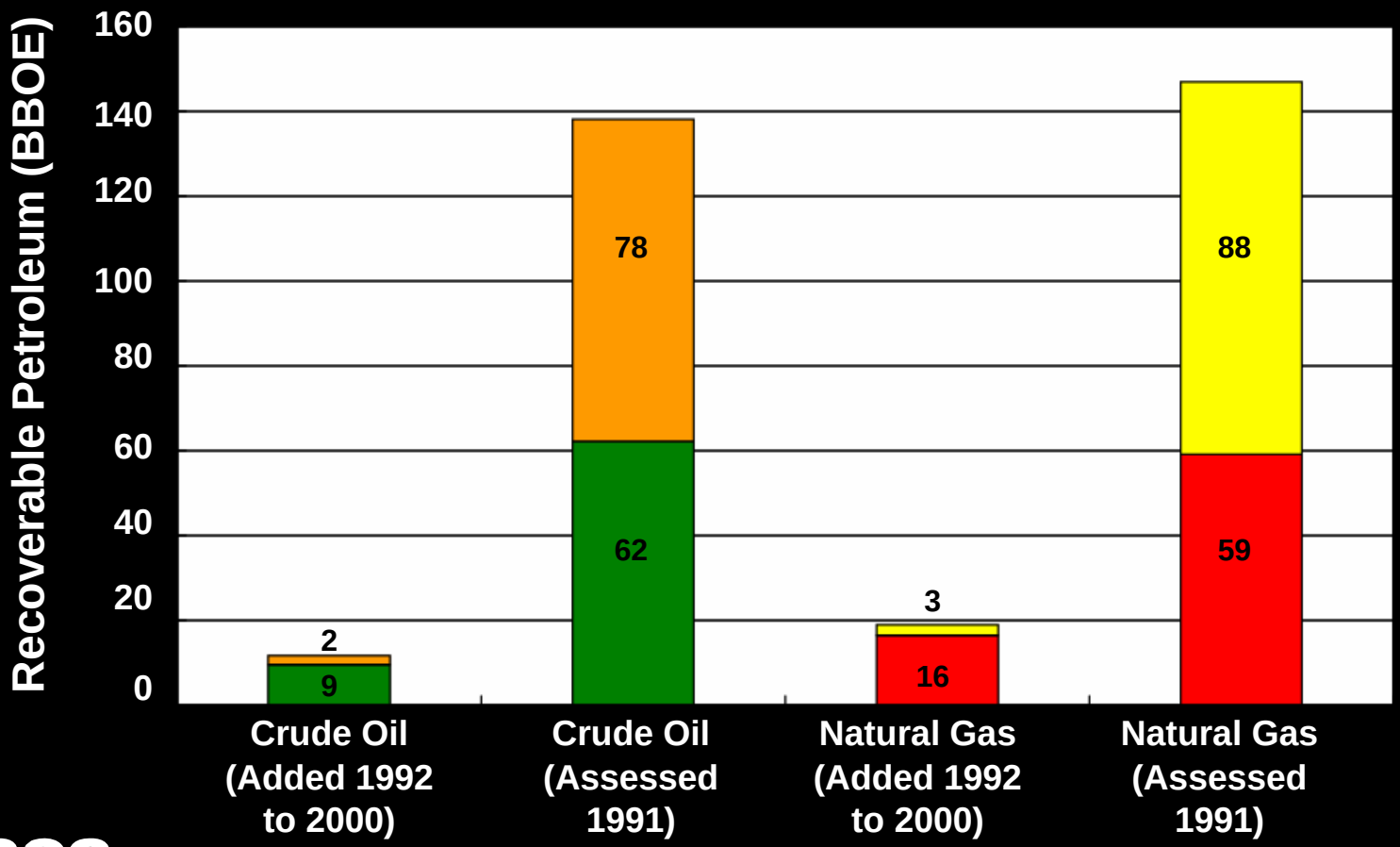
USGS

Data from IHS Energy (1996 to 2003)

U.S. Additions to Reserves 1992-2000

Orange: New oil field discoveries
Green: Reserve growth of existing oil fields

Yellow: New gas field discoveries
Red: Reserve growth of existing gas fields

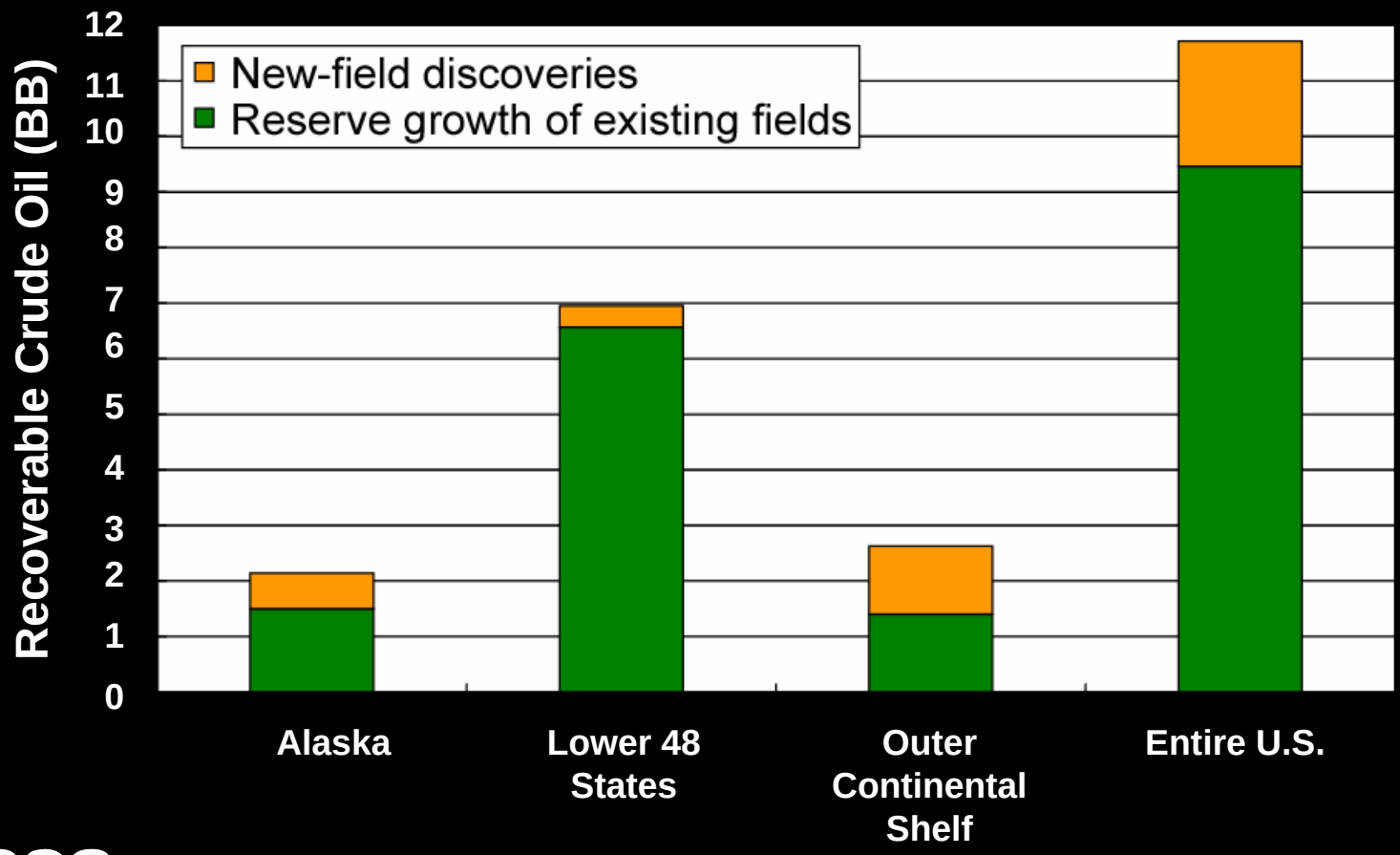


USGS

Data from NRG Associates (2002); USGS (1995), Lore and others (1996)

U.S. Additions to Oil Reserves 1992-2000

By Region

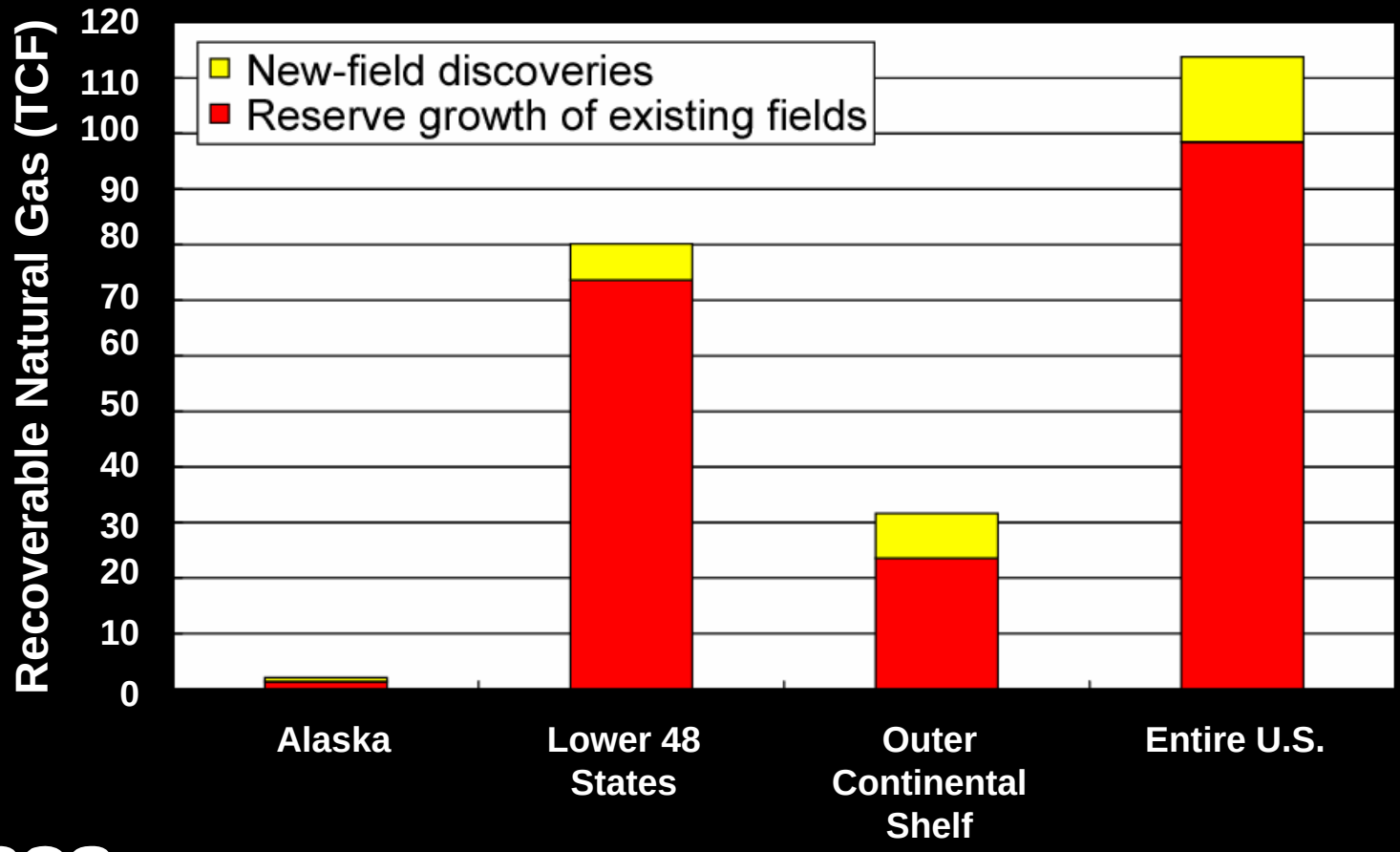


USGS

Data from NRG Associates (2002); USGS (1995), Lore and others (1996)

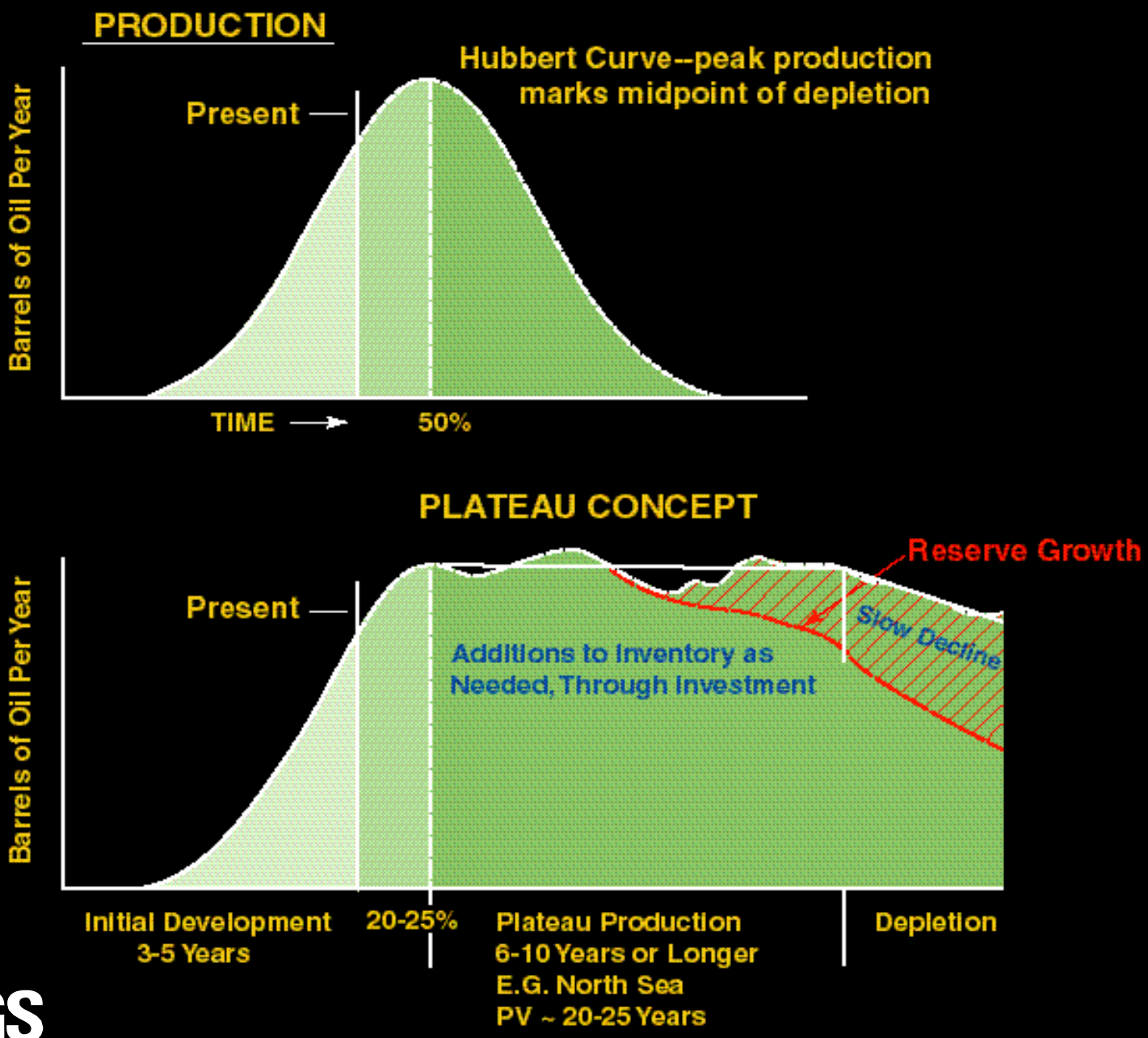
U.S. Additions to Gas Reserves 1992-2000

By Region



USGS

Data from NRG Associates (2002); USGS (1995), Lore and others (1996)



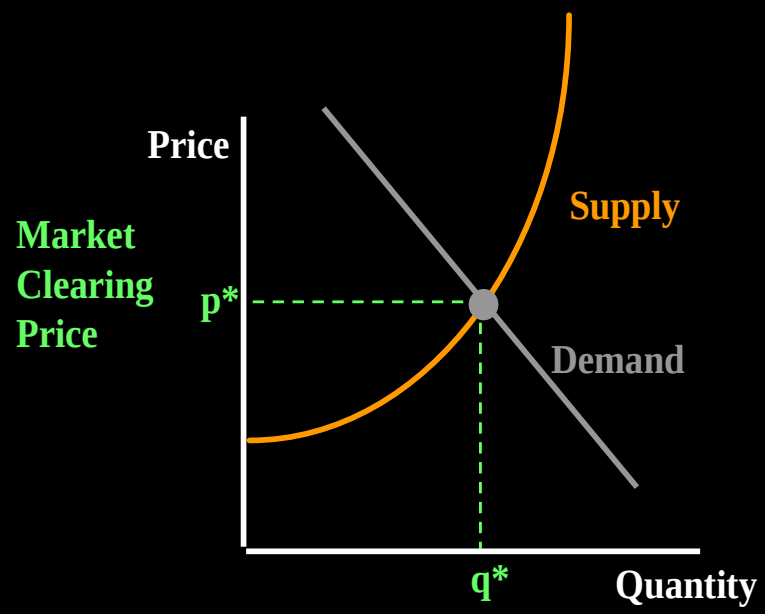
USGS

From Ahlbrandt and the USGS World Energy Assessment Team(2001)

What Will Drive Future Oil Production?

- Not just the world resource volume
- Demand
  - Competition among energy sources – oil, natural gas, coal, nuclear, others
  - Technology
  - Economics
  - Politics

Production is determined by supply & demand!



USGS

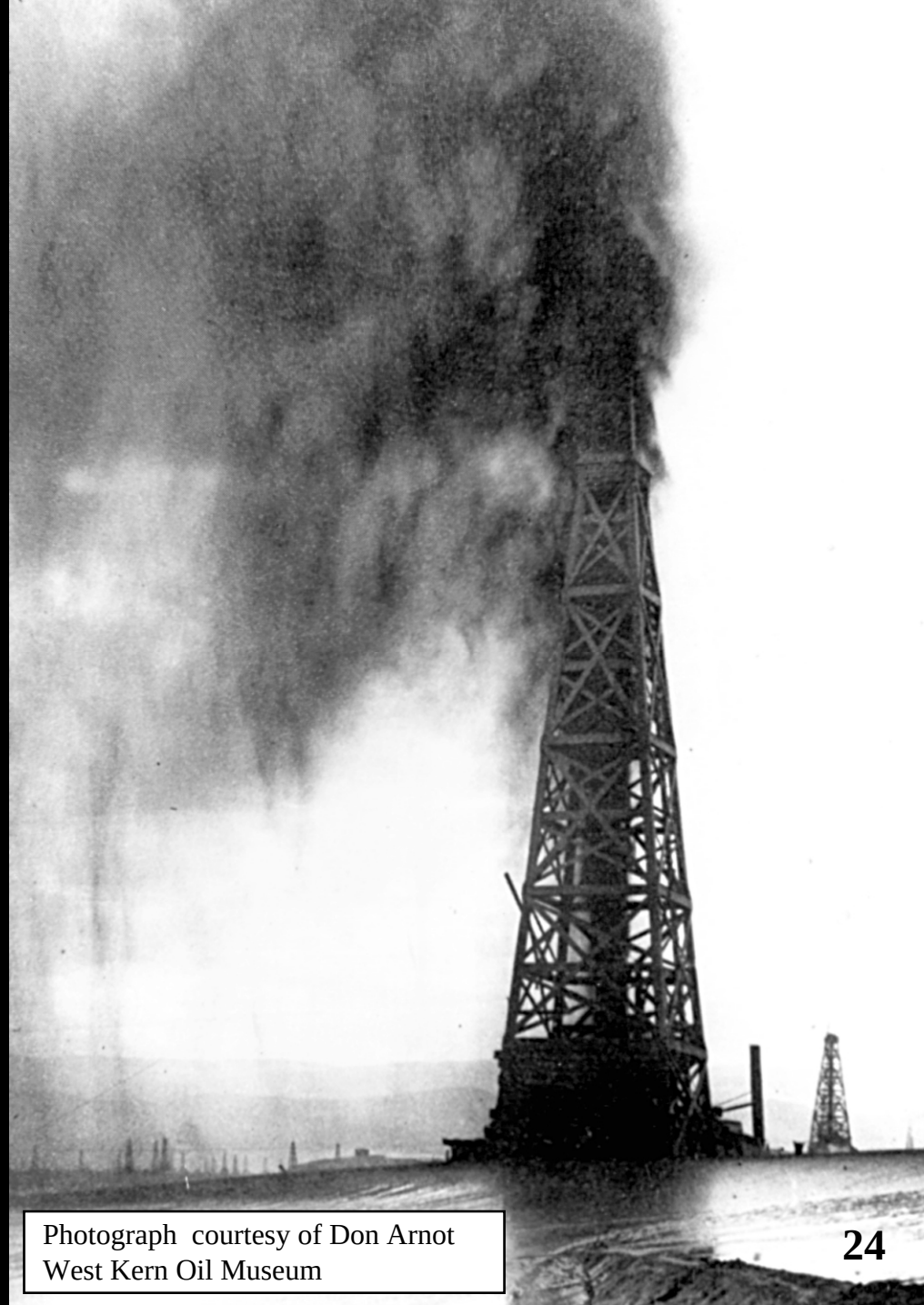
CONCLUSIONS

SJB-type reserve growth is possible worldwide

Remaining world oil resources are very large

Experience in SJB fields may be useful in identifying global targets

Don’t be too quick to extrapolate from creaming curves



Photograph courtesy of Don Arnot
West Kern Oil Museum

USGS
science for a changing world

Thank You for Your Attention

- Tim Klett – tklett@usgs.gov
- Don Gautier – gautier@usgs.gov
- Brenda Pierce – bpierce@usgs.gov

- http://energy.usgs.gov

USGS