U.S.Geological Survey

World Petroleum Assessment 2000

Compiled PowerPoint* Slides

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U.S. Geological Survey Open-File Report 99-50-Z

USGS
U.S. DEPARTMENT OF THE
U.S. GEOLOGICAL SURVEY

* Use of brand names does not constitute endorsement by the U.S. Geological Survey

DESCRIPTION:

The slides in this compilation have been produced for a number of presentations on the World Petroleum Assessment 2000. Many of the figures are taken directly from the publication "U.S. Geological Survey World Petroleum Assessment 2000" – Description and Results: USGS Digital Data Series DDS-60, 2000. Some of the slides are modifications of figures from DDS-60, some are new descriptive slides, and a few are new slides. Several of the slides appear to be duplicates, but in fact are slight modifications of format or content from the same image.

Forty-one people participated in this effort as part of the World Energy Assessment Team. The full list of contributors is given on DDS-60.

Acknowledgements: Susan Walden, Timothy Klett, Ron Charpentier, Sandra Lindquist, Doug Steinshouer, and Gene Whitney kindly drafted several of the slides.

USGS World Petroleum Assessment 2000

- History
- USGS World Energy Project
- Estimates-- undiscovered resources & field growth
- Perspectives-- onshore, offshore, OPEC / OECD
- Geologic insights
- Conclusions

USGS World Energy Team

- Geologic Team
- 8 Regional Coordinators
- 76 Priority Provinces
- 52 Boutique Provinces
- 35 Geoscientists + other support
- Total Petroleum System write-ups (Standardized)
- Digital geologic maps--7 CD's released (only Europe remains)~ 50,000 distributed
- Internet site—heavily used

- Assessment Team
- 6 members
- Consistent review
- Record assessment digitally
- Truncated shifted lognormal (TSL) for field size (Monte Carlo), ASSESS (Analytic)--QC
- Triangular distribution for number of fields
- Assessment Form, Co-Products, Allocations
- FORSPAN--continuous

http://energy.usgs.gov Contact: ahlbrandt@usgs.gov 303-236-5776

USGS

USGS WORLD ENERGY PROJECT

- 5 year project--1995-2000
- Reviewed by 1) AAPG, Core (Executive Committee approval), 2) World Energy Consortium—38 organizations—quarterly meetings, 3) NRC, 4) GIS World
- Assess recoverable conventional oil and gas resources of the World by 200Theoremse DDS 60 at WPC--Calgary, 6/2000
- Use geologic basis (Province, Total Petroleum System and Assessment Unit)
- New assessment methodology for undiscovered and *field growth*
- Allocate to countries, onshore / offshore, OPEC, OECD, other
- All information is digital including geologic province maps, TPS write-ups --publication series (OFR 97-450, Bulletin 2200), http://energy.usgs.gov

Assessment Process

- Identify geologic provinces, allocate resources, prioritize, identify "Boutiques"
- Database reality checks--Petroconsultants, Nehring, Geomark, proprietary; e.g. Iraq, FSU, industry
- Identify, map, and write-up Total Petroleum Systems (TPS) using a standardized format
- Geologic definition of TPS--define ASSESSMENT UNIT
  - Allocation, GIS support, grow field data, supporting data such as burial history curves
- Industry / other organization calibration
- Completion of data form (sizes and numbers)
- Geologic assessment meeting
- Resource calculation / dependencies
- Final review
- Digital publication for WPC--6/2000

USGS World Petroleum Assessment 2000

- Undiscovered petroleum (Masters vs World w/o US. +5% at mean) 1556 BBOE vs 1634 BBOE
  - Undiscovered oil (649 BB; +20.5%)
  - Undiscovered gas (4669 TCF or 778 BBOE; -14.1%)
  - Undiscovered NGL (207 BBOE; +130%)

USGS World Petroleum Assessment 2000

1. Summary of the USGS assessment process

2. Results, with implications for future world energy supply

USGS World Petroleum Assessment 2000

- GOAL: ASSESS TECHNICALLY RECOVERABLE CONVENTIONAL OIL AND GAS RESOURCES OF THE WORLD EXCLUDING U.S.
- 5 YEAR PROJECT--1995-2000
- METHODOLOGY AND RESULTS THOROUGHLY REVIEWED BY CONSORTIUM PARTNERS (industry, government, associations)

World Energy Consortium- Reviews, Quarterly Geologic Meetings, Many Visits

INDUSTRY

- EXXON*
- AMOCO*
- MOBIL*
- CONOCO
- PHILLIPS
- SHELL
- TEXACO*
- ORYX
- PETRO-CANADA
- CHEVRON *
- ENRON
- OCCIDENTAL
- KERR-MCGEE

ORGANIZATIONS

- DEPARTMENT OF ENERGY
- ENERGY INFORMATION ADMINISTRATION
- INTERNATIONAL ENERGY AGENCY
- U.S. STATE DEPT., USAID
- DOD, "OTHER GROUPS"
- UNESCO
- PETROCONSULTANTS
- CENTRE FOR GLOBAL ENERGY STUDIES
- GEOMARK
- ESRI

* Names subsequently changed via mergers and acquisitions

USGS World Petroleum Assessment 2000

- 8 Regional Coordinators, 35+ geoscientists, 5 yrs.
- Digital geologic maps of the World: 8 regions
- 10 CD's released so far ~ 50,000 distributed
- Digital/GIS: Results allocated to countries, onshore / offshore, OPEC, OECD, other geographic entities
- Final report (DDS-60) = 32,000 pages, 900+ maps
- Internet site— http://energy.usgs.gov

USGS World Petroleum Assessment 2000

- Uses geologic basis (not political) for Provinces, Total Petroleum Systems and Assessment Units
- Estimates of "UNDISCOVERED RESOURCES" are based on understanding of petroleum formation and accumulation processes
- Assessment extends to water depths of 2000 m
- This World assessment excludes U.S. (separate assessment process)

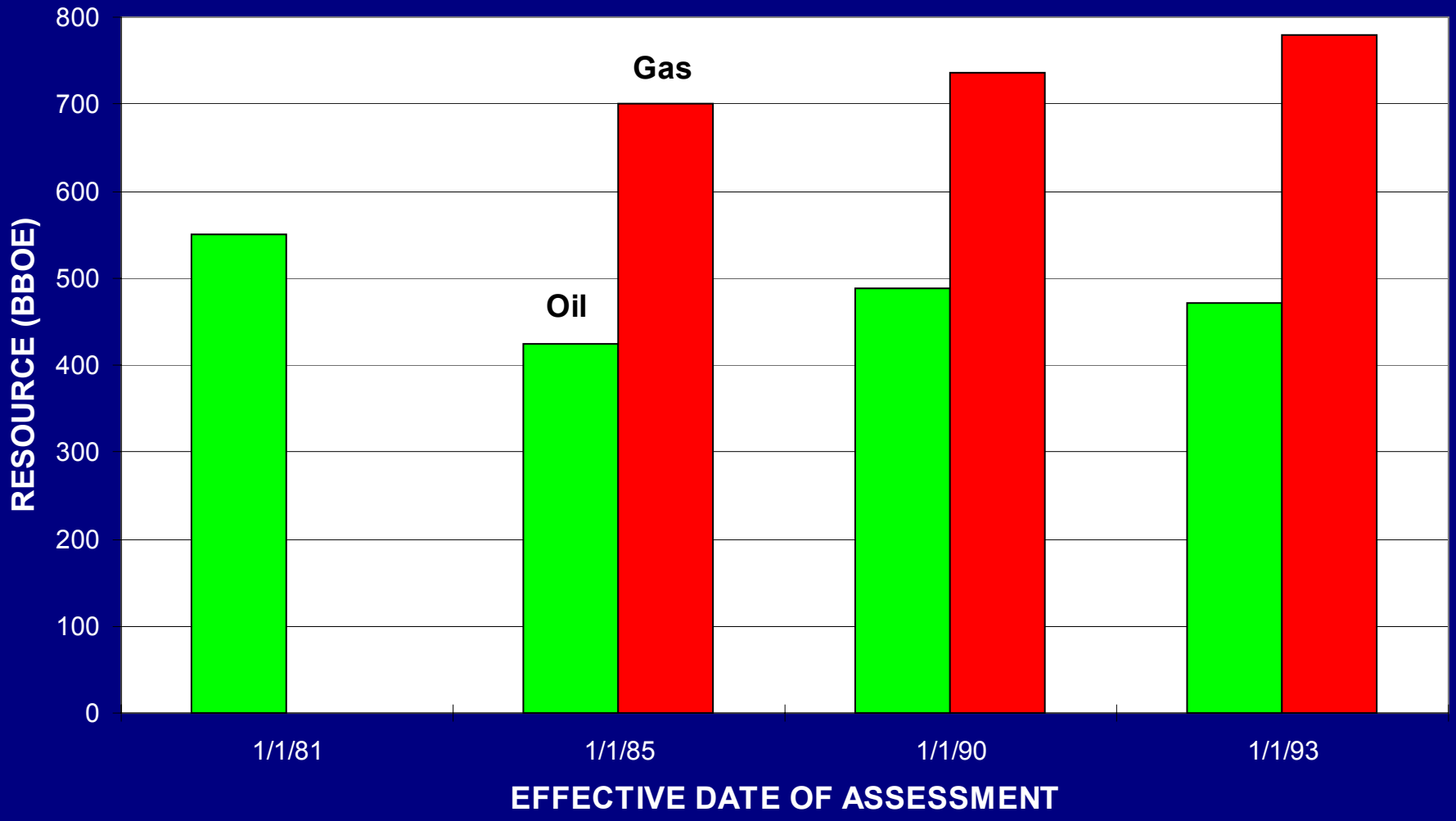
USGS World Petroleum Assessment 2000

- 8 regions (similar to State Dept. economic regions)
- 1000 provinces defined geologically
- 406 provinces contain some oil and gas
  - 76 priority provinces assessed = 95% of past oil & gas production
  - 52 boutique provinces assessed = prospective
- 149 Total Petroleum Systems assessed
- 246 Assessment Units assessed

USGS World Petroleum Assessment 2000

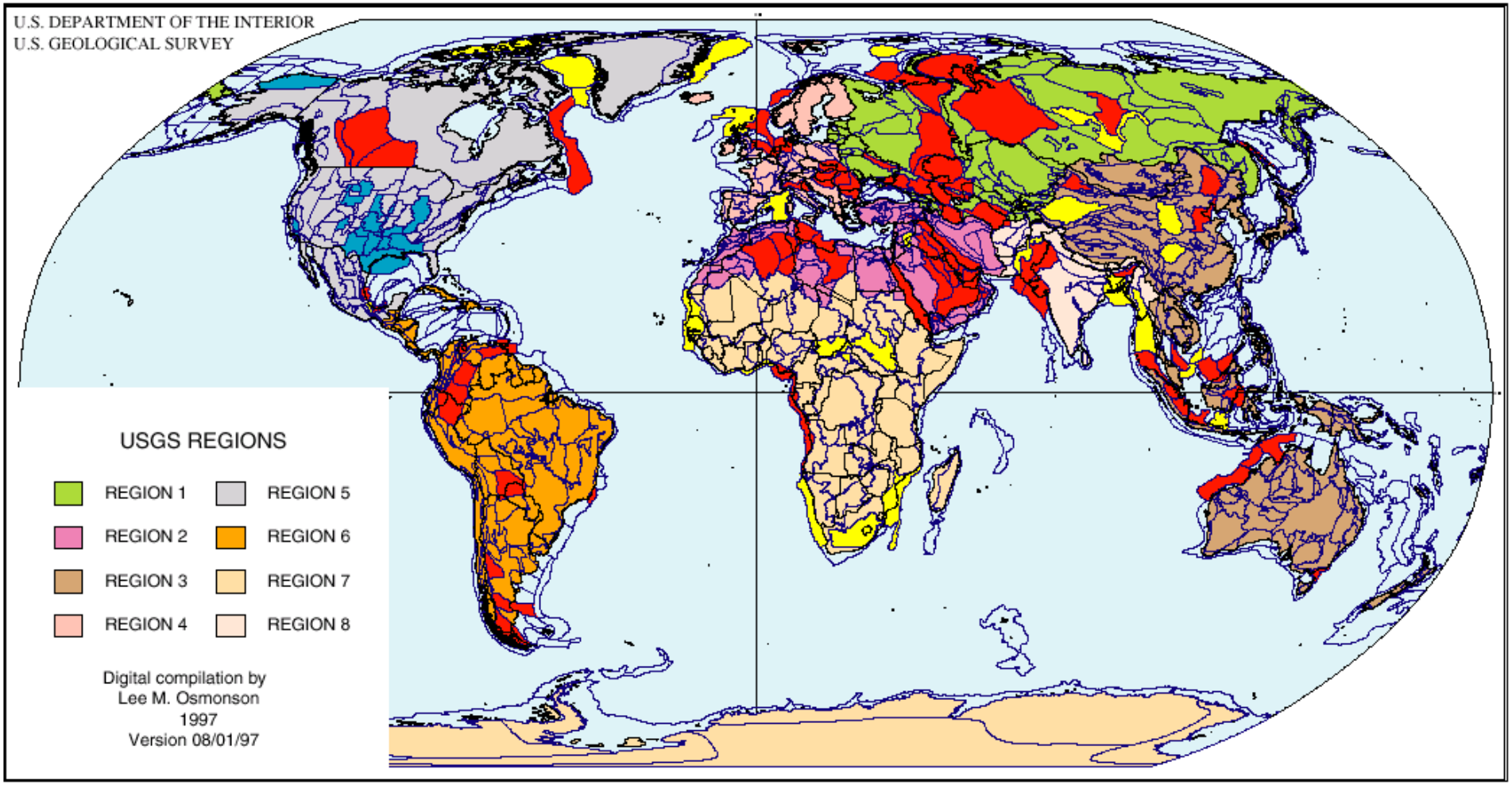
- Represents a "snapshot" in time based on current data – must be updated periodically
- Internally consistent – single assessment team using single process throughout
- Thoroughly documented – published summaries of all petroleum systems
- Results are probabilistic, not deterministic (distribution rather than single value)

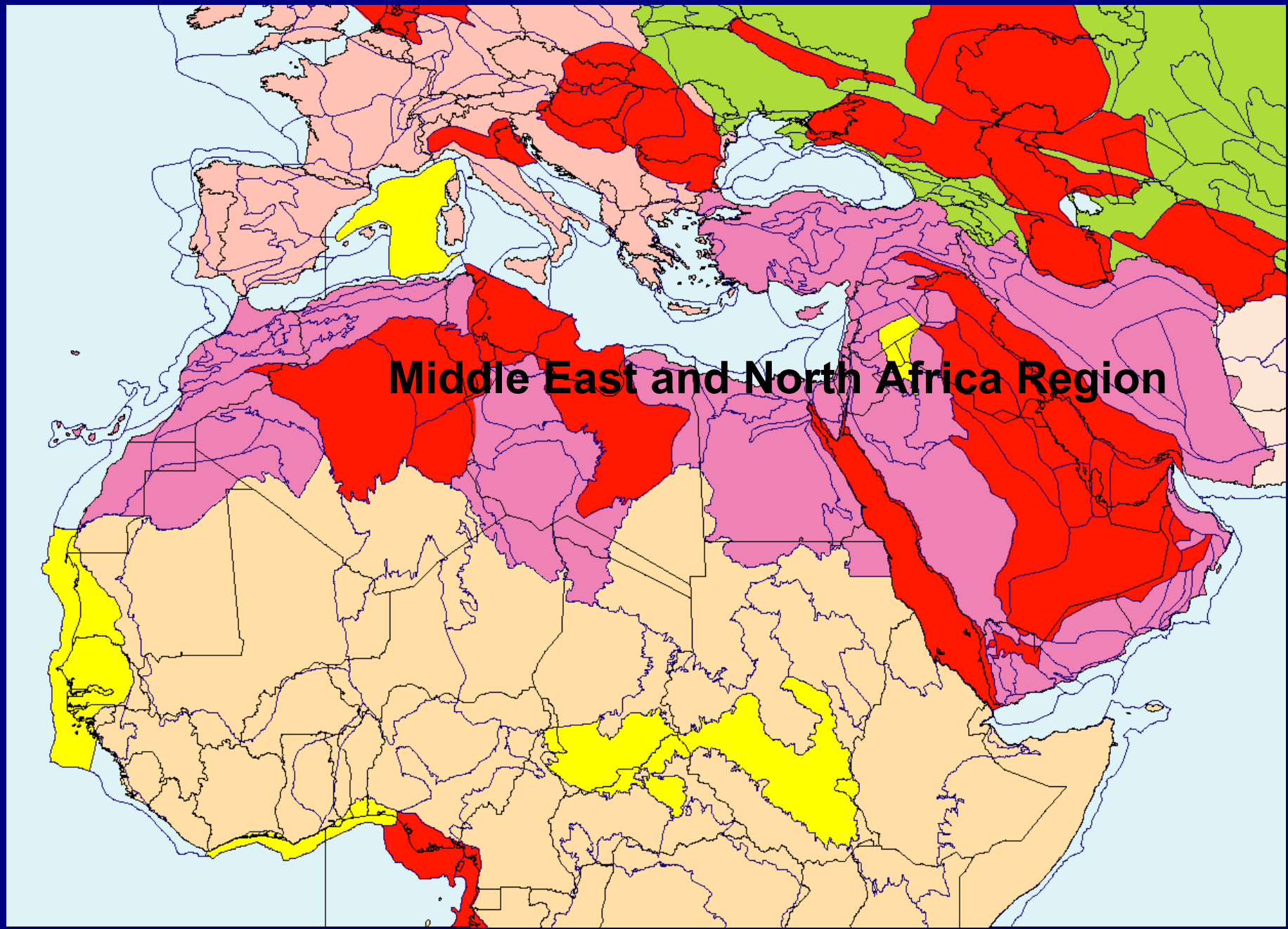
Successive USGS Estimates of World Undiscovered Resources for Conventional Oil and Natural Gas

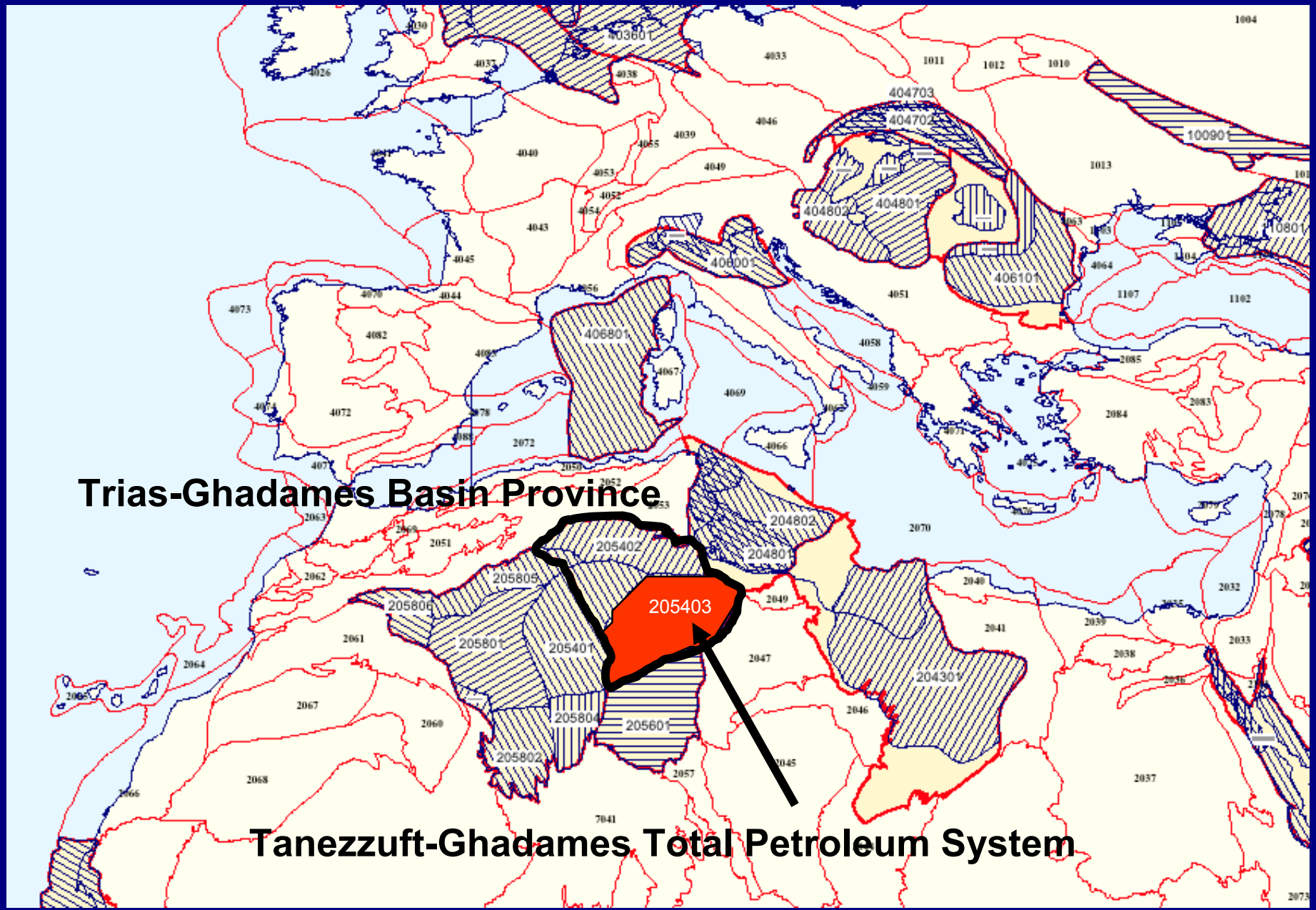


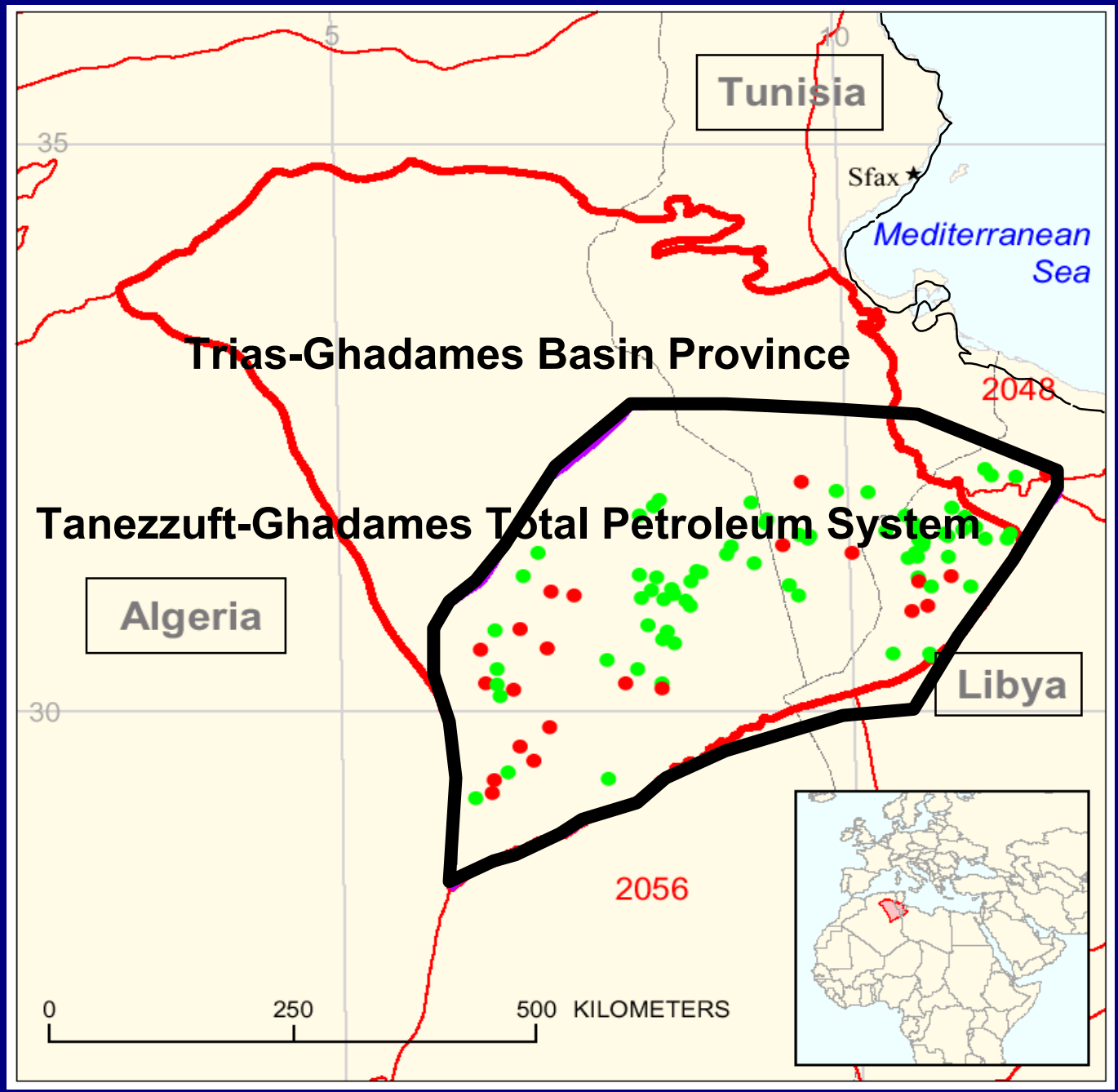
USGS

USGS Assessment Regions and Provinces

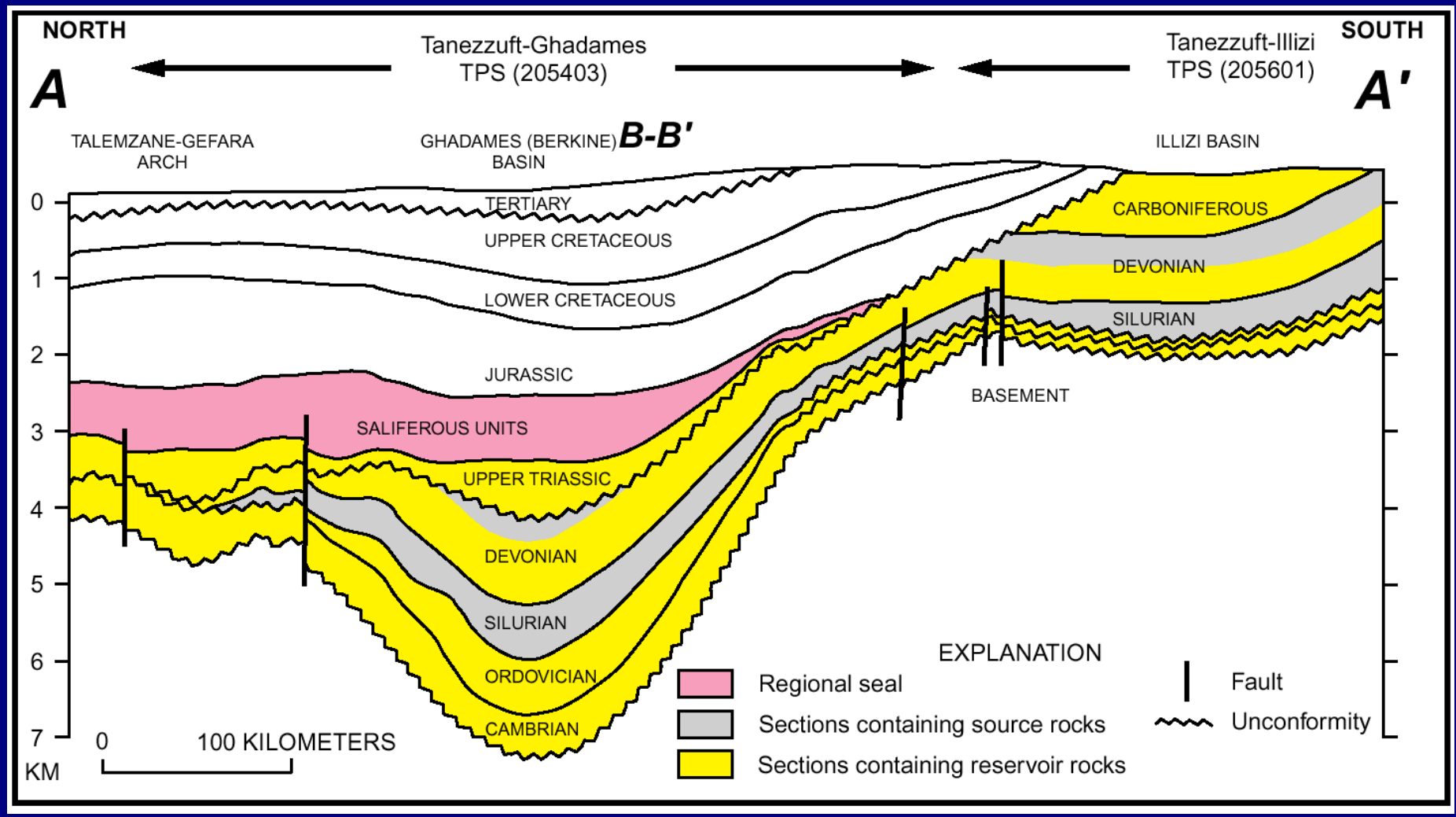



Middle East and North Africa Region


Trias-Ghadames Basin Province
205403
Tanezzuft-Ghadames Total Petroleum System


Tunisia
Sfax
Mediterranean Sea
Trias-Ghadames Basin Province
2048
Tanezzuft-Ghadames Total Petroleum System
Algeria
Libya
2056
0
250
500 KILOMETERS

Tanezzuft-Ghadames Total Petroleum System



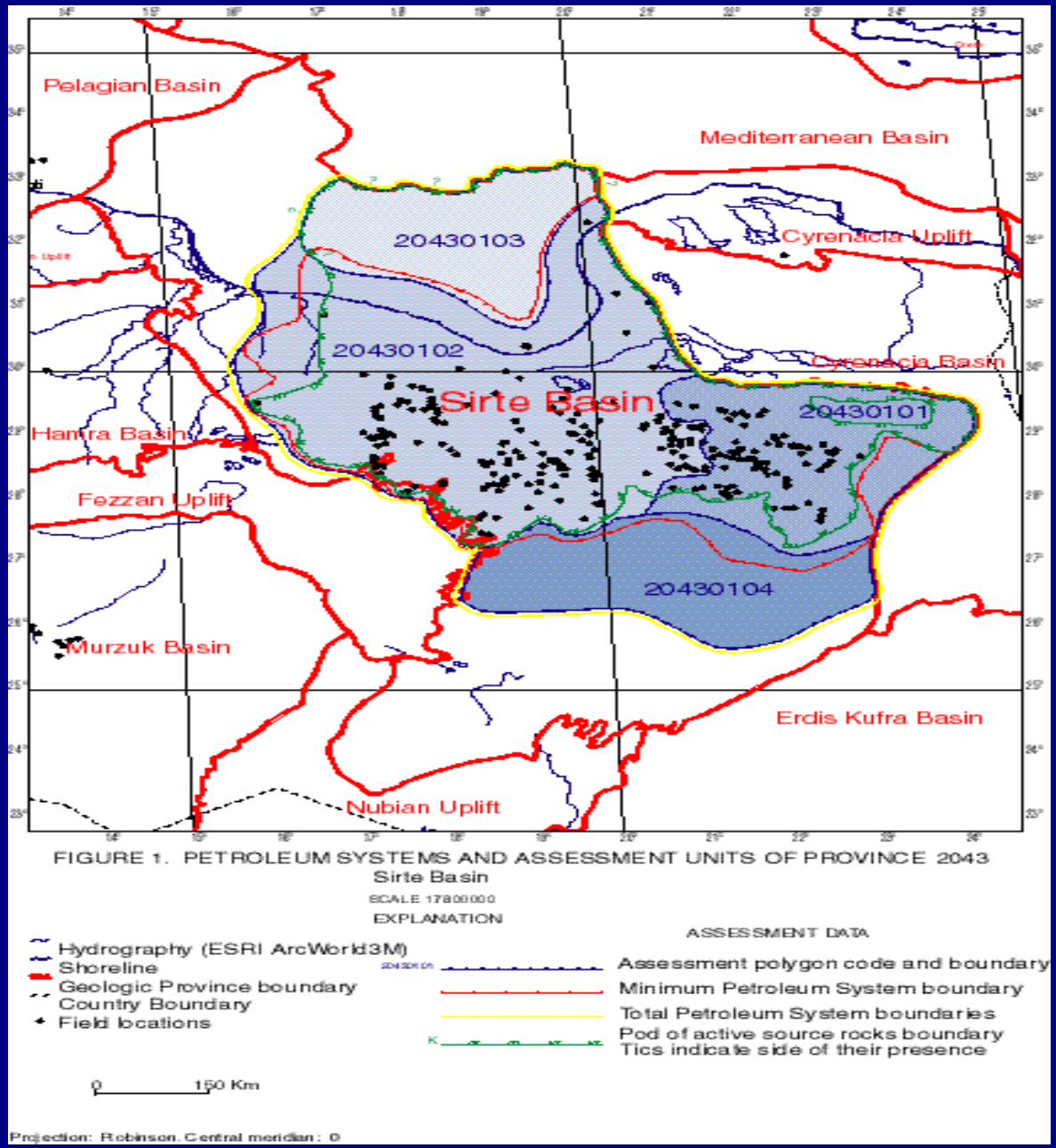
Oil: 4.5 billion barrels Gas: 12 tcf

TOP 15 PETROLEUM PROVINCES OF THE WORLD

1. West Siberian Basin
2. Mesopotamian Foredeep Basin
3. Greater Ghawar Uplift
4. Zagros Fold Belt
5. Rub Al Khali Basin
6. Qatar Arch
7. Volga-Ural Region
8. North Sea Graben
9. Western Gulf of Mexico
10. Permian Basin
11. Maracaibo Basin
12. Niger Delta
13. East Venezuela Basin
14. North Caspian Basin
15. Sirte Basin

70+ % of total

USGS


Pelagian Basin
Mediterranean Basin
20430103
Cyrenacia Uplift
20430102
Cyrenacia Basin
Sirte Basin
20430101
Hamra Basin
Fezzan Uplift
20430104
Murzuk Basin
Erdis Kufra Basin
Nubian Uplift
FIGURE 1. PETROLEUM SYSTEMS AND ASSESSMENT UNITS OF PROVINCE 2043
Sirte Basin
SCALE 17800000
EXPLANATION
Hydrography (ESRI ArcWorld3M)
Shoreline
Geologic Province boundary
Country Boundary
Field locations
ASSESSMENT DATA
Assessment polygon code and boundary
Minimum Petroleum System boundary
Total Petroleum System boundaries
Pod of active source rocks boundary
Tics indicate side of their presence
0
150 Km
Projection: Robinson. Central meridian: 0

THE VOCABULARY OF RESOURCE ASSESSMENT:

Cumulative production

Reserves

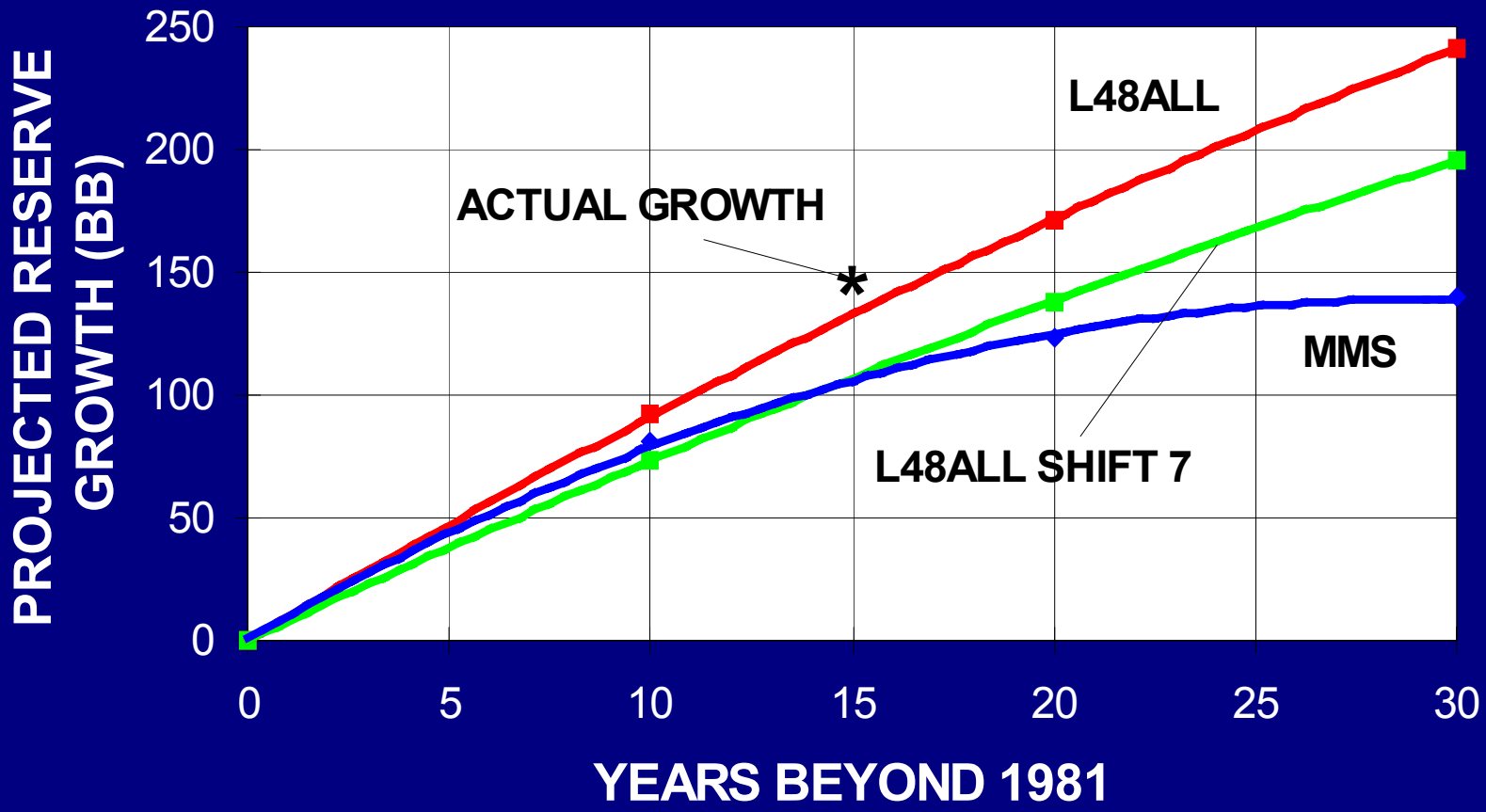
Reserve growth*

Undiscovered resources*

- Conventional*
- Unconventional (continuous)

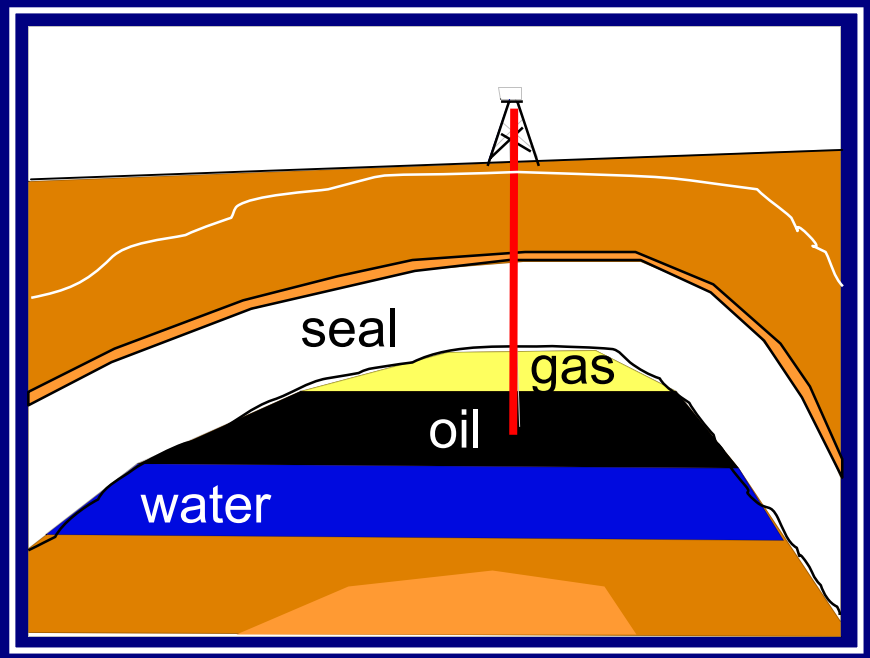
* This assessment

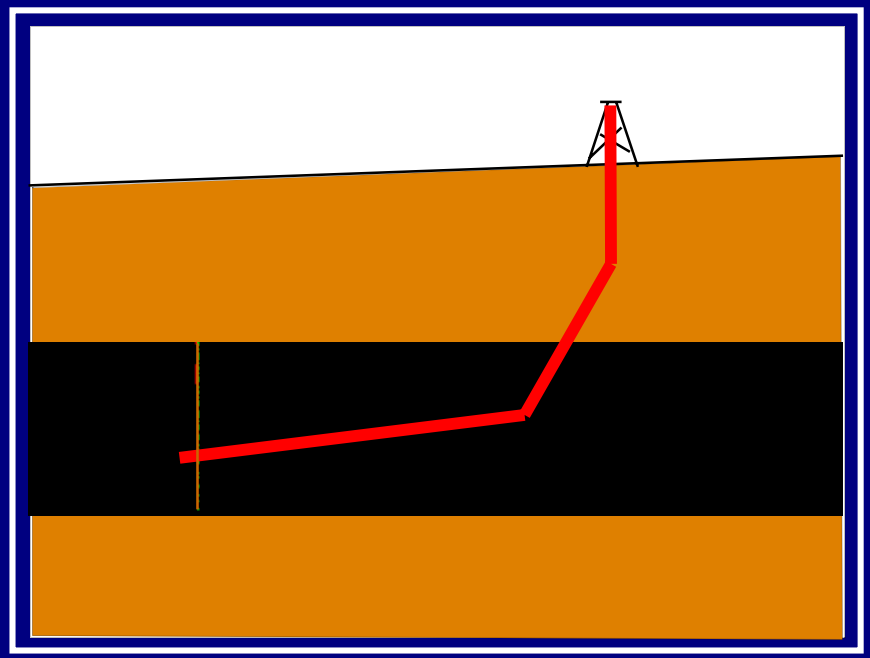
RESERVE GROWTH HISTORY MATCHING: LARGE OIL FIELDS



Note: World Petroleum Assessment 2000 estimates reserve growth for world, not individual fields

USGS



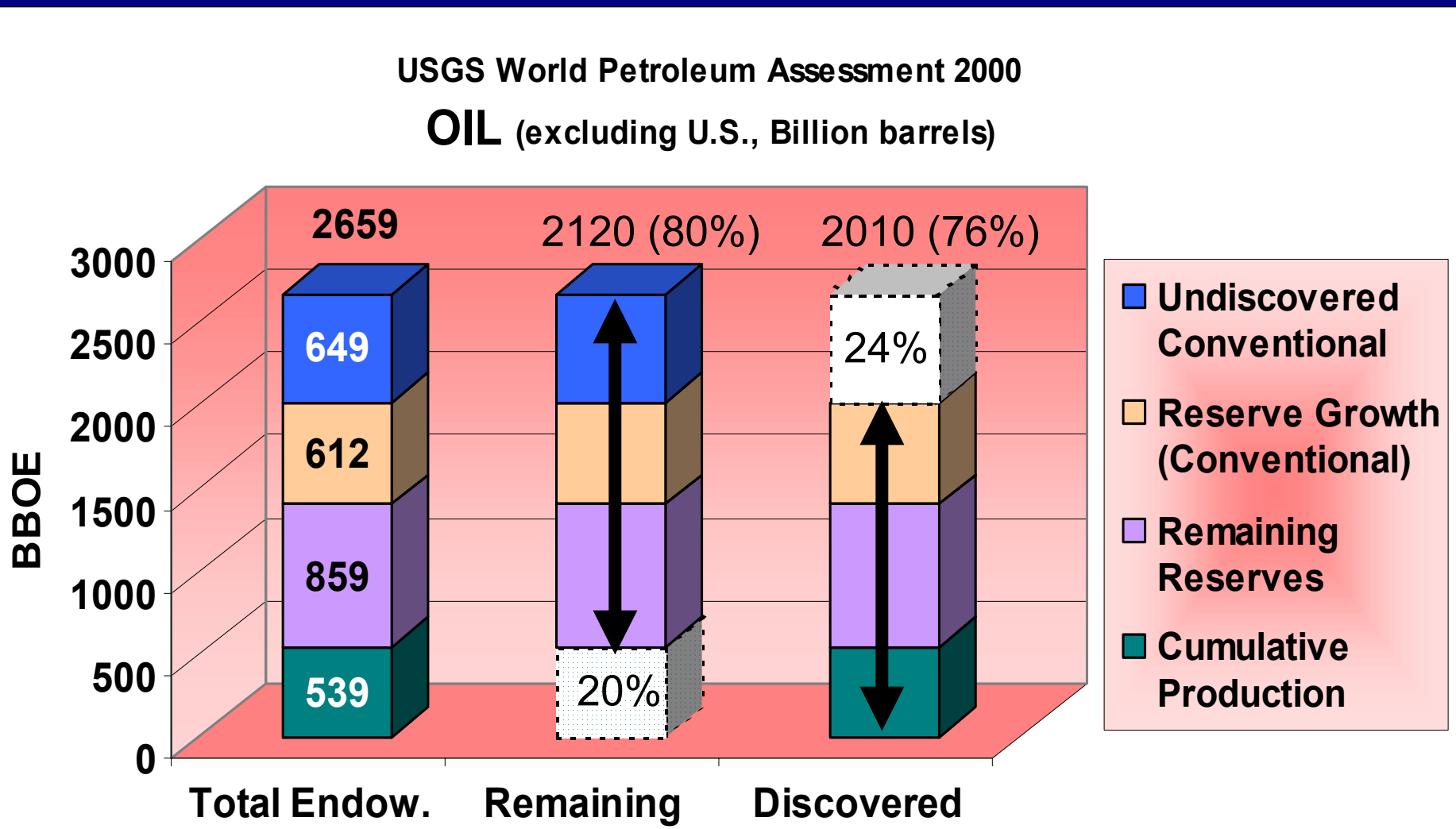


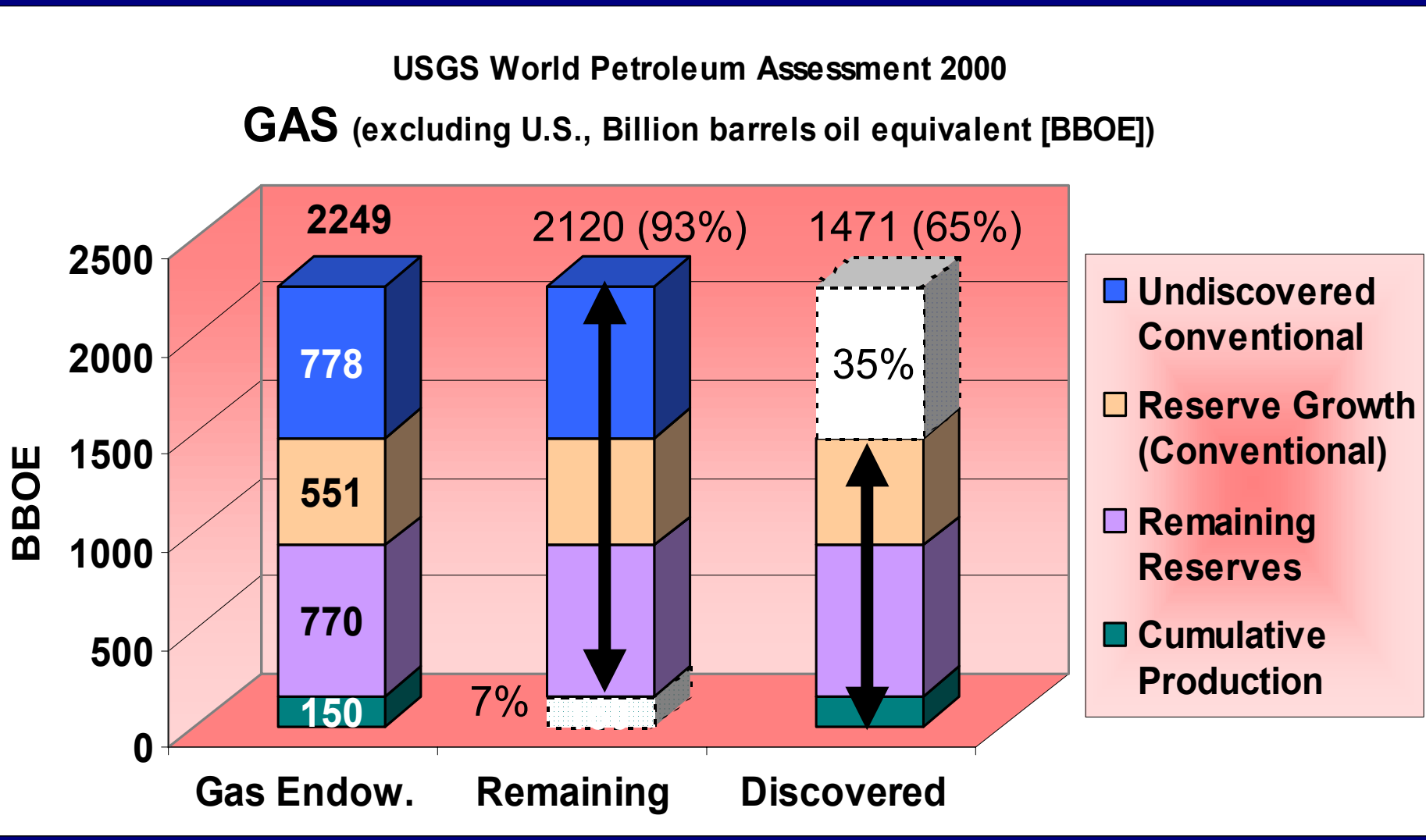
Conventional

- Gas-oil-water column
- Pooled accumulation

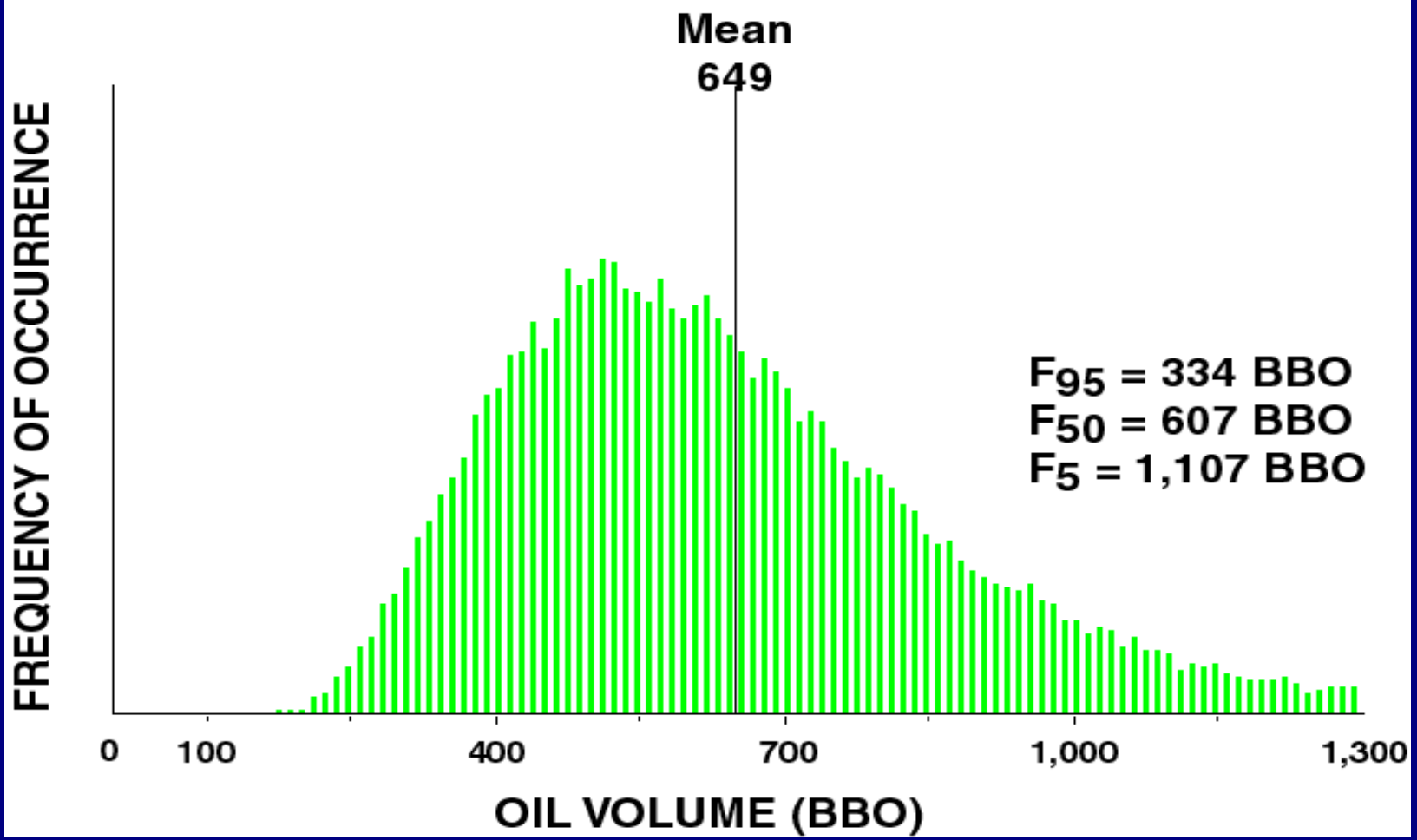
Unconventional (continuous)

- No gas-oil-water column
- Distributed throughout rock
- Special production techniques
- Examples: tar sands, heavy oil, coalbed methane, oil shale, gas hydrates.

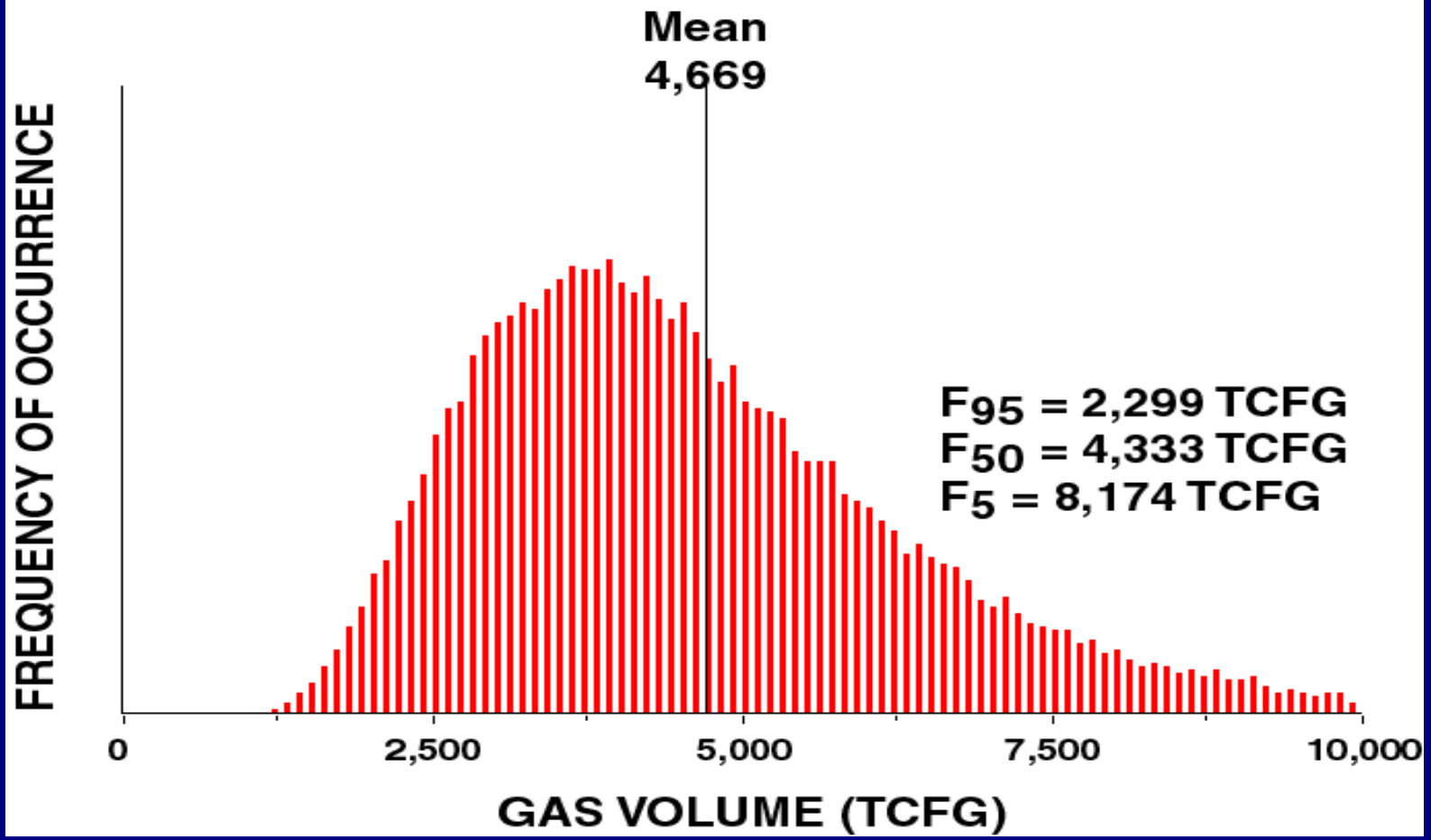

USGS World Petroleum Assessment 2000
OIL (excluding U.S., Billion barrels)
BBOE
3000
2500
2000
1500
1000
500
0
2659
2120 (80%)
2010 (76%)
649
612
859
539
20%
24%
Total Endow.
Remaining
Discovered
Undiscovered Conventional
Reserve Growth (Conventional)
Remaining Reserves
Cumulative Production


USGS World Petroleum Assessment 2000
GAS (excluding U.S., Billion barrels oil equivalent [BBOE])
BBOE
2500
2000
1500
1000
500
0
2249
2120 (93%)
1471 (65%)
778
551
770
150
7%
35%
Gas Endow.
Remaining
Discovered
Undiscovered Conventional
Reserve Growth (Conventional)
Remaining Reserves
Cumulative Production

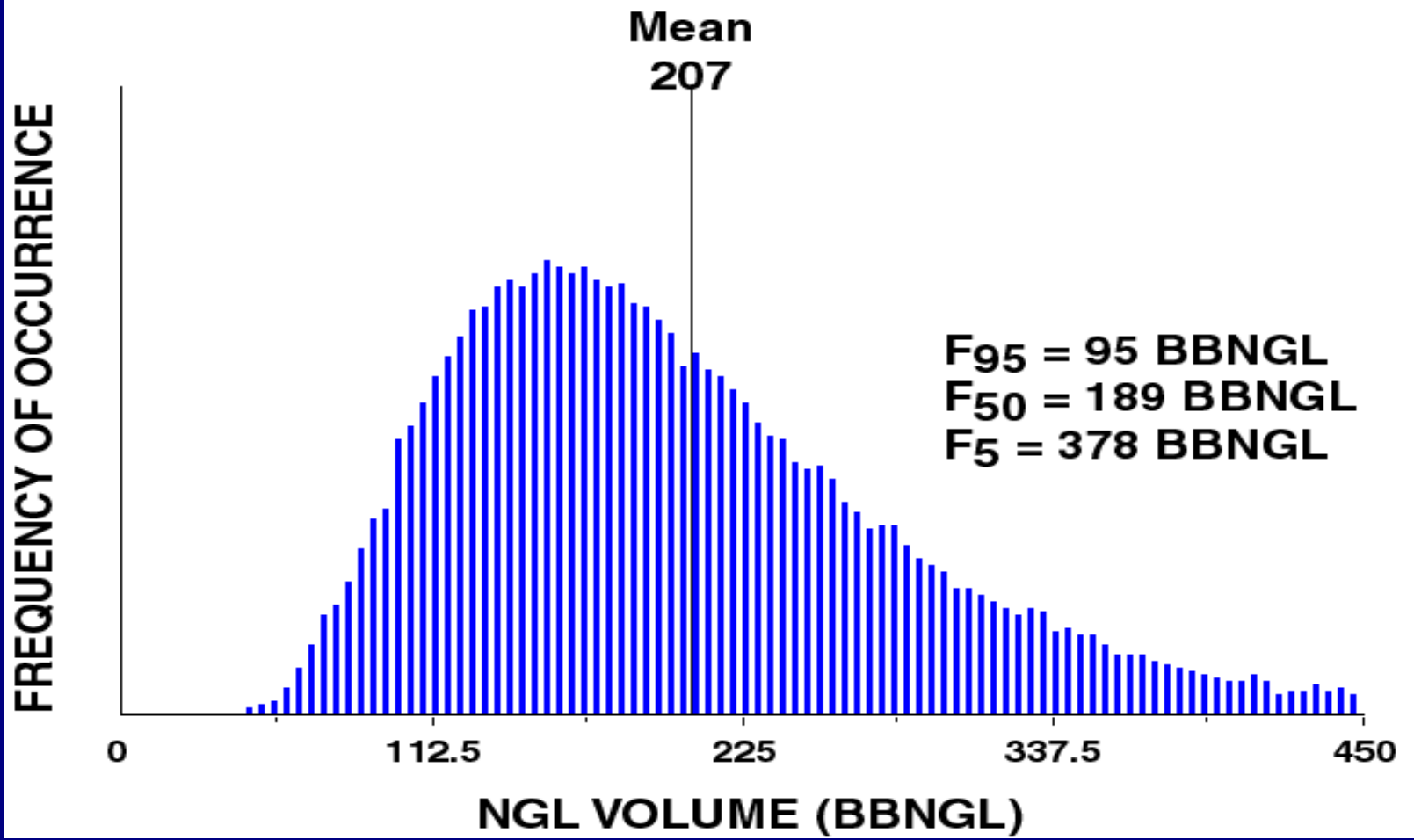
World Undiscovered Petroleum Resources
Oil



World Undiscovered Petroleum Resources
Gas



World Undiscovered Petroleum Resources
NGL



Reserve Growth

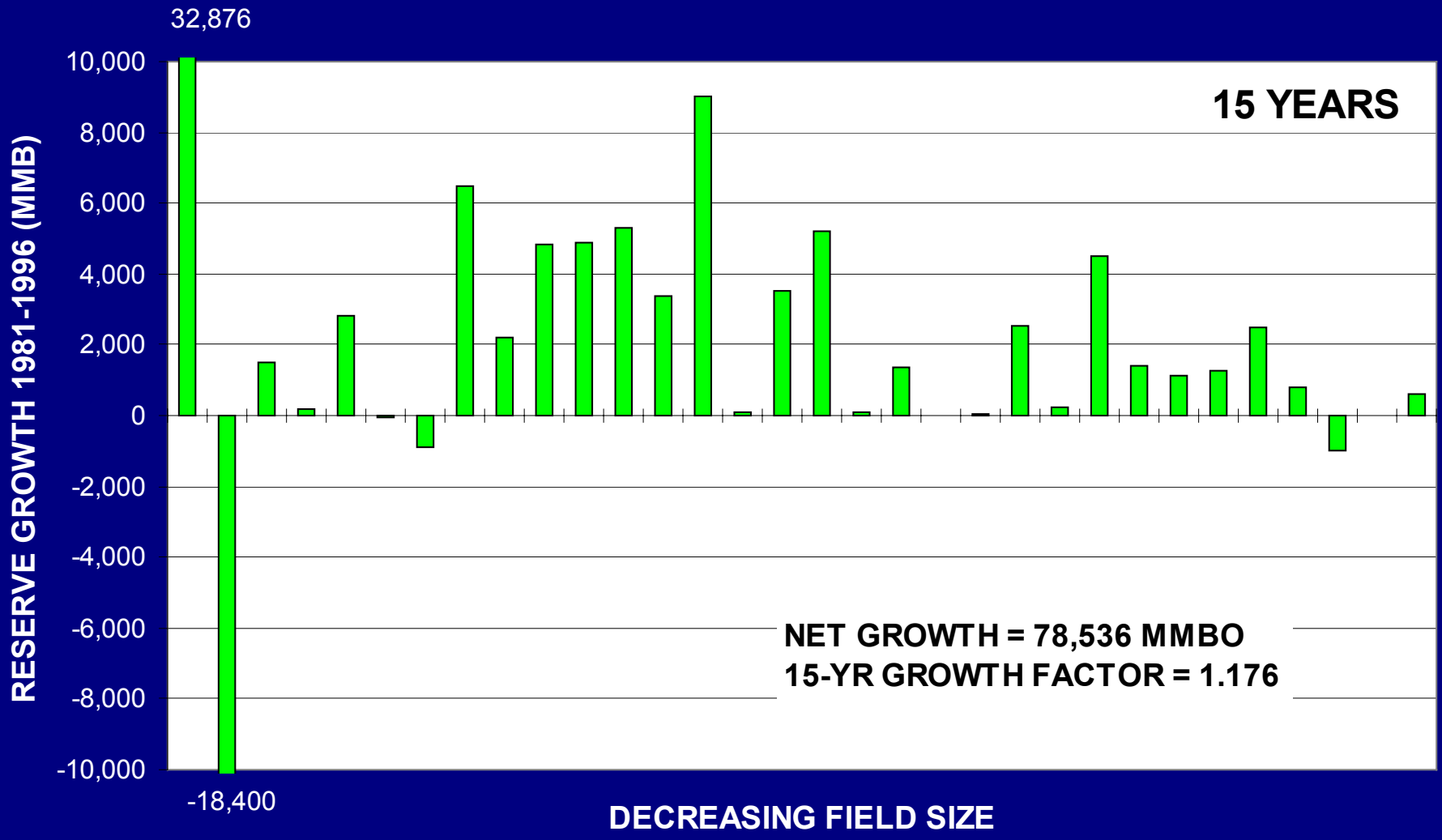
Definition: Reserve growth is the observed increase in reserves for a particular field over time. That is, the initial estimates of reserves in many fields is lower than the ultimate volume of oil produced from that field.

Causes of reserve growth:

- Conservative initial estimates (SEC requirements, corporate psychology)
- Exploration technology (e.g., 3-D, 4-D seismic)
- Drilling technology (horizontal, multilateral, directional)
- Production technology (enhanced oil recovery)

RESERVE GROWTH OF WORLD'S LARGEST OIL FIELDS

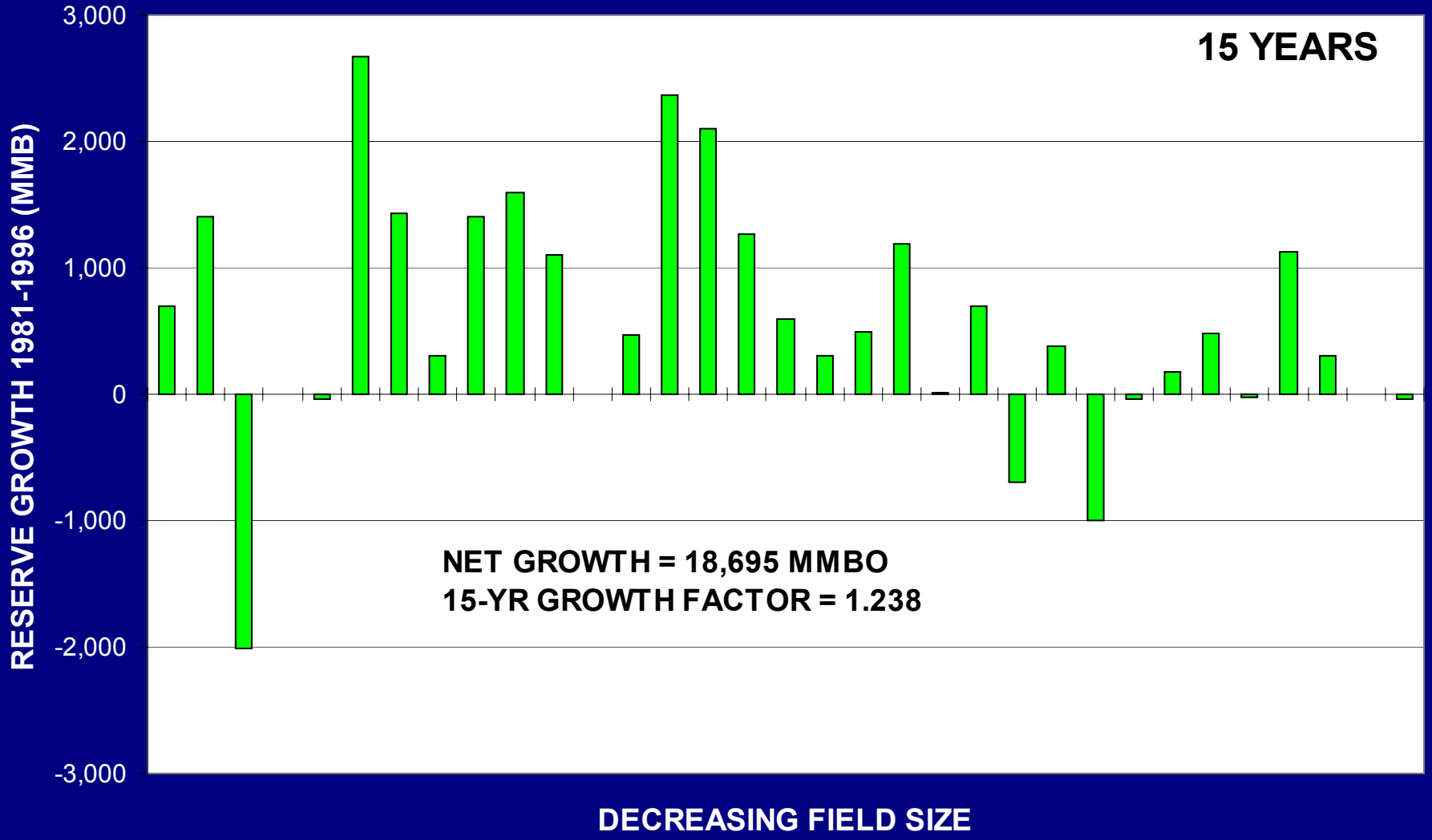
FIRST LARGEST GROUP (115,000 TO 5,000 MMB)



USGS

RESERVE GROWTH OF WORLD'S LARGEST OIL FIELDS

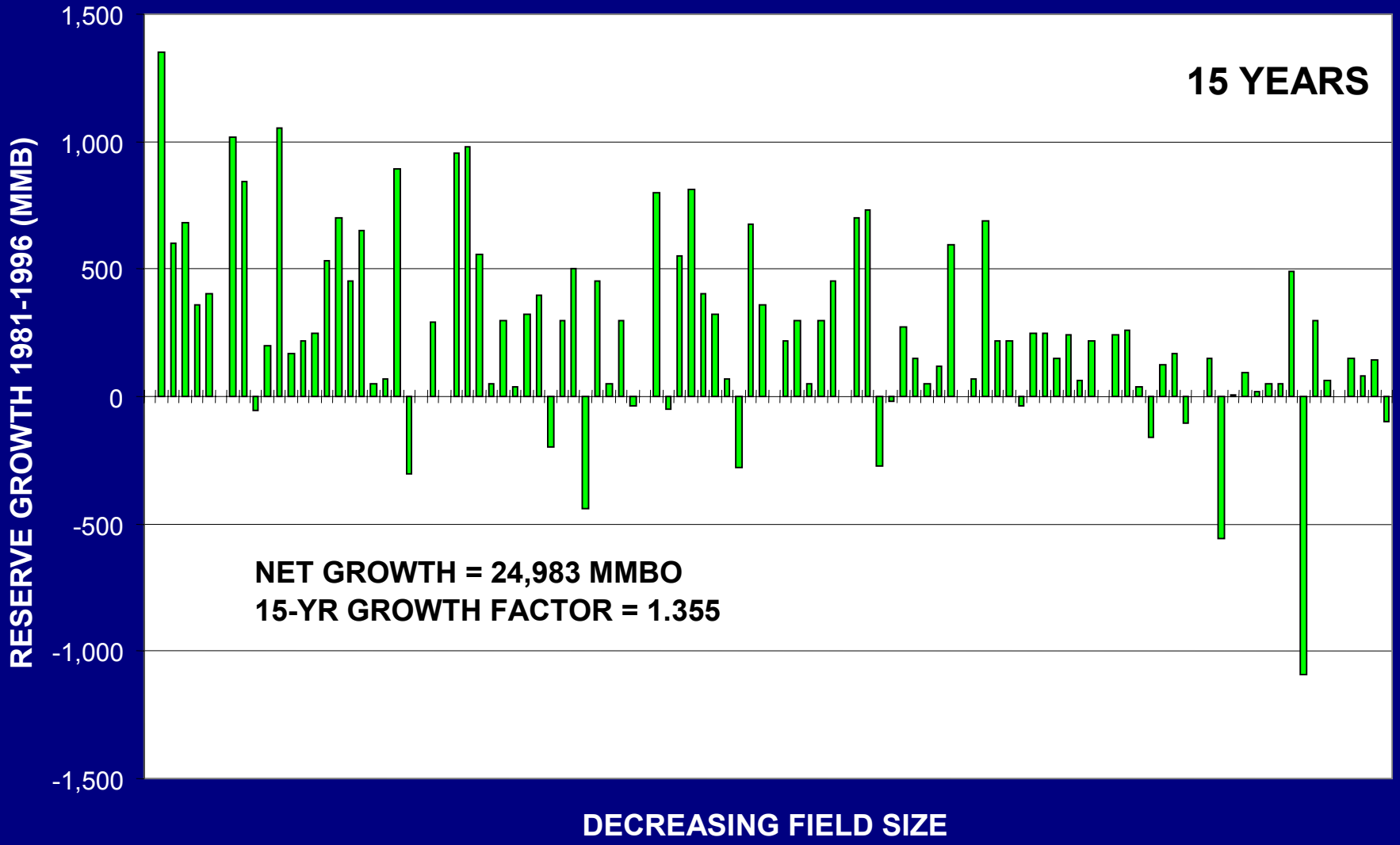
SECOND LARGEST GROUP (5,000 TO 1,800 MMB)



USGS

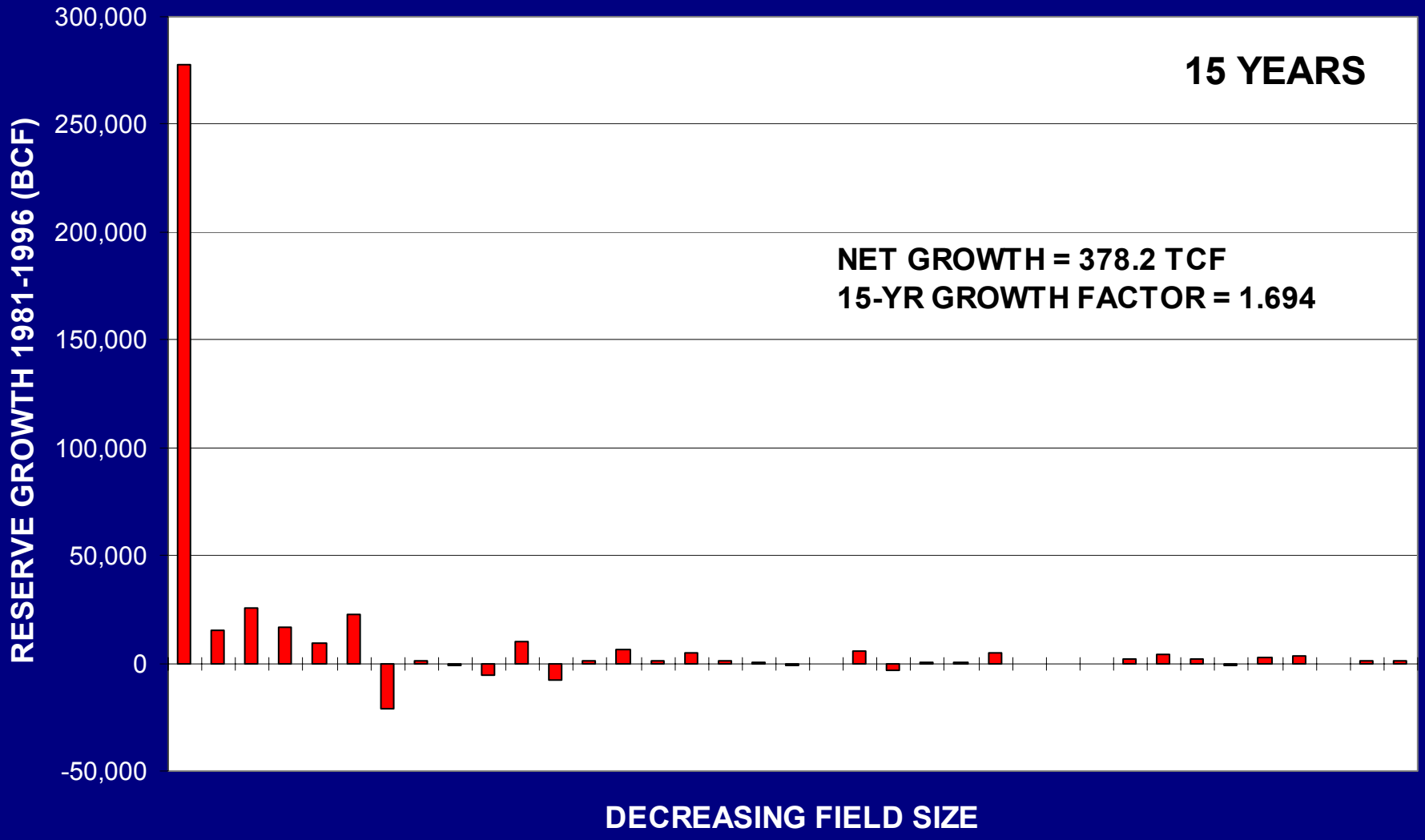
RESERVE GROWTH OF WORLD'S LARGEST OIL FIELDS

THIRD LARGEST GROUP (1,800 TO 500 MMB)



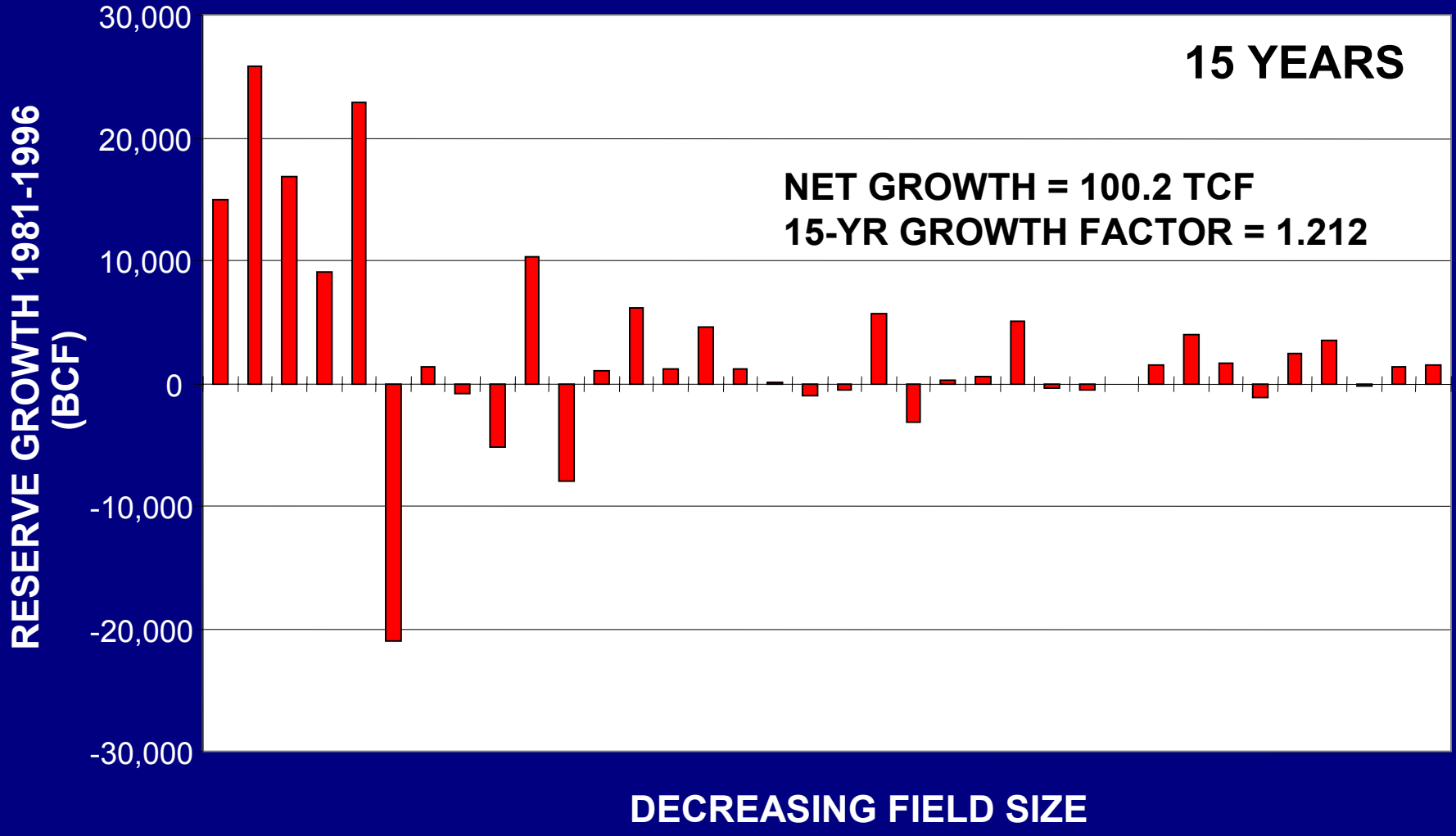
USGS

RESERVE GROWTH OF WORLD'S LARGEST GAS FIELDS
(>3 TCF [preliminary analysis])

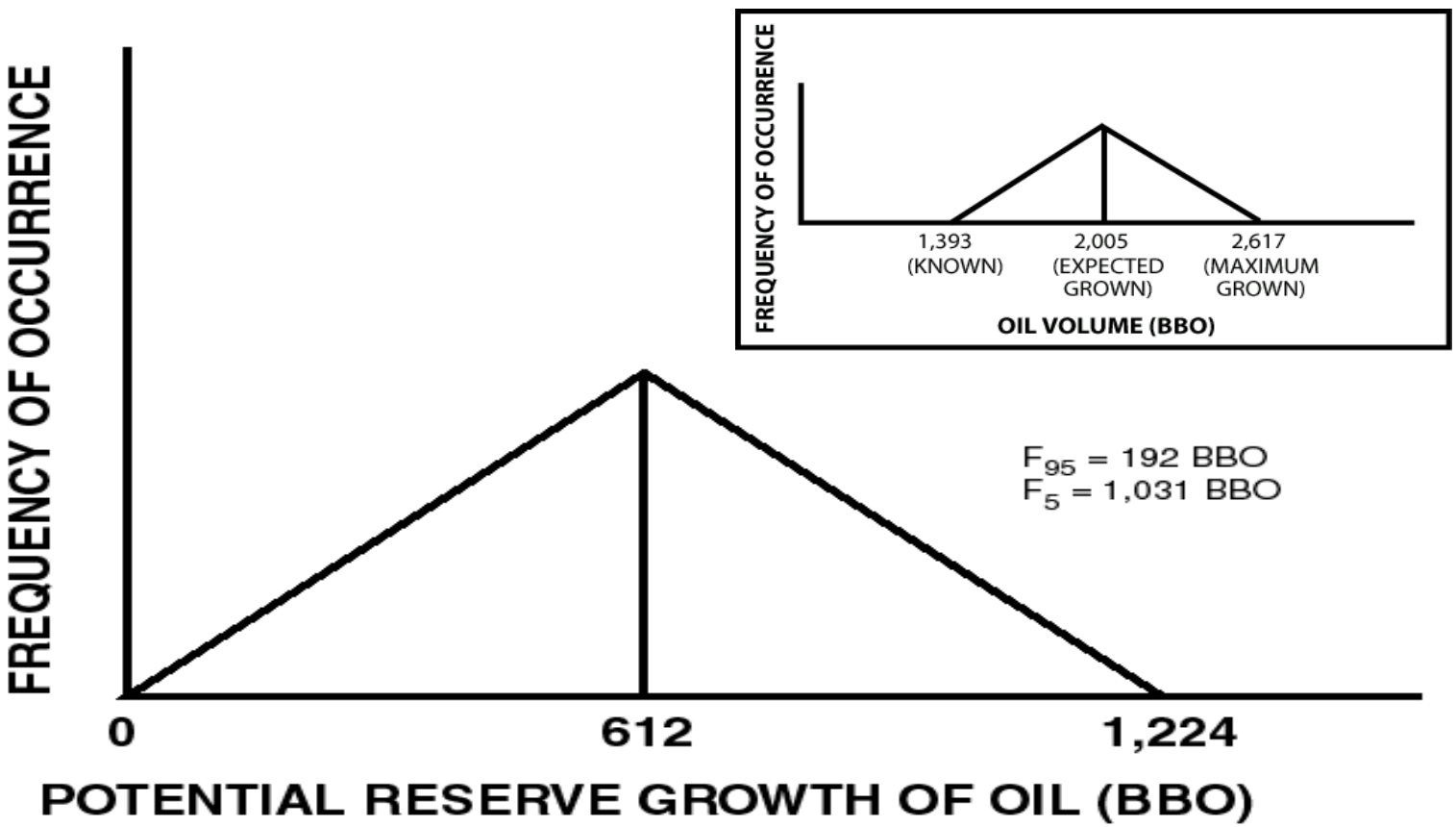


USGS

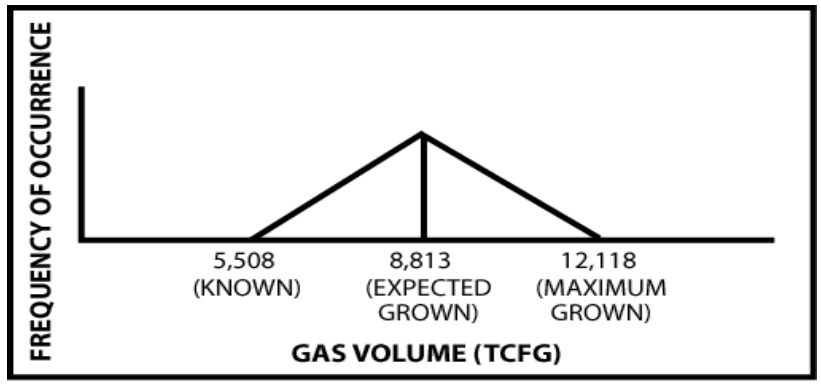
RESERVE GROWTH OF WORLD'S LARGEST GAS FIELDS (>3 TCF [preliminary analysis]), EXCLUDING NORTH FIELD



World Potential Reserve Growth
Oil



World Potential Reserve Growth
Gas



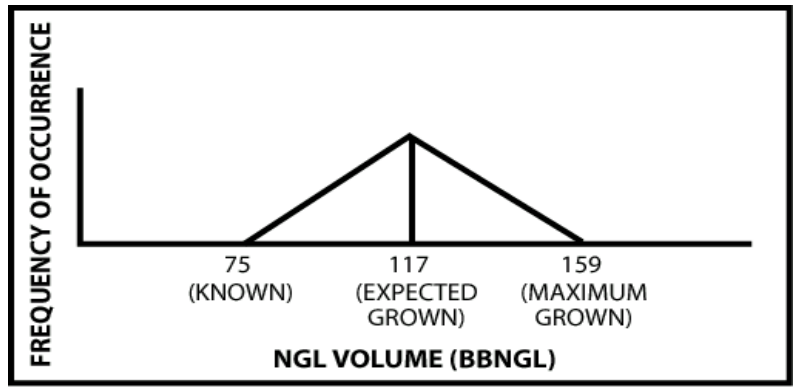
FREQUENCY OF OCCURRENCE

F_{95} = 1,049 TCFG
F_5 = 5,543 TCFG

0 3,305 6,610

POTENTIAL RESERVE GROWTH OF GAS (TCFG)

World Potential Reserve Growth
NGL



FREQUENCY OF OCCURRENCE

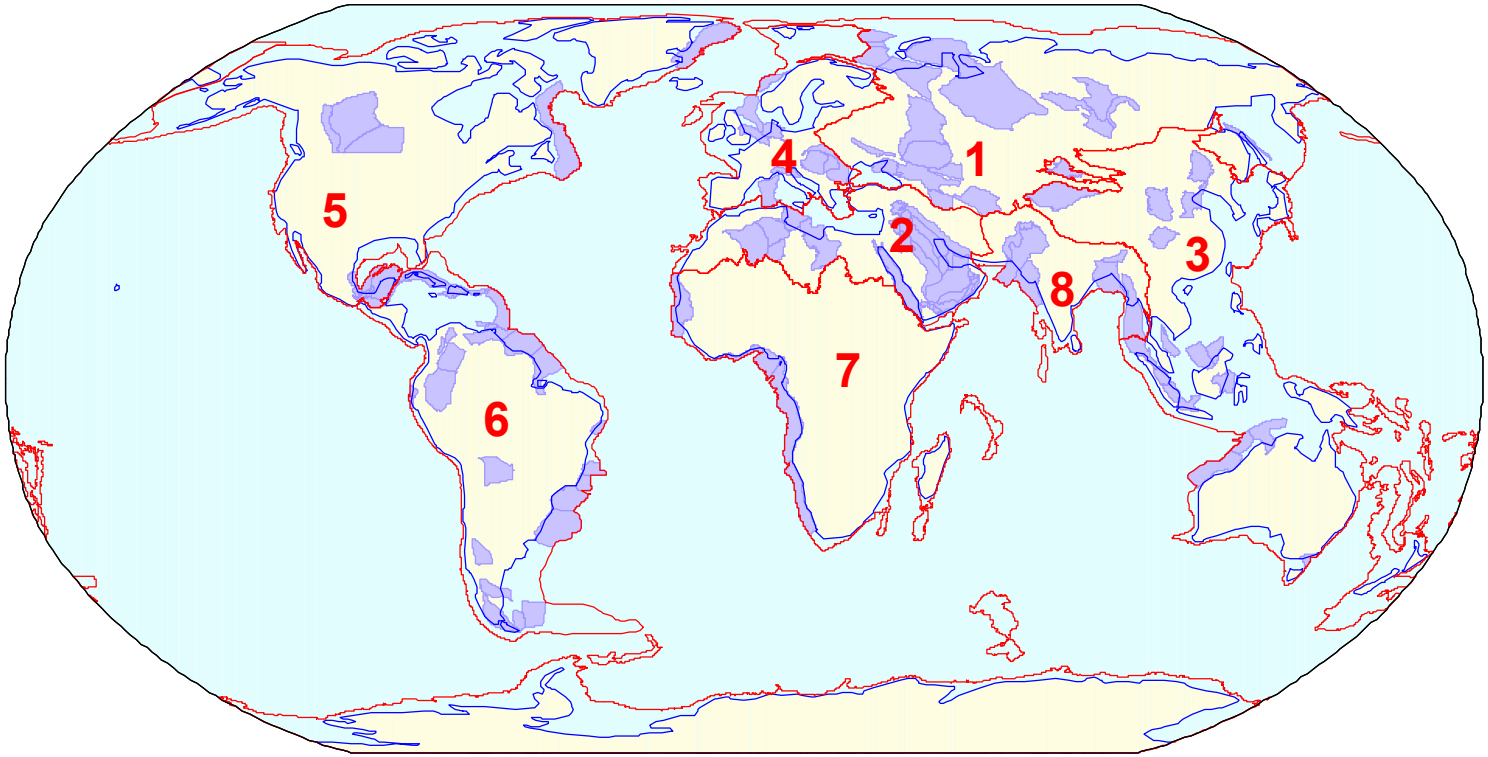
F_{95} = 13 BBNGL
F_5 = 71 BBNGL

0 42 84

POTENTIAL RESERVE GROWTH OF NGL (BBNGL)

USGS
science for a changing world

World Petroleum Assessment 2000



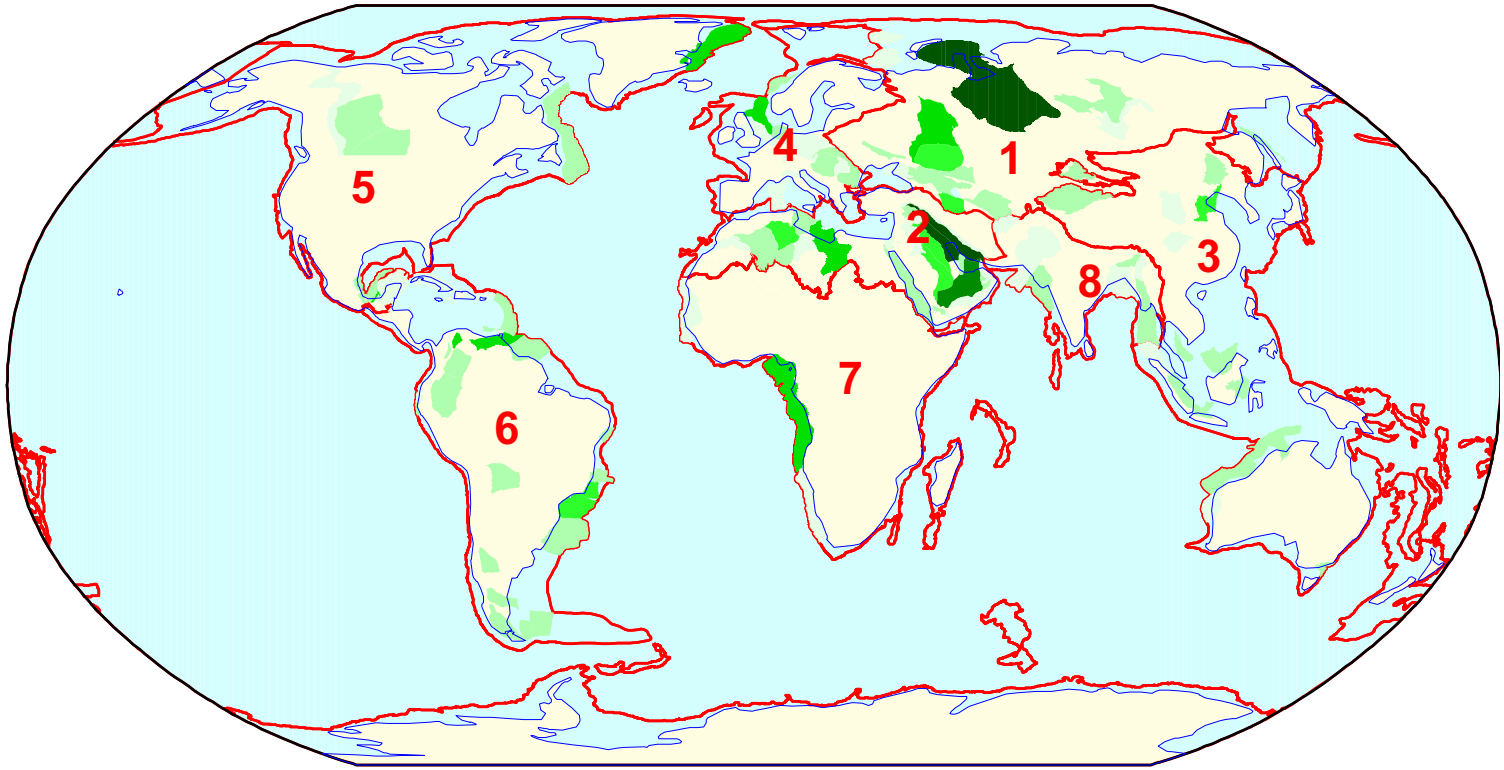
Assessed Geologic Provinces

REGIONS

1 Former Soviet Union
2 Middle East and North Africa
3 Asia Pacific
4 Europe
5 North America
6 Central and South America
7 Sub-Saharan Africa and Antarctica
8 South Asia

Assessed geologic province

World Petroleum Assessment 2000



Conventional Oil Endowment of the World by Province

REGIONS

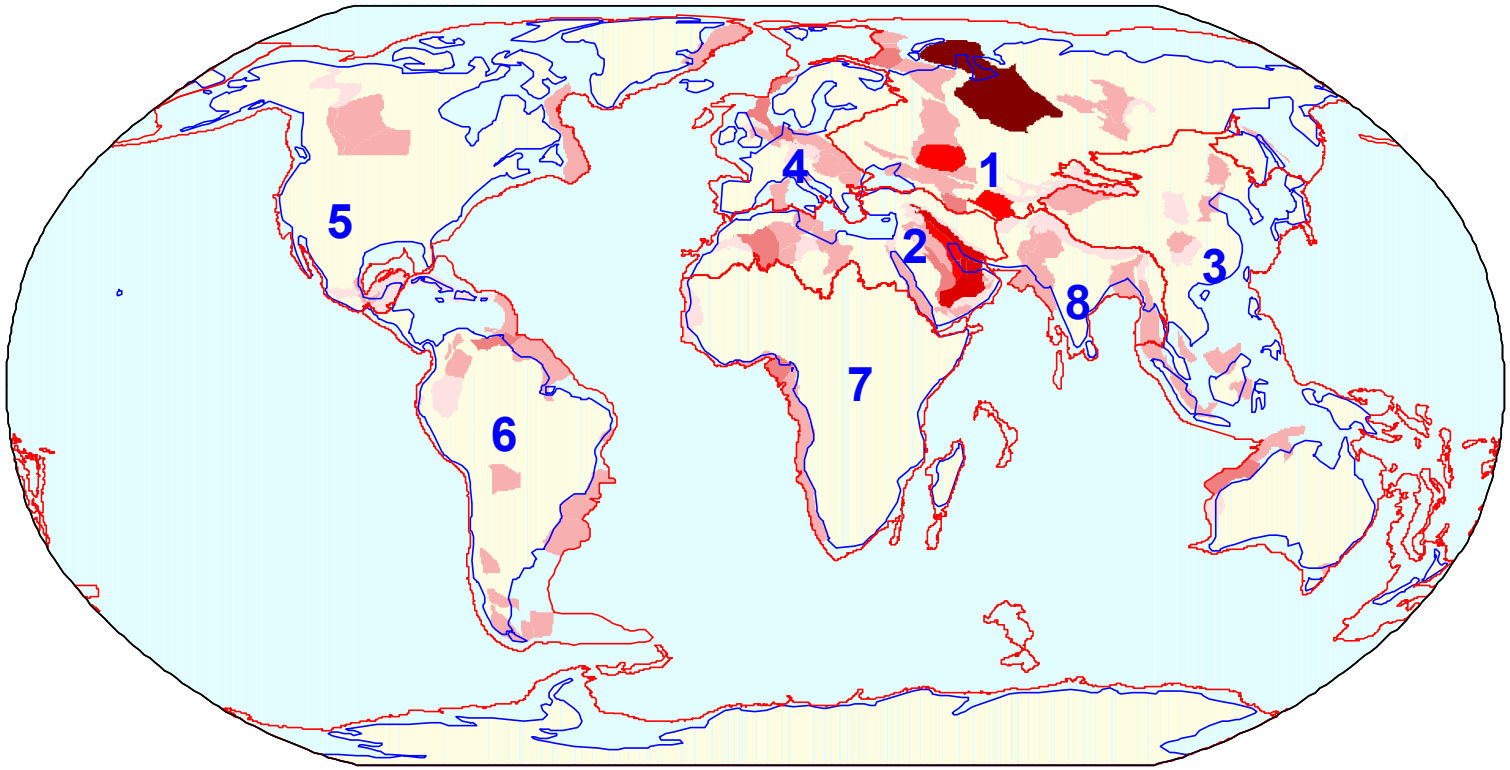
1 Former Soviet Union
2 Middle East and North Africa
3 Asia Pacific
4 Europe
5 North America
6 Central and South America
7 Sub-Saharan Africa and Antarctica
8 South Asia

Conventional Oil Endowment in Billions of Barrels

- Less than 1 BBO
- 1 - 20 BBO
- 20 - 40 BBO
- 40 - 80 BBO
- 80 - 160 BBO
- Greater than 160 BBO

USGS science for a changing world

World Petroleum Assessment 2000



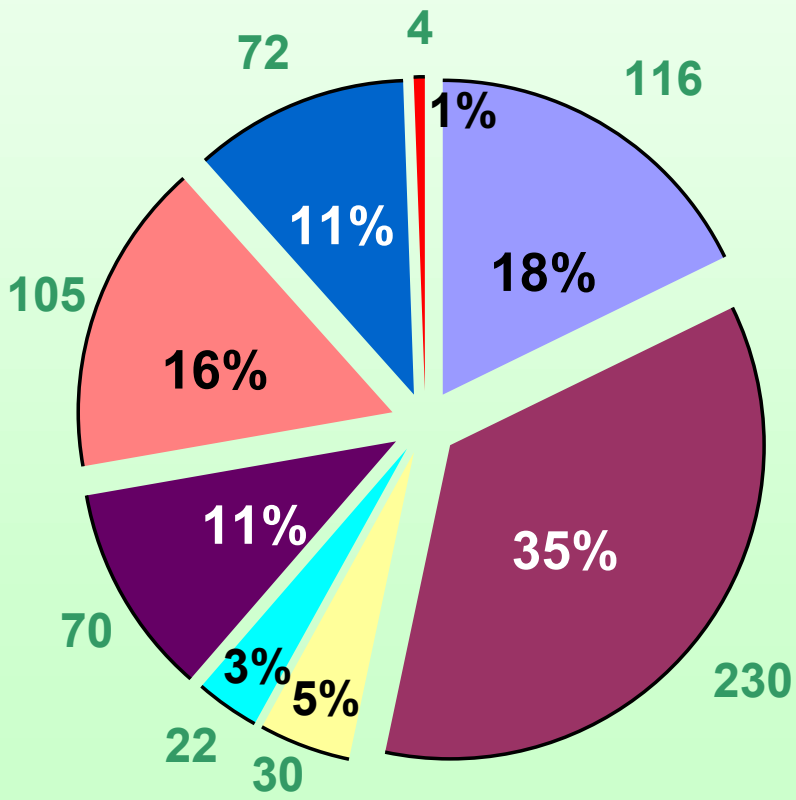
Conventional Natural Gas Endowment of the World by Province

REGIONS

1 Former Soviet Union
2 Middle East and North Africa
3 Asia Pacific
4 Europe
5 North America
6 Central and South America
7 Sub-Saharan Africa and Antarctica
8 South Asia

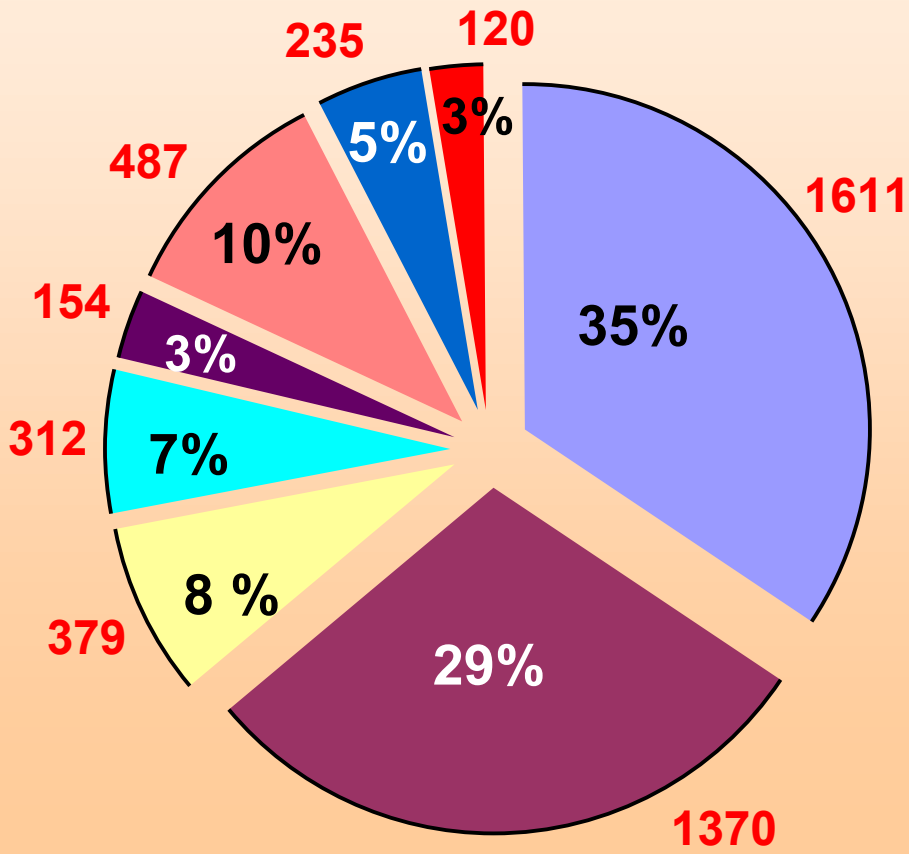
Less than 6 TCF
6 - 120 TCF
120 - 240 TCF
240 - 480 TCF
480 - 960 TCF
Greater than 960 TCF

USGS World Petroleum Assessment 2000: Mean Estimates of Undiscovered Oil (BBO) by Geographic Region (excluding U.S.)



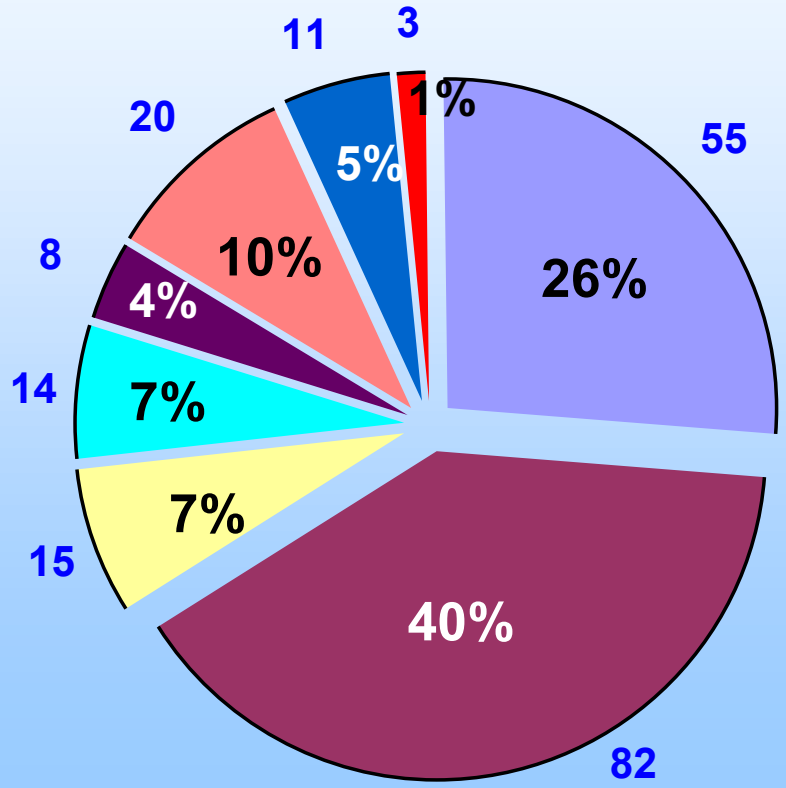
- (1) FSU
- (2) Mid.E. & N.Afr.
- (3) Asia Pacific
- (4) Europe
- (5) N.Am.
- (6) Cent.& S.Am.
- (7) S.Afr.& Antarc.
- (8) S. Asia

USGS World Petroleum Assessment 2000: Mean Estimates of Undiscovered Gas (TCF) by Geographic Region (excluding U.S.)



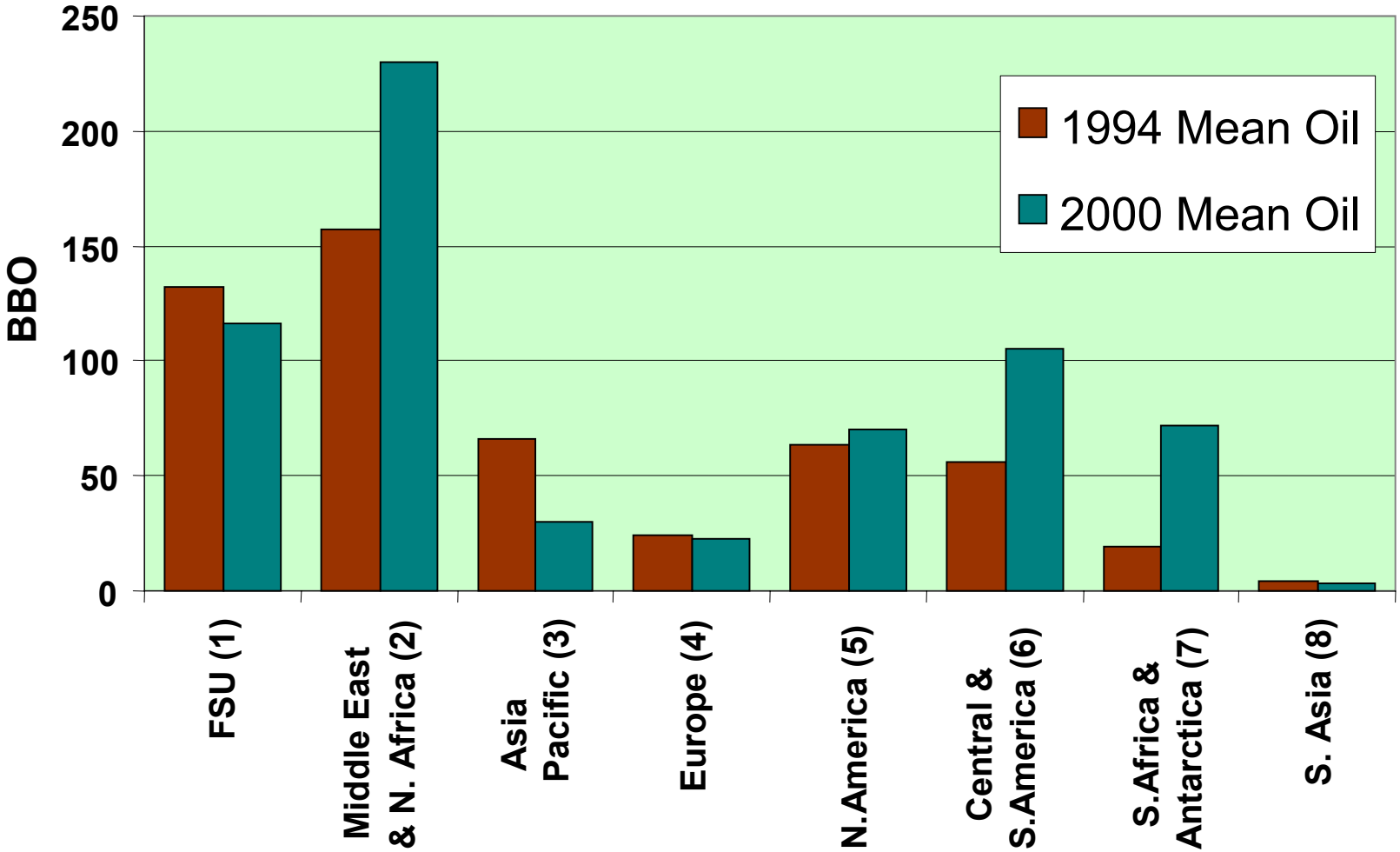
- (1) FSU
- (2) Mid.E. & N.Afr.
- (3) Asia Pacific
- (4) Europe
- (5) N.Am.
- (6) Cent.& S.Am.
- (7) S.Afr.& Antarc.
- (8) S. Asia

USGS World Petroleum Assessment 2000: Mean Estimates of Undiscovered NGL (BBNGL) by Geographic Region (excluding U.S.)

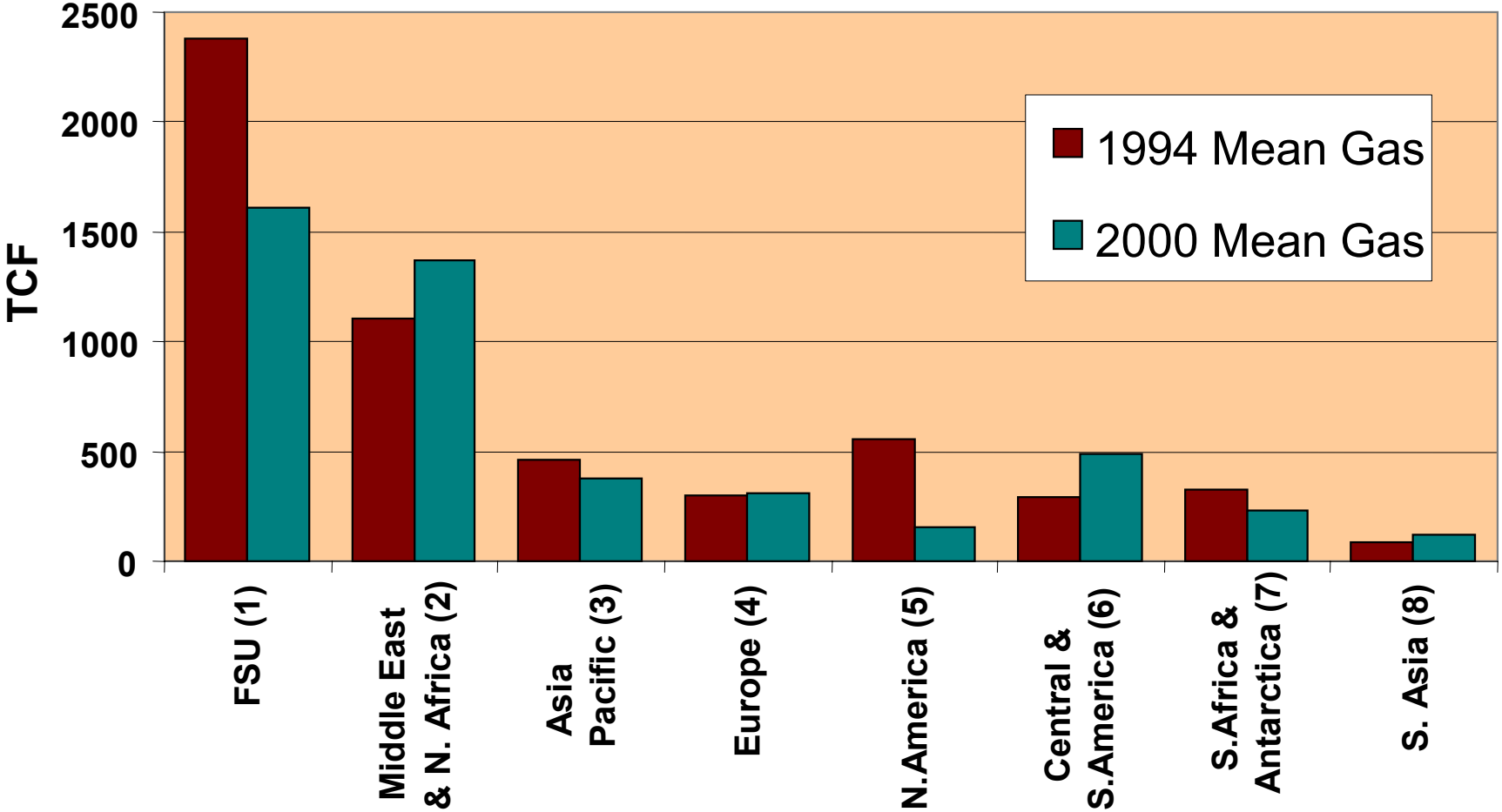


- (1) FSU
- (2) Mid.E. & N.Afr.
- (3) Asia Pacific
- (4) Europe
- (5) N.Am.
- (6) Cent.& S.Am.
- (7) S.Afr.& Antarc.
- (8) S. Asia

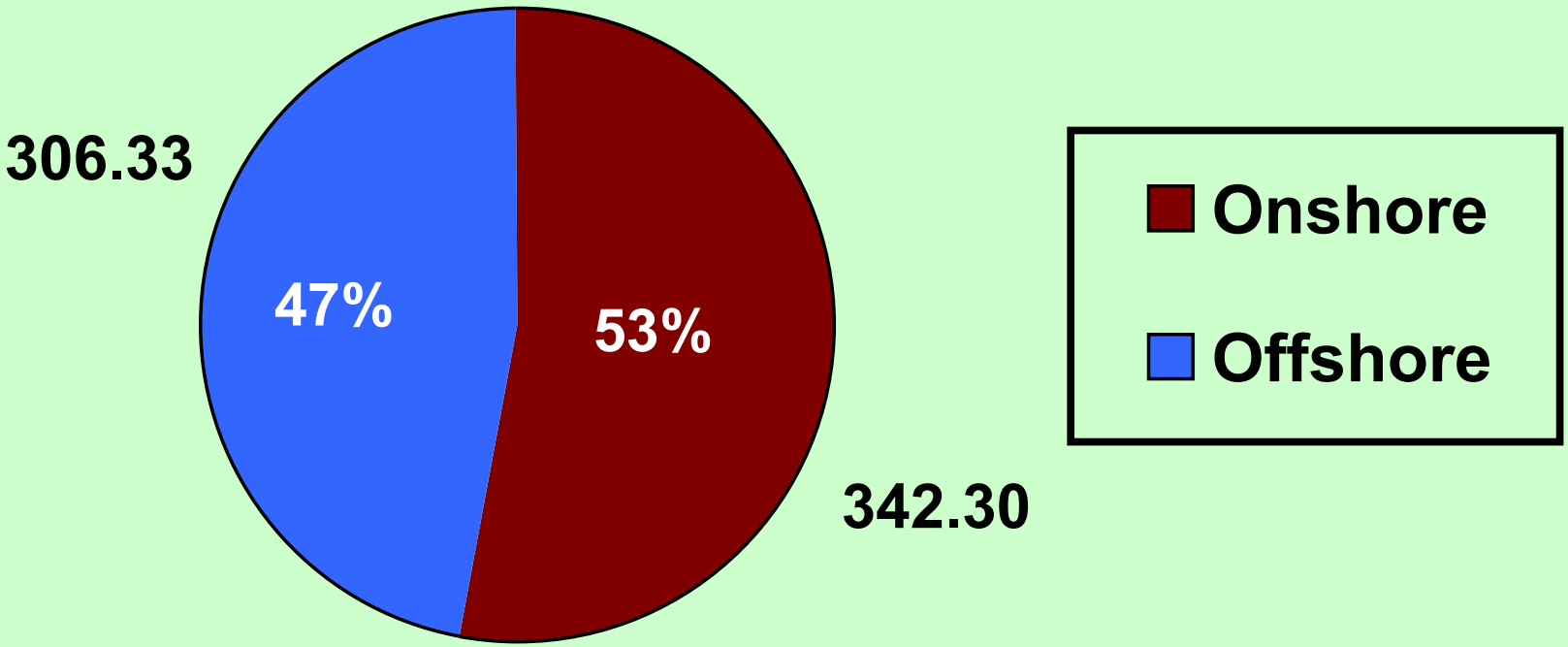
Comparison of USGS Mean Estimates of Undiscovered Oil by Region (excluding U.S.)



Comparison of USGS Mean Estimates of Undiscovered Gas by Region (excluding U.S.)

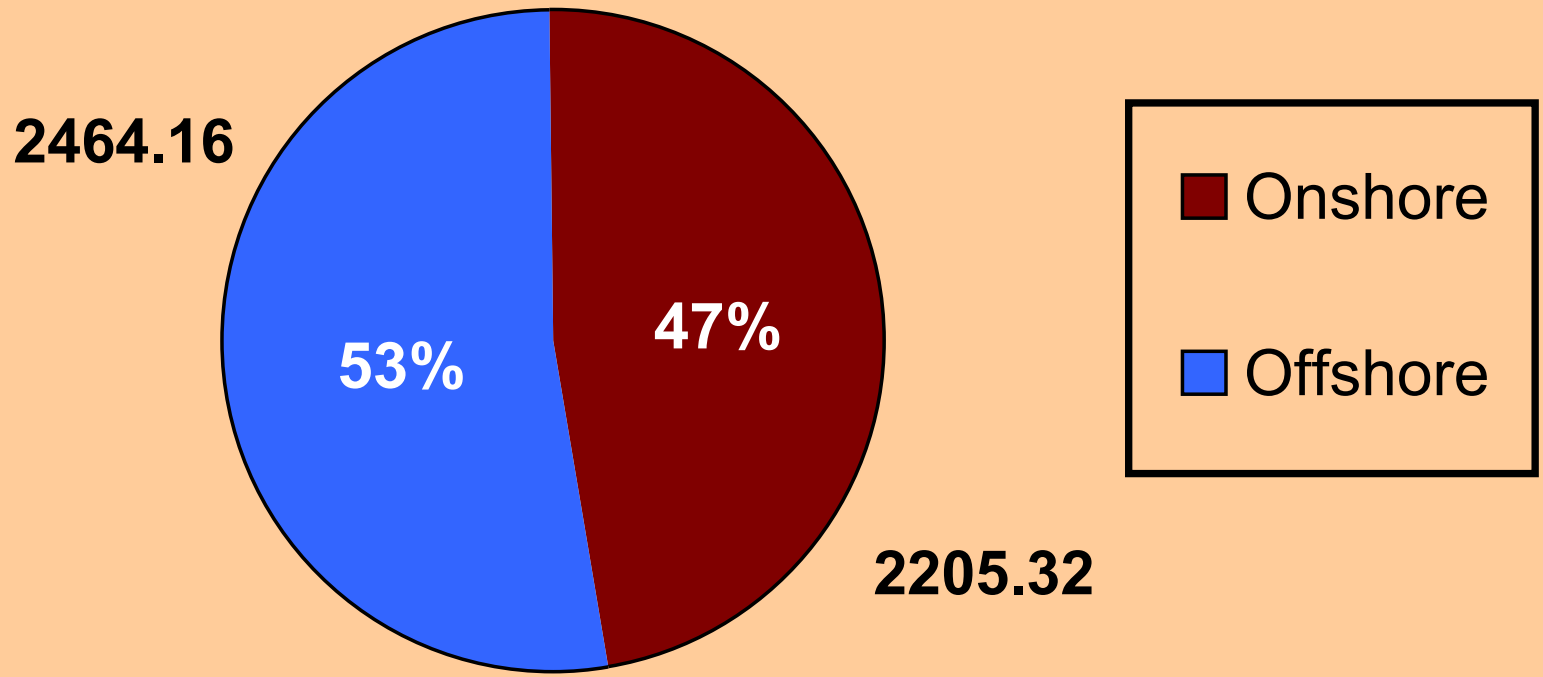


USGS World Petroleum Assessment2000
Mean Estimate of Undiscovered Oil (BBO)



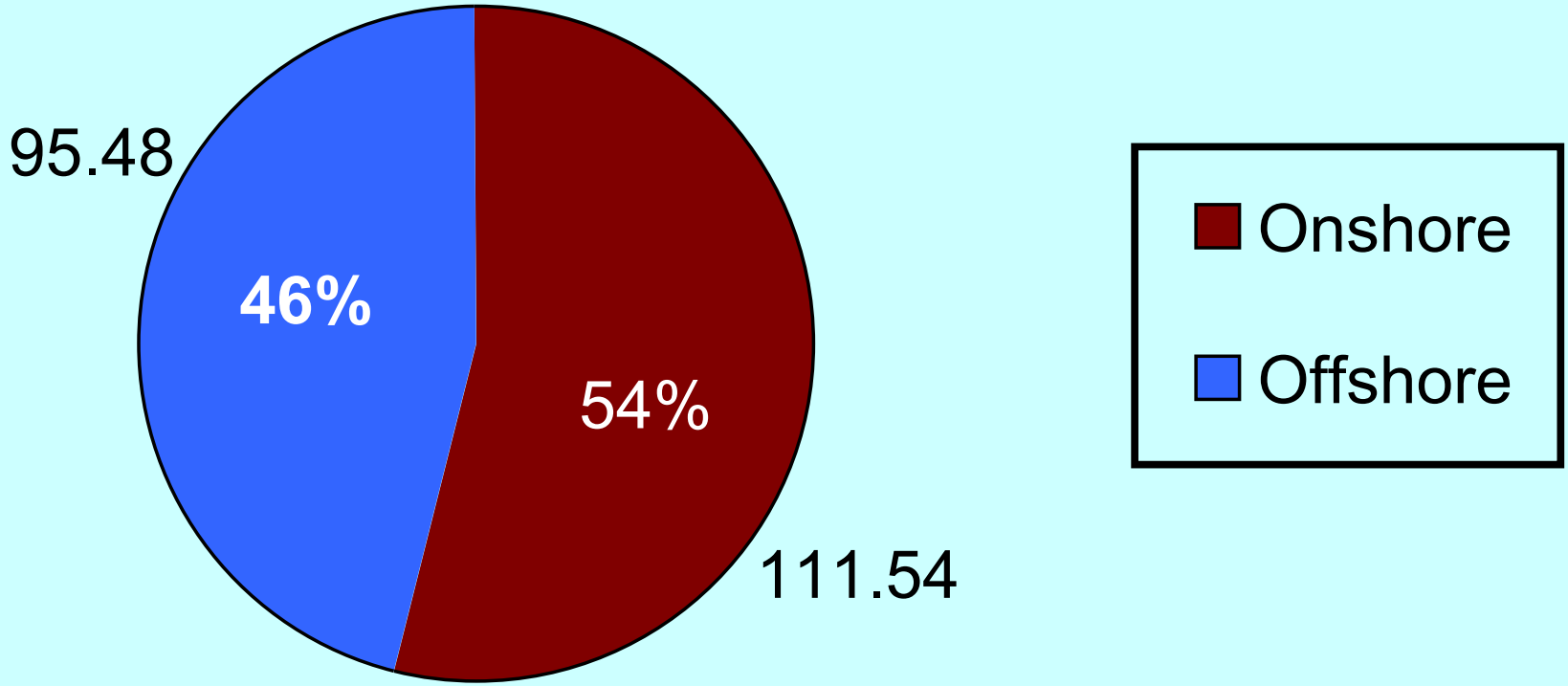
USGS World Petroleum Assessment 2000

Mean Estimate of Undiscovered Gas (TCF)



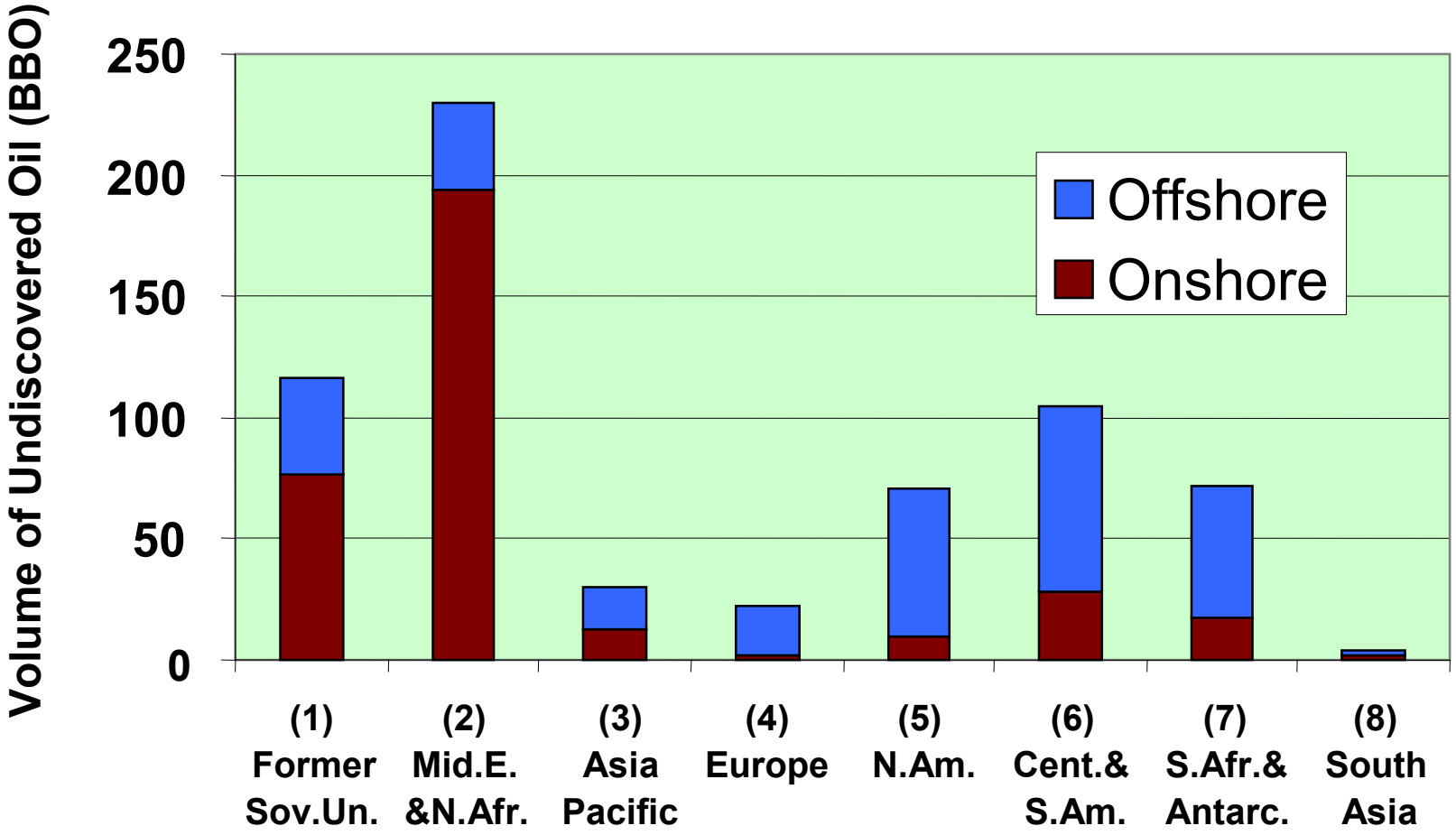
USGS World Petroleum Assessment 2000

Mean Estimate of Undiscovered NGL (BBNGL)



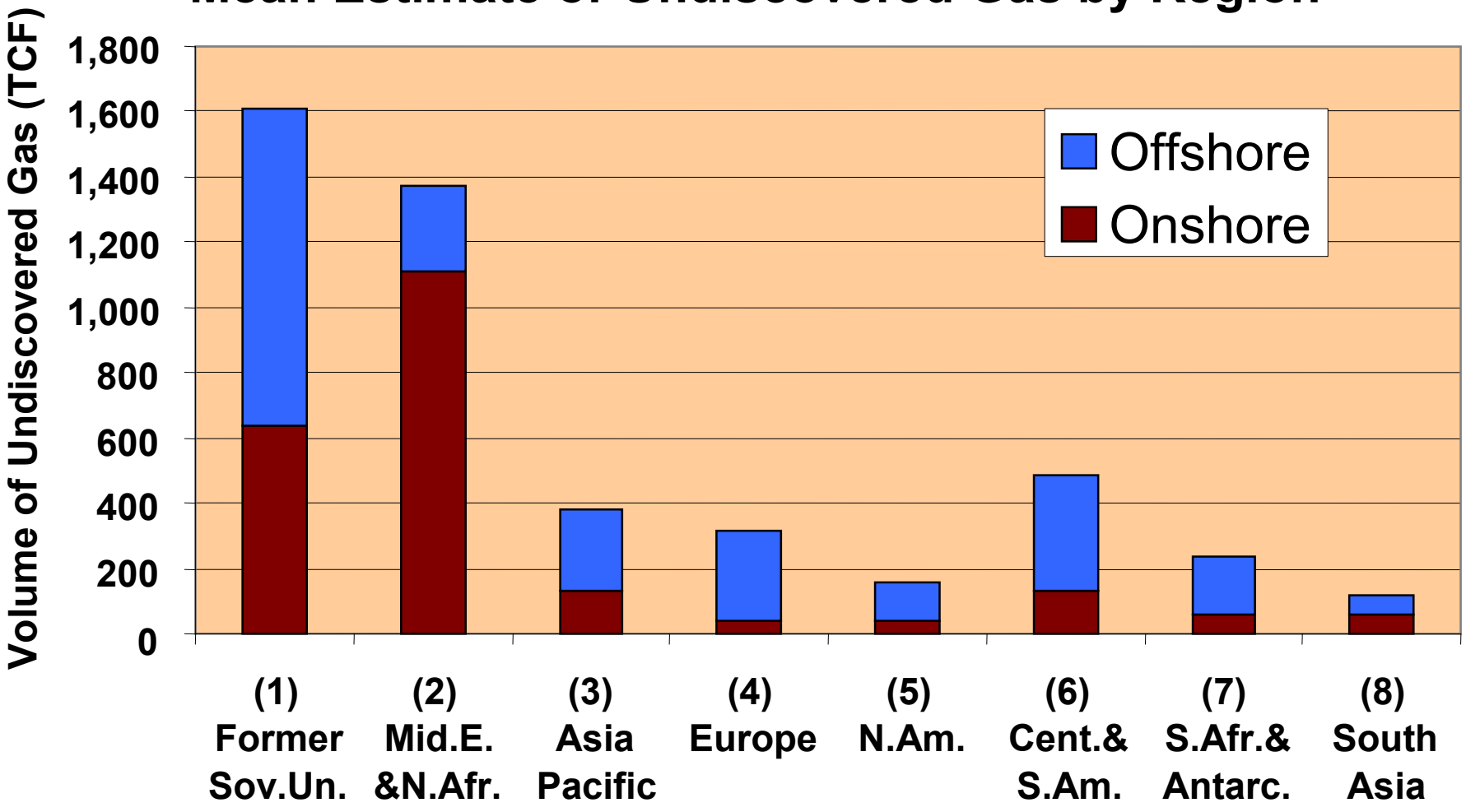
USGS World Petroleum Assessment 2000

Mean Estimate of Undiscovered Oil by Region



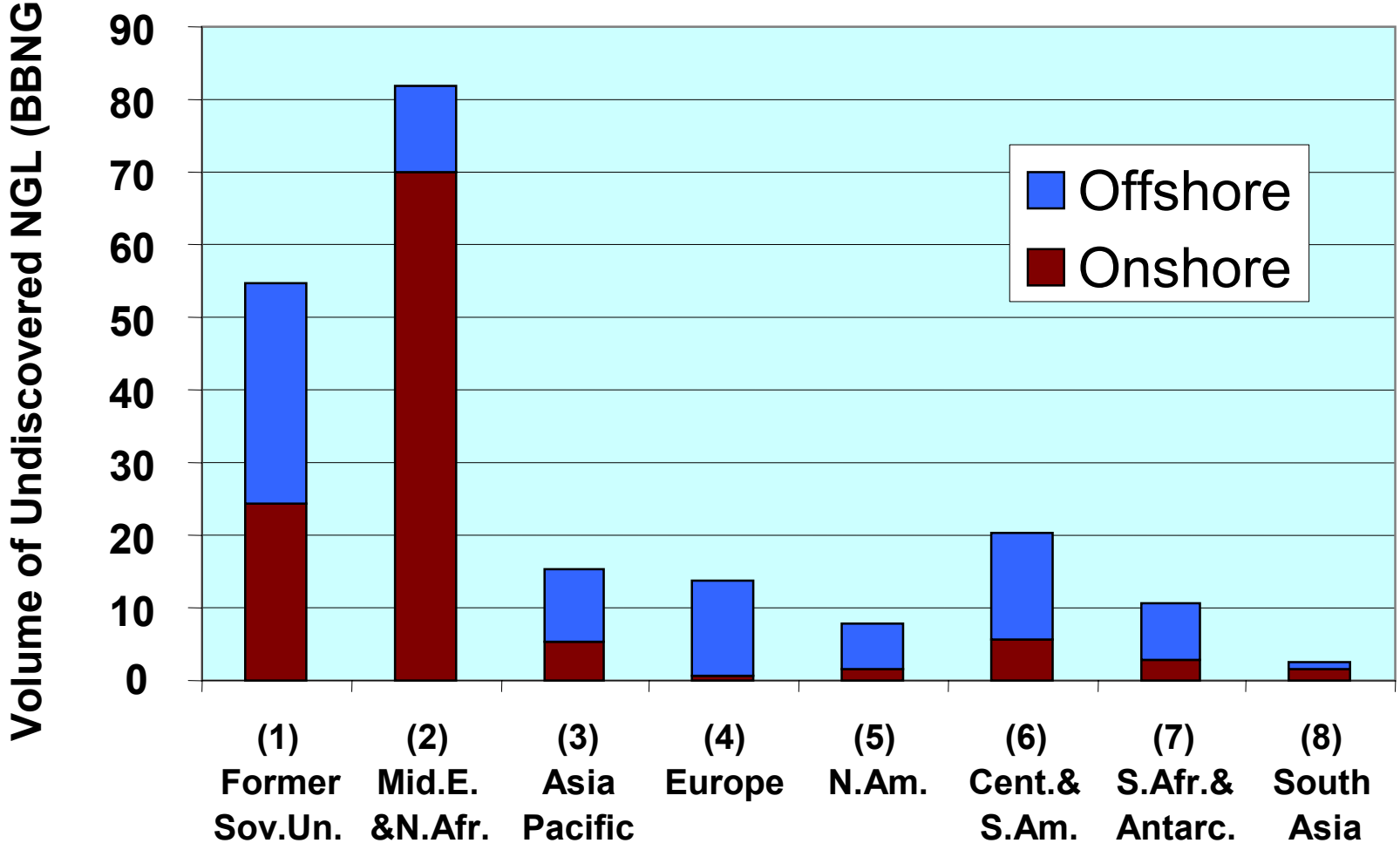
USGS World Petroleum Assessment 2000

Mean Estimate of Undiscovered Gas by Region

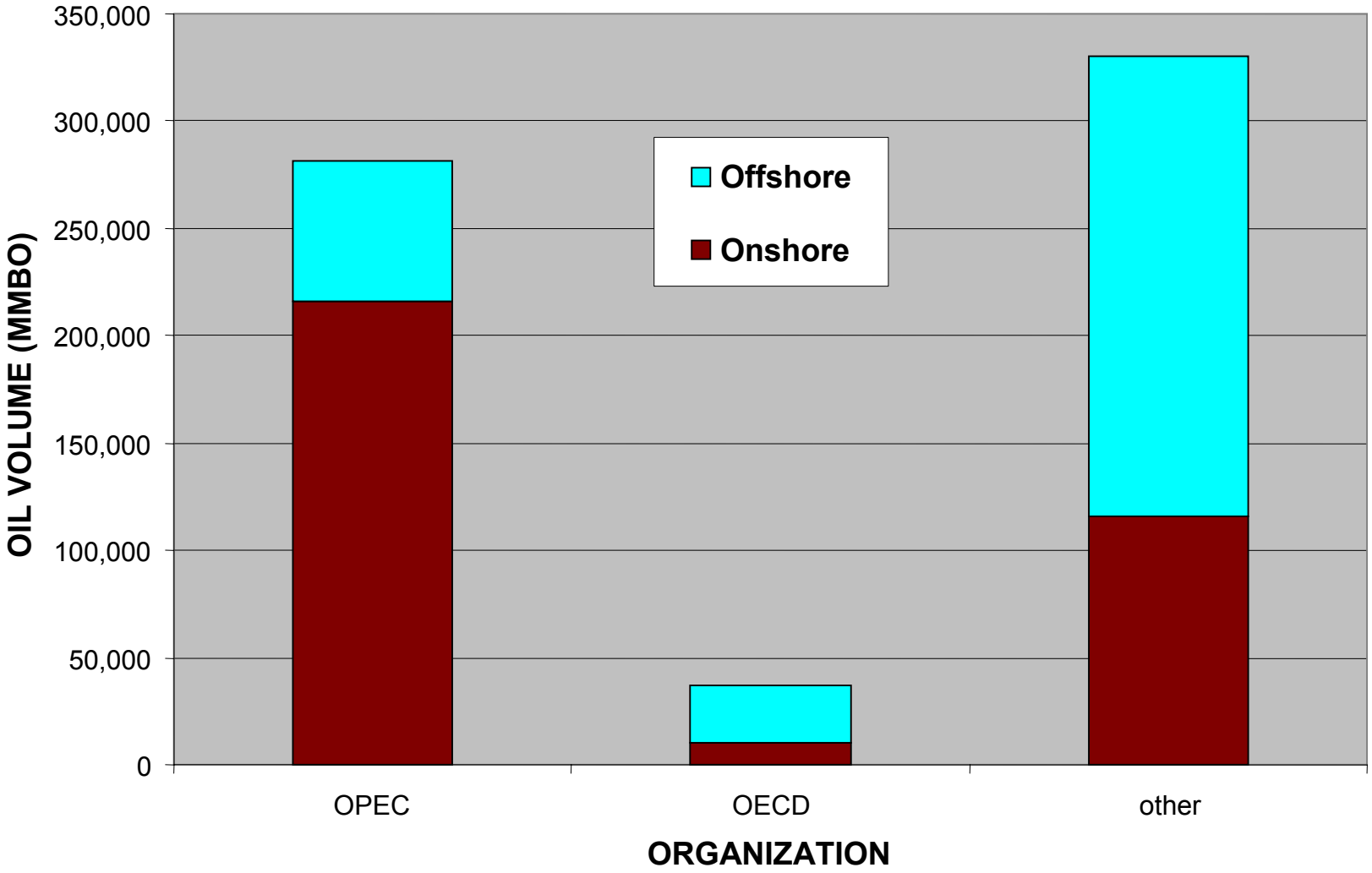


USGS World Petroleum Assessment 2000

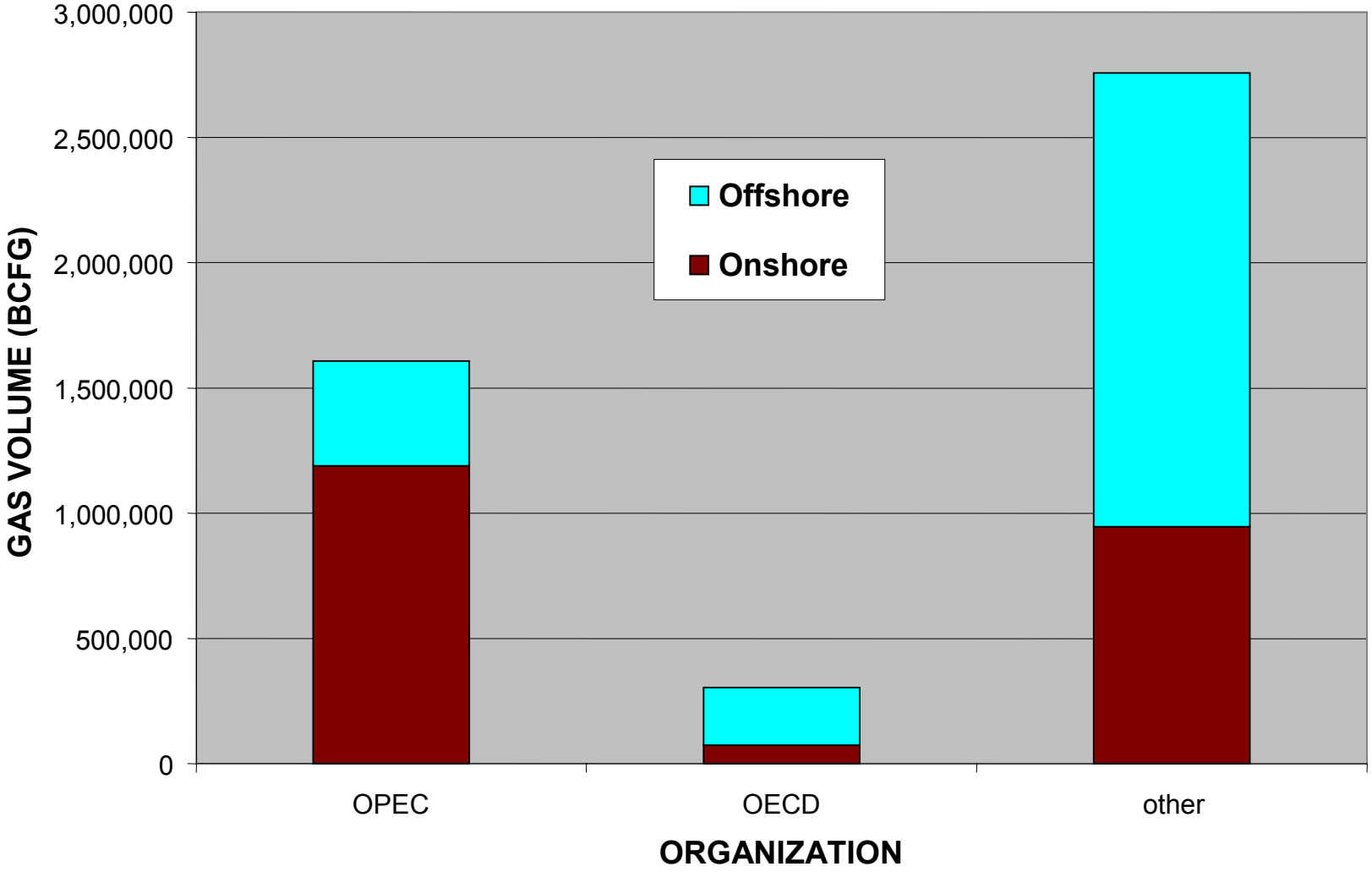
Mean Estimate of Undiscovered NGL by Region



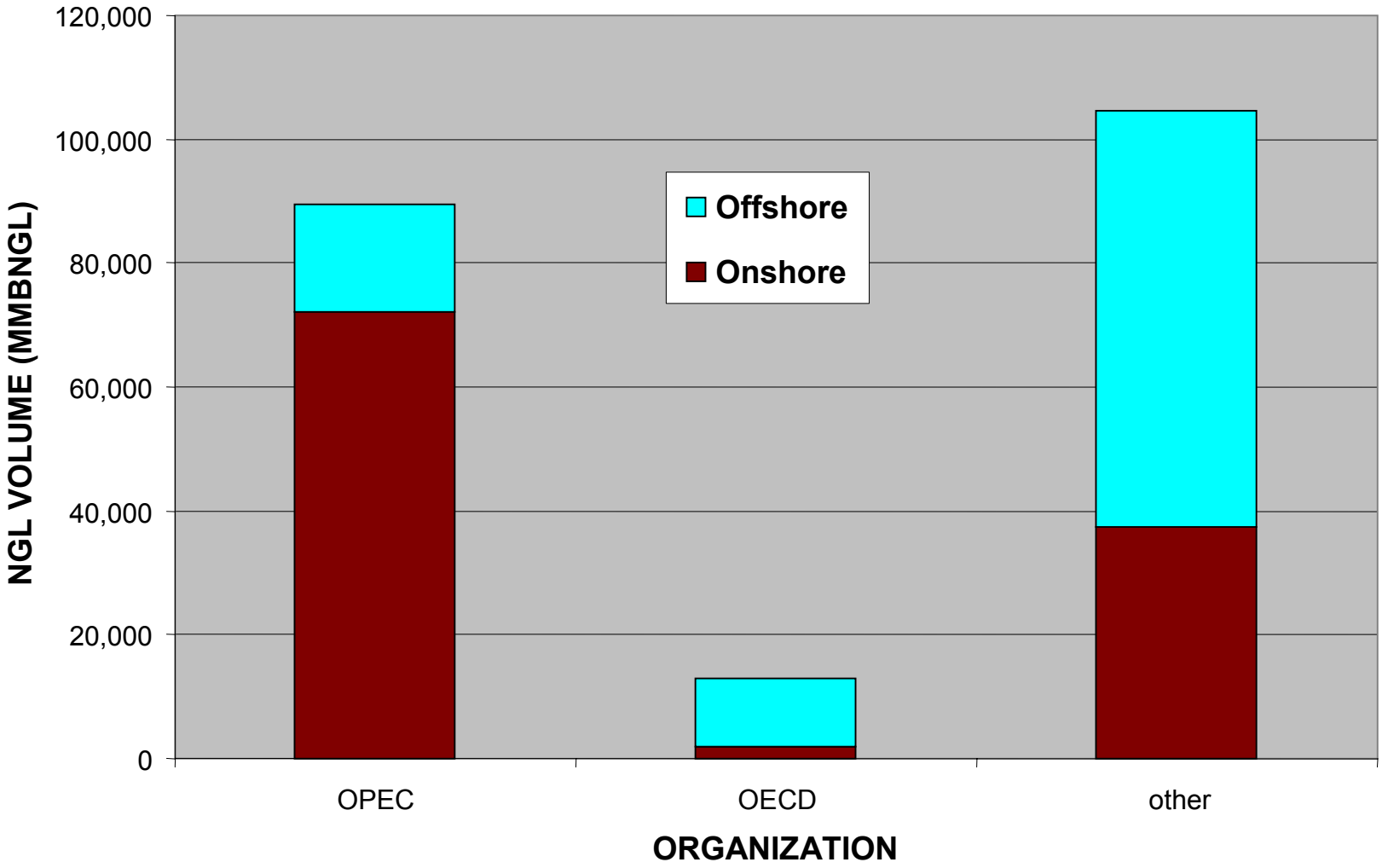
Distribution of Mean Undiscovered Oil by Organization



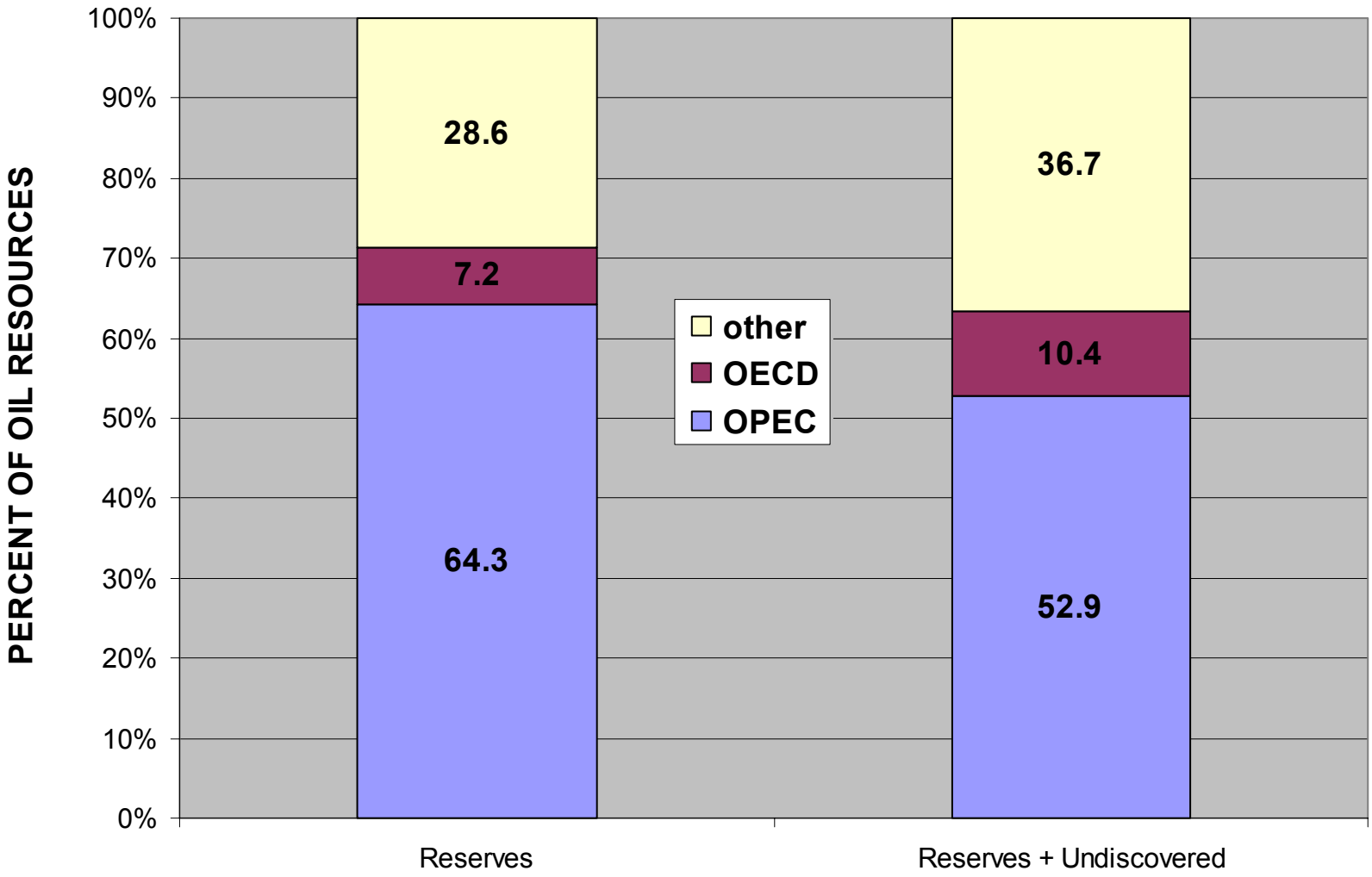
Distribution of Mean Undiscovered Gas by Organization



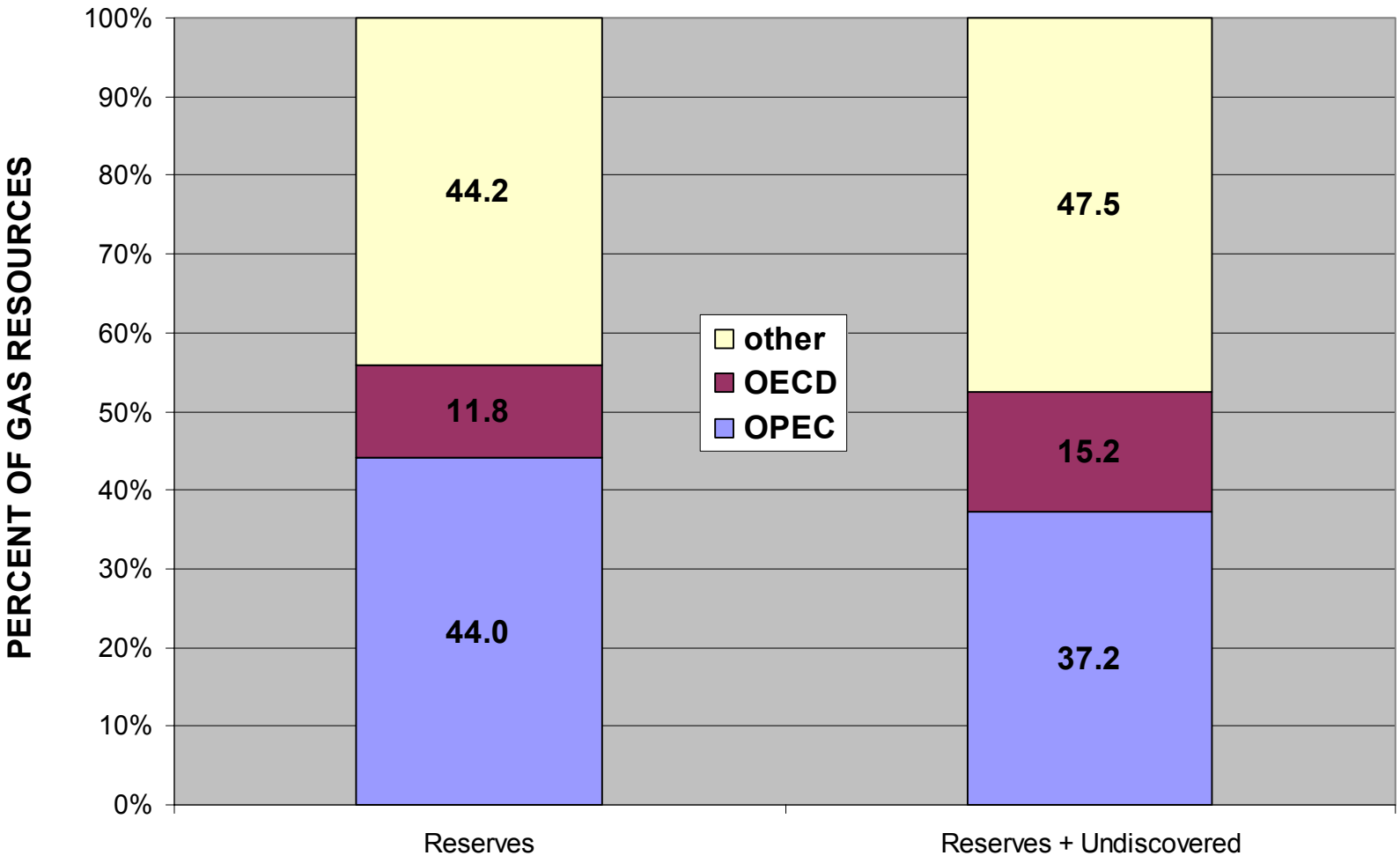
Distribution of Mean Undiscovered NGL by Organization



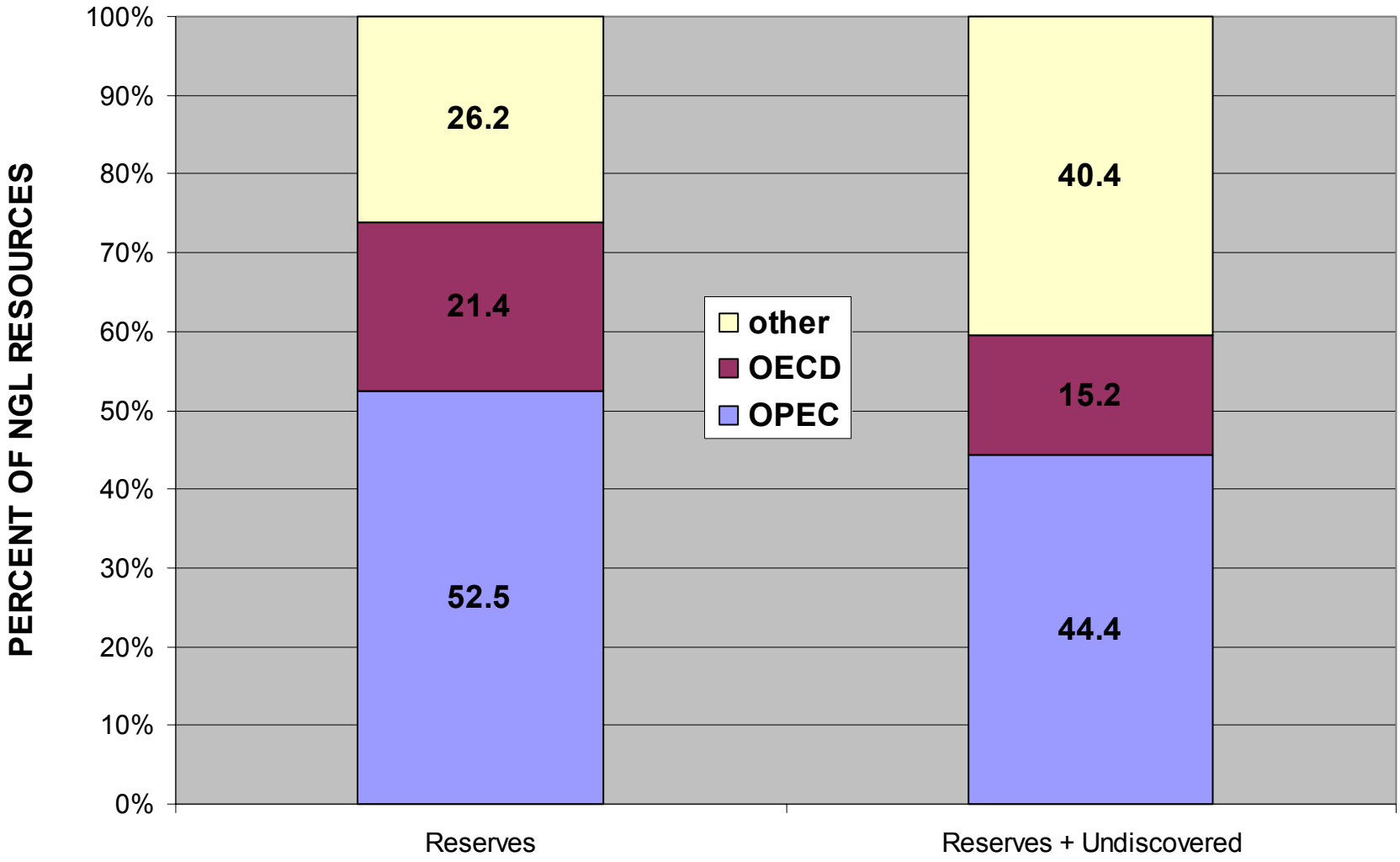
Possible Changes in Organization Share of Oil



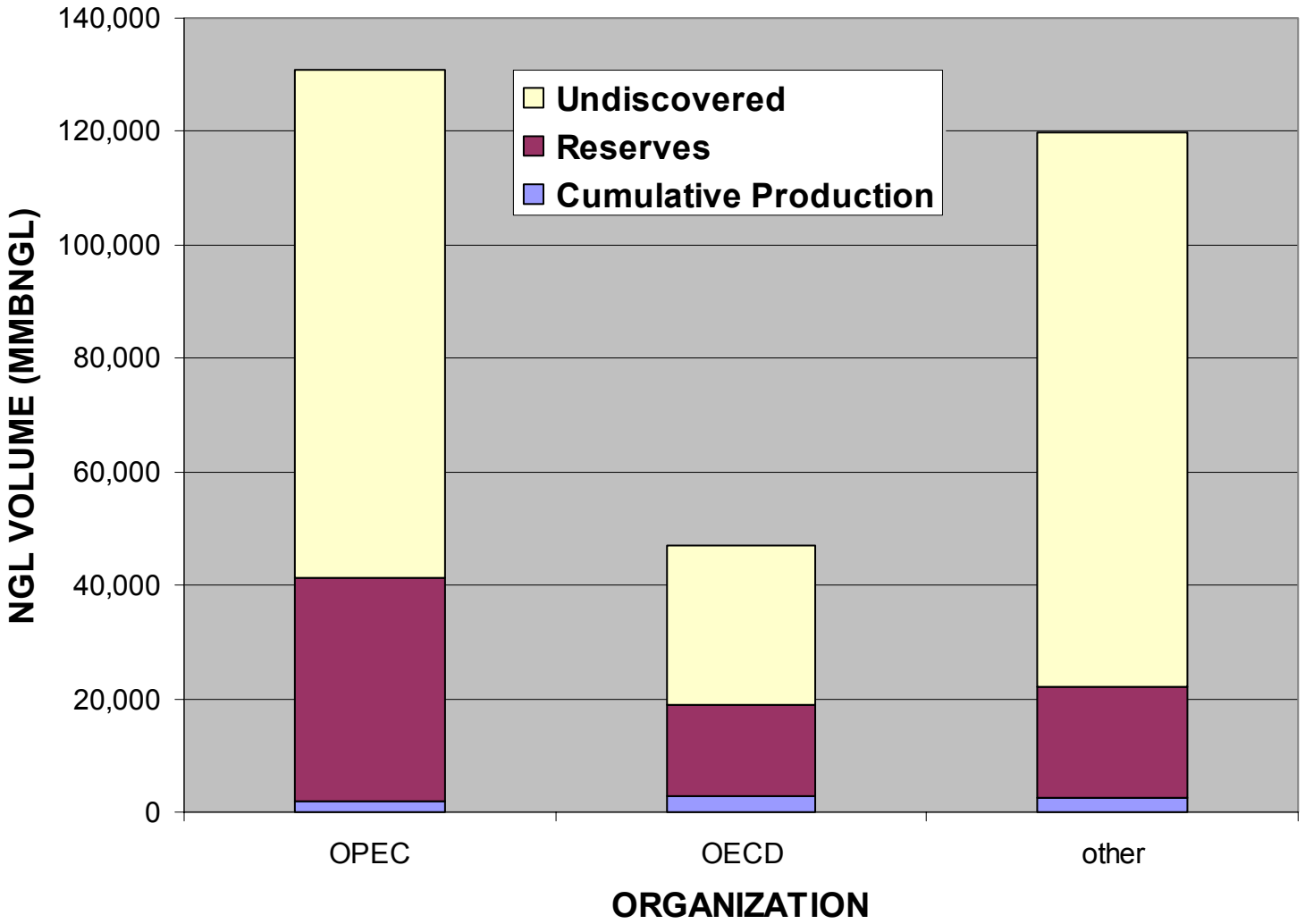
Possible Changes in Organization Share of Gas

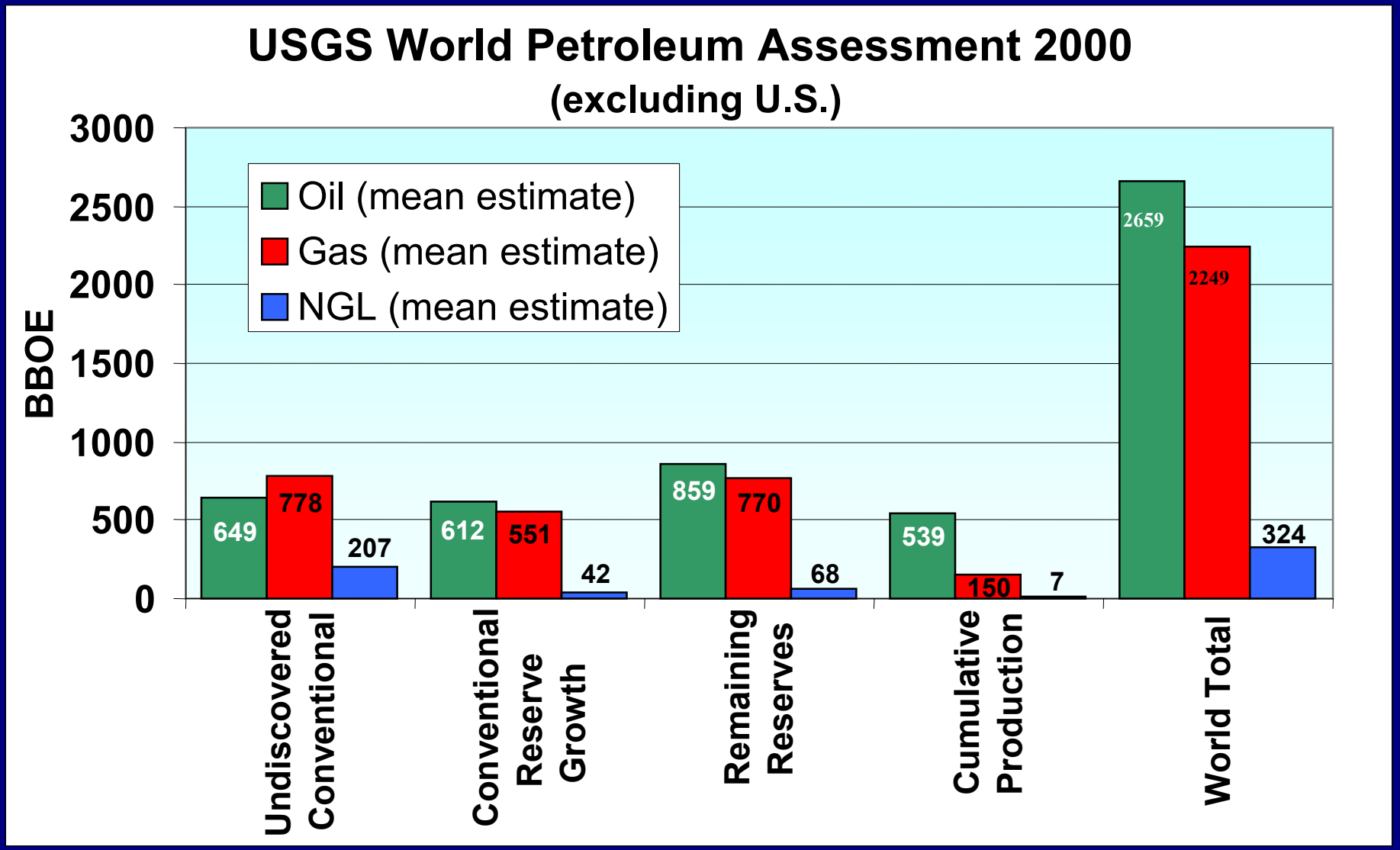


Possible Changes in Organization Share of NGL

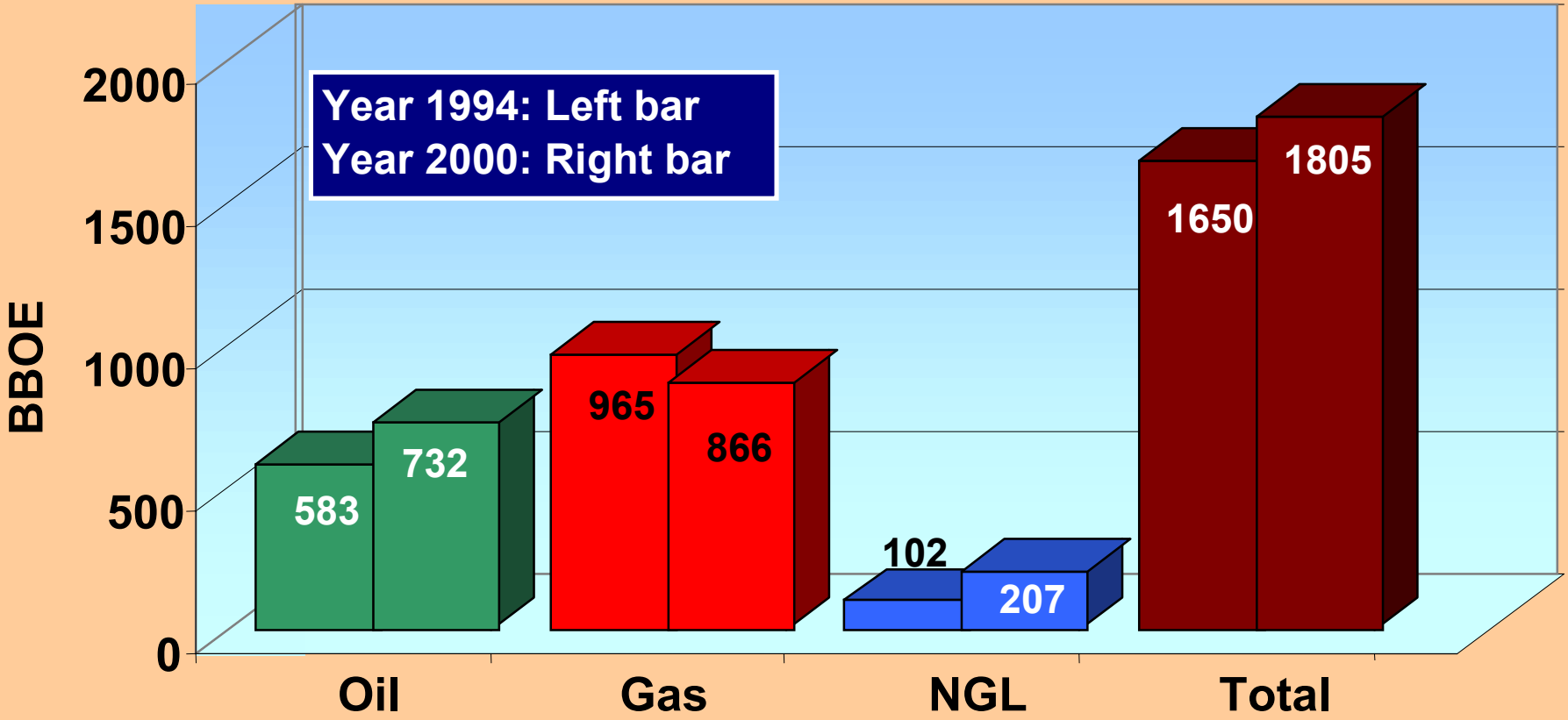


NGL Distribution by Organization

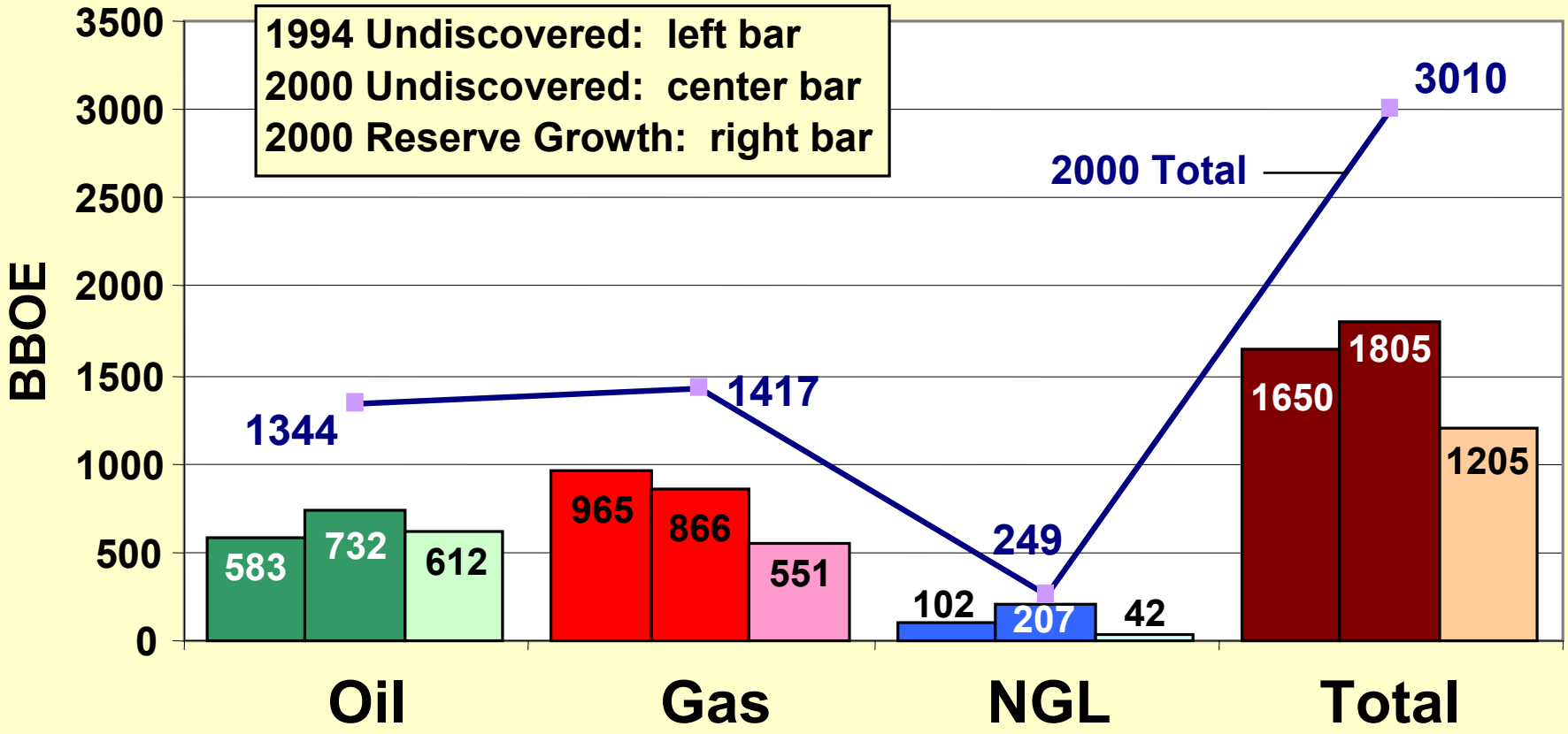


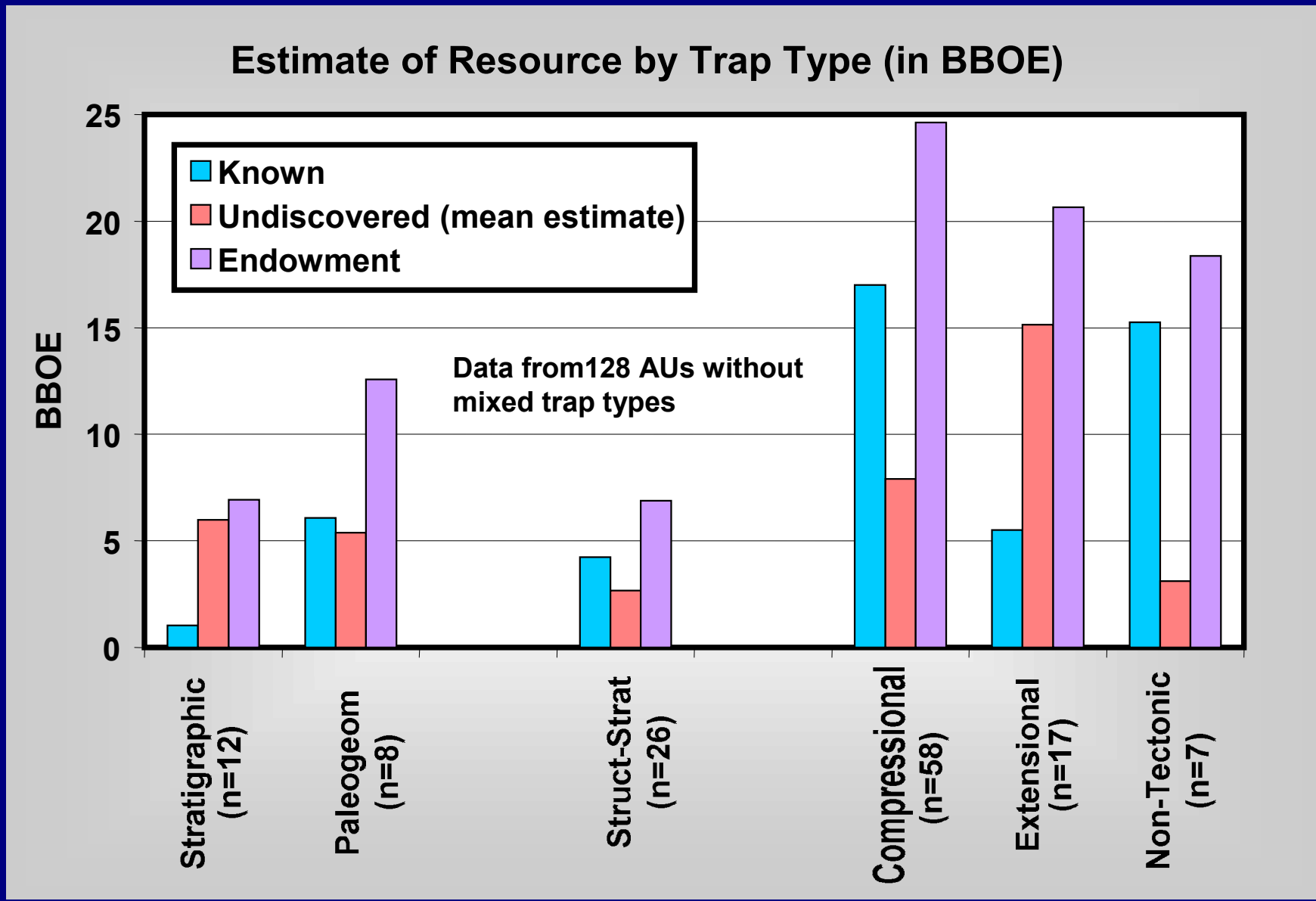

USGS World Petroleum Assessment 2000
(excluding U.S.)
BBOE
3000
2500
2000
1500
1000
500
0
Oil (mean estimate)
Gas (mean estimate)
NGL (mean estimate)
649
778
207
612
551
42
859
770
68
539
150
7
2659
2249
324
Undiscovered Conventional
Conventional Reserve Growth
Remaining Reserves
Cumulative Production
World Total

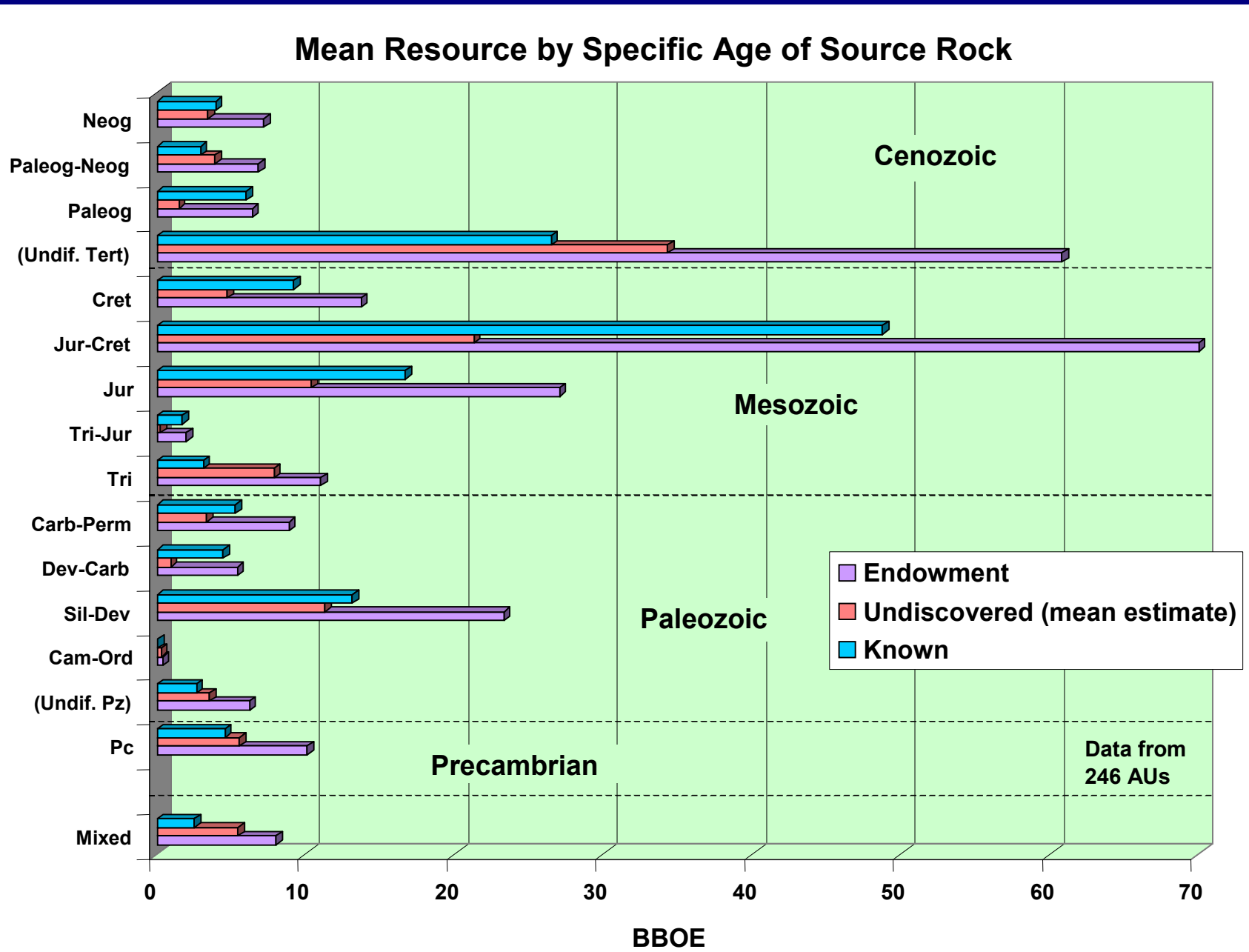
USGS World Petroleum Assessments 1994 and 2000 (including U.S.): Mean Estimates of Undiscovered, Recoverable Resource (in BBOE)

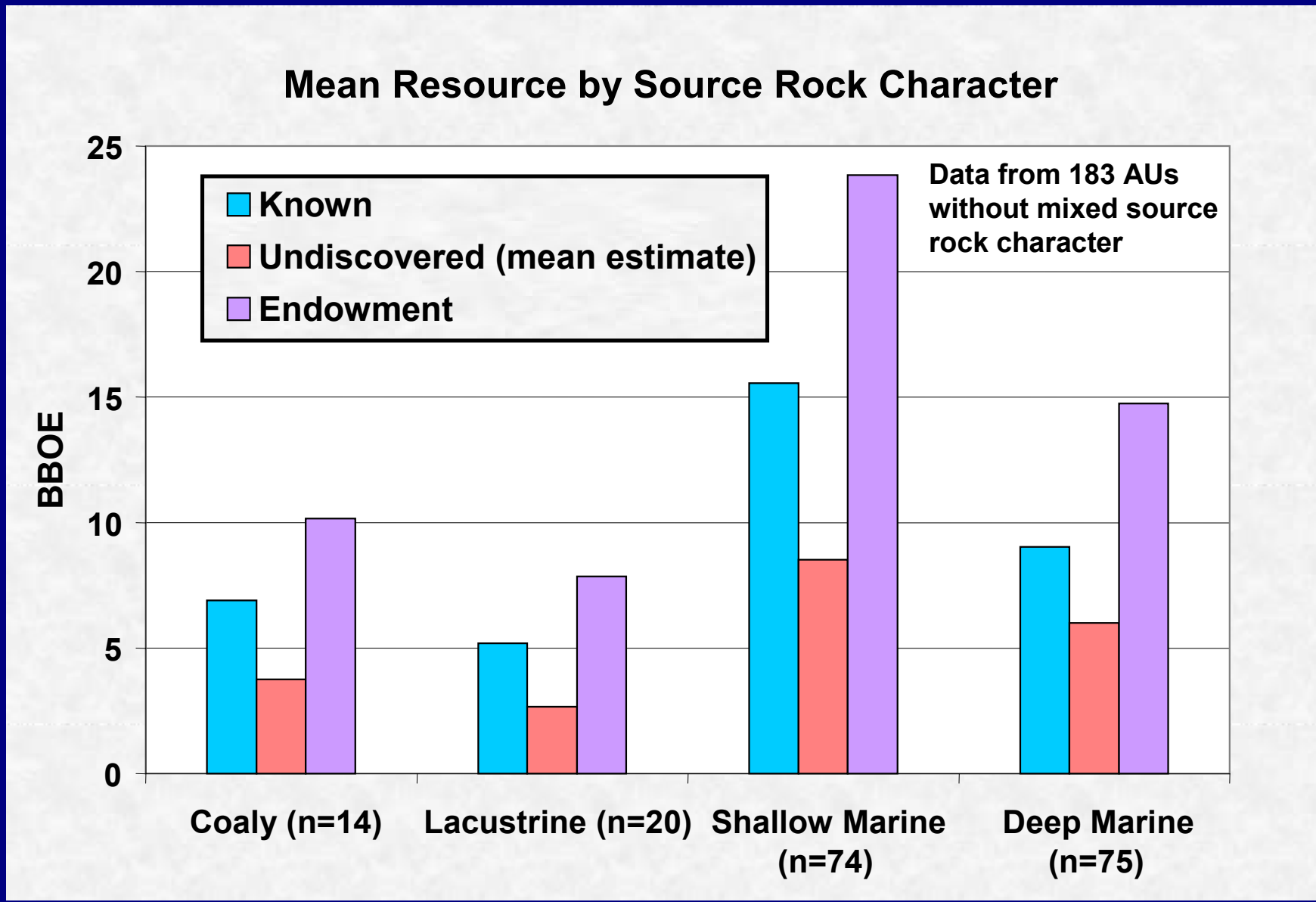


USGS World Petroleum Assessments 1994 and 2000 (including U.S.): Mean Estimates of Future Petroleum Resources (in BBOE)



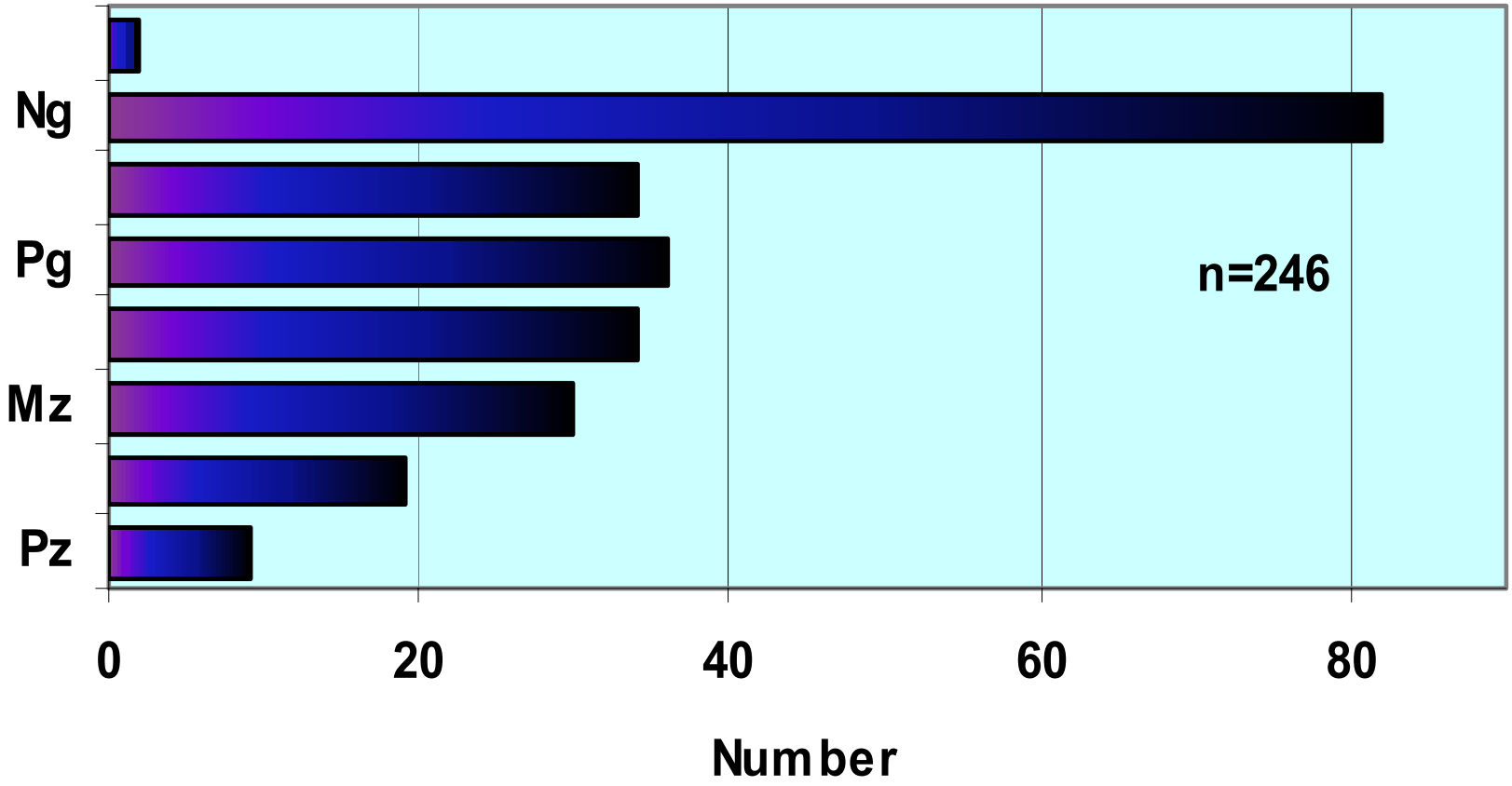

Estimate of Resource by Trap Type (in BBOE)
BBOE
25
20
15
10
5
0
Known
Undiscovered (mean estimate)
Endowment
Data from128 AUs without mixed trap types
Stratigraphic (n=12)
Paleogeom (n=8)
Struct-Strat (n=26)
Compressional (n=58)
Extensional (n=17)
Non-Tectonic (n=7)


Mean Resource by Specific Age of Source Rock
Neog
Paleog-Neog
Paleog
(Undif. Tert)
Cret
Jur-Cret
Jur
Tri-Jur
Tri
Carb-Perm
Dev-Carb
Sil-Dev
Cam-Ord
(Undif. Pz)
Pc
Mixed
Cenozoic
Mesozoic
Paleozoic
Precambrian
Endowment
Undiscovered (mean estimate)
Known
Data from
246 AUs
0
10
20
30
40
50
60
70
BBOE

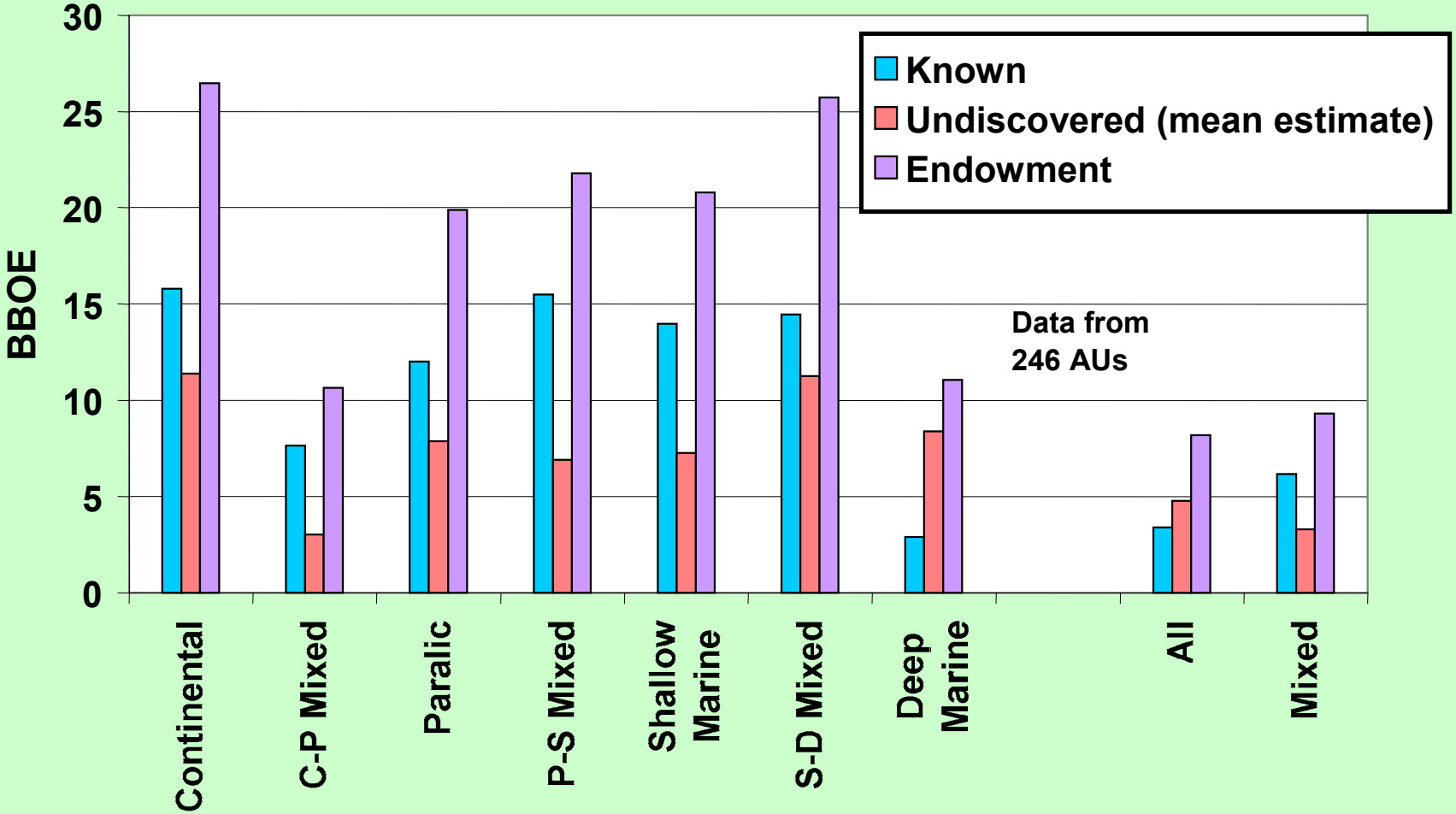

Mean Resource by Source Rock Character
25
20
15
10
5
0
BBOE
Known
Undiscovered (mean estimate)
Endowment
Data from 183 AUs without mixed source rock character
Coaly (n=14)
Lacustrine (n=20)
Shallow Marine (n=74)
Deep Marine (n=75)

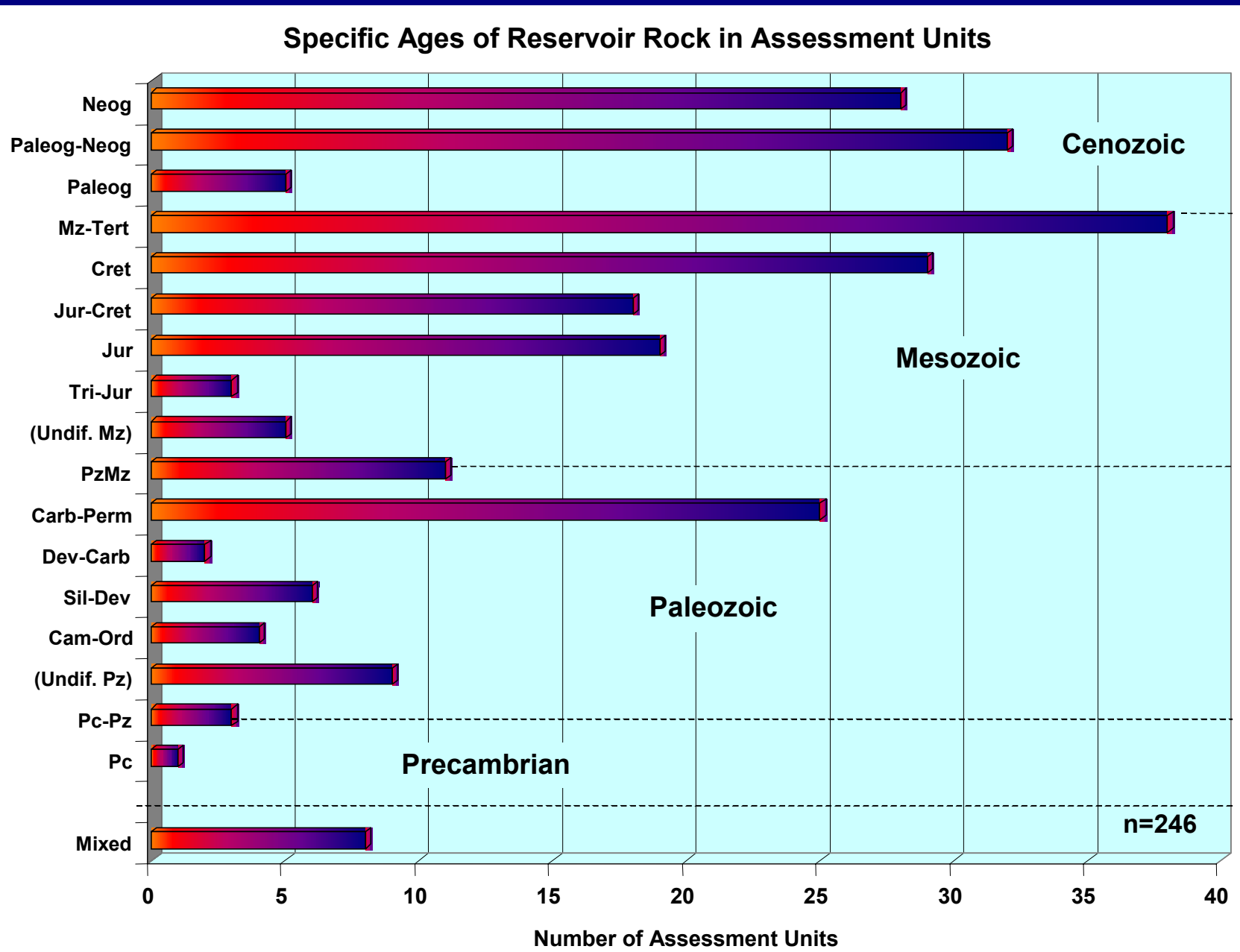
USGS World Petroleum Assessment 2000

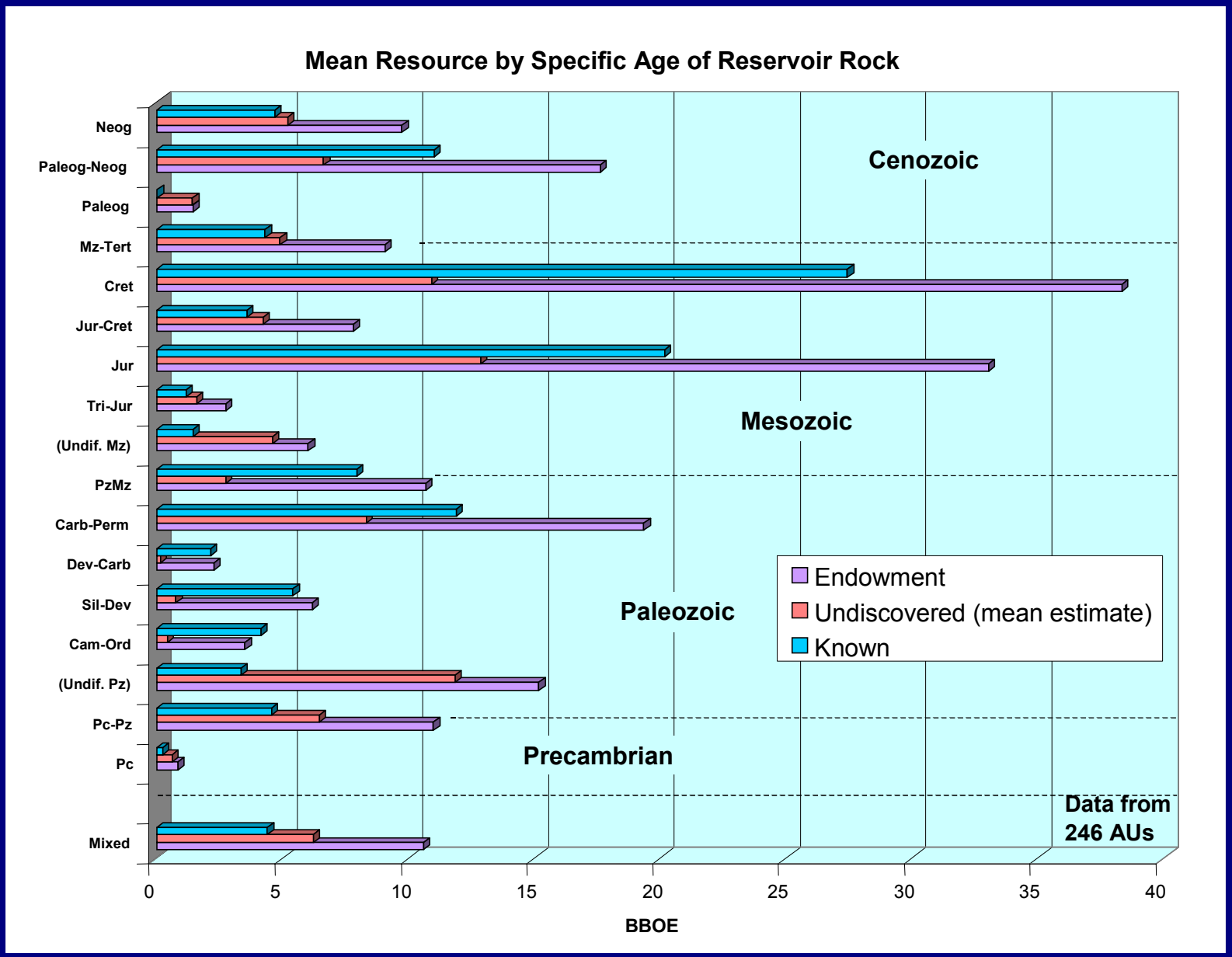
AU Peak Maturation Time

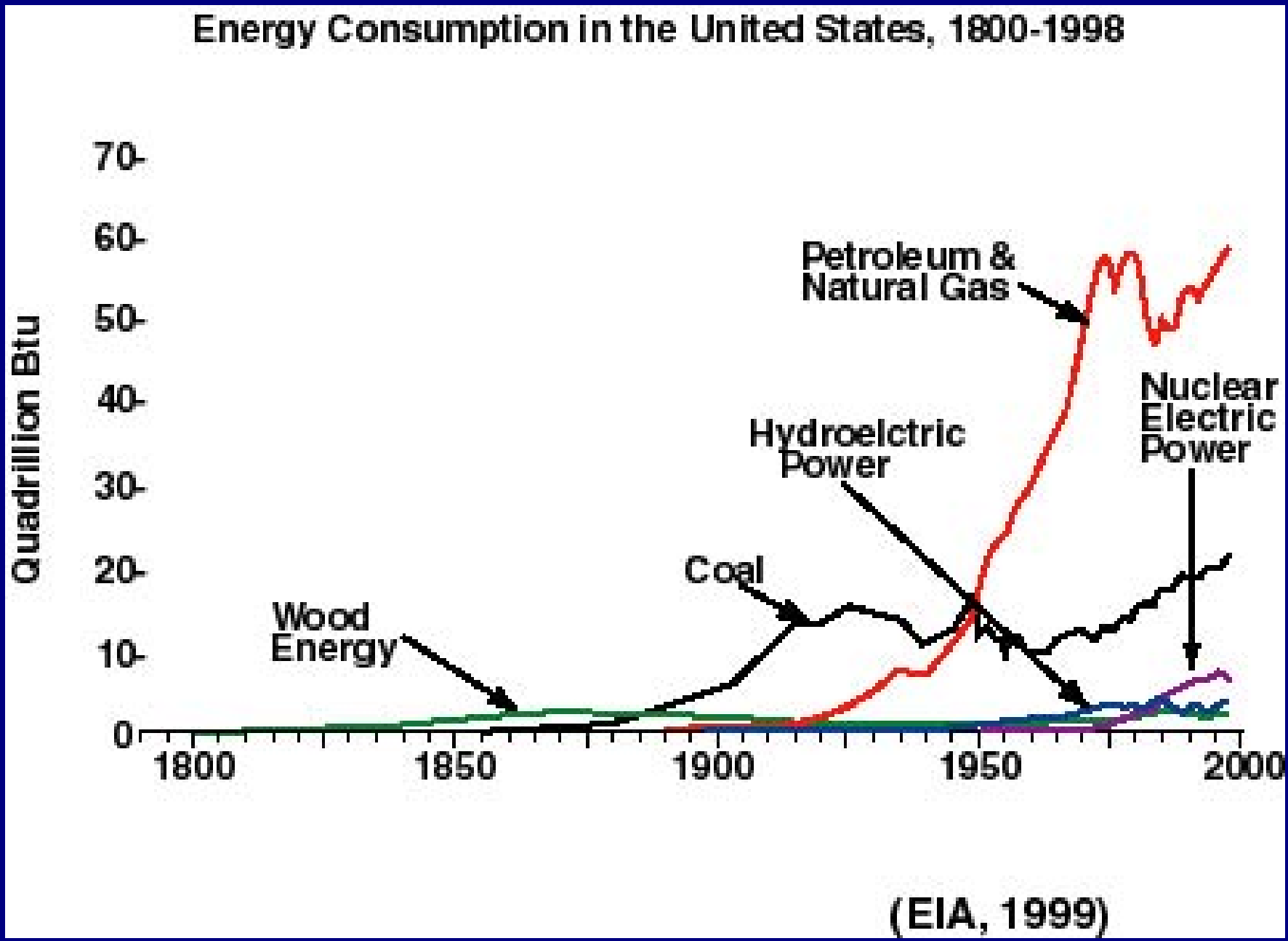


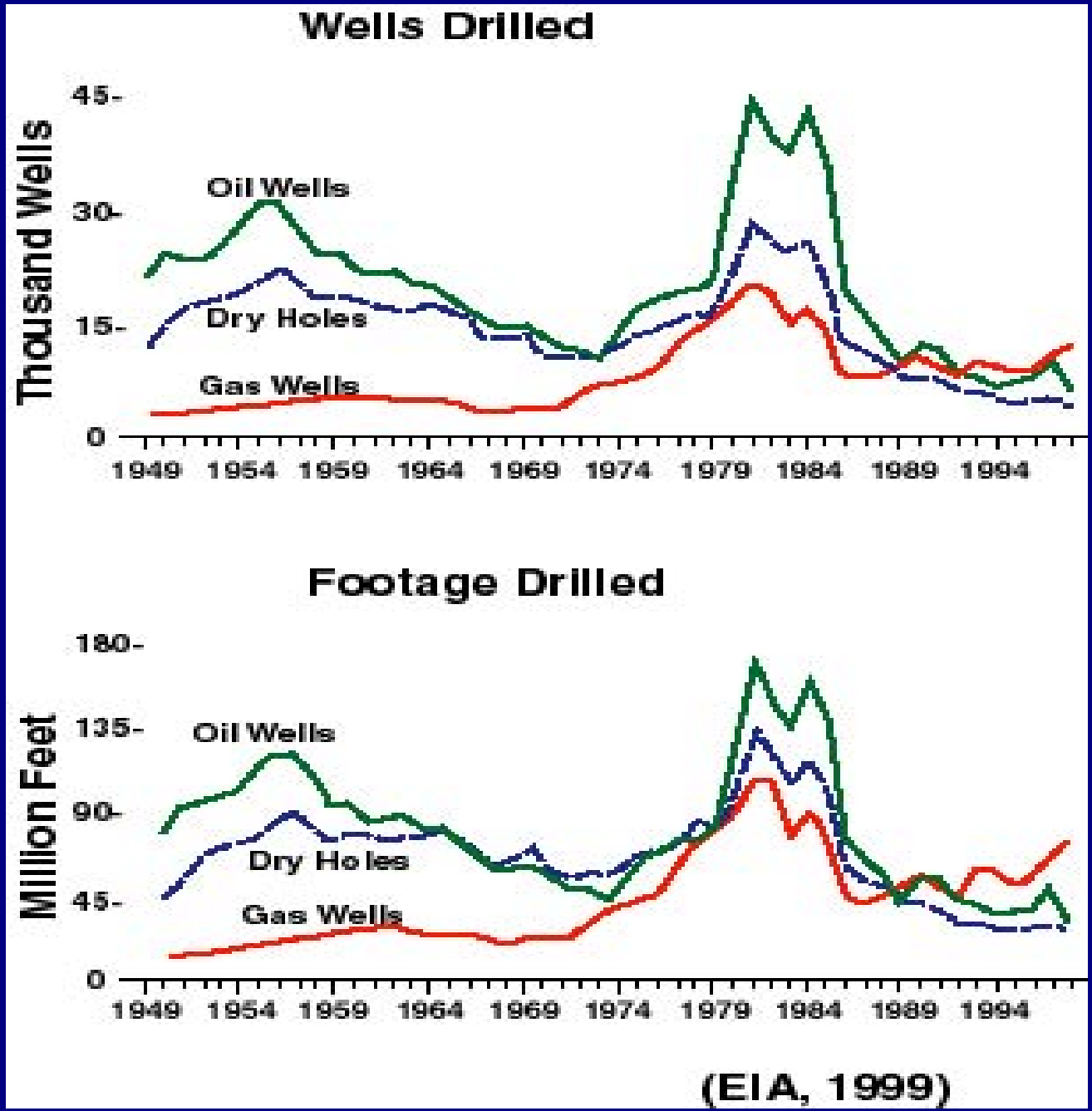
Mean Resource by Depositional Environment of Reservoir Rock



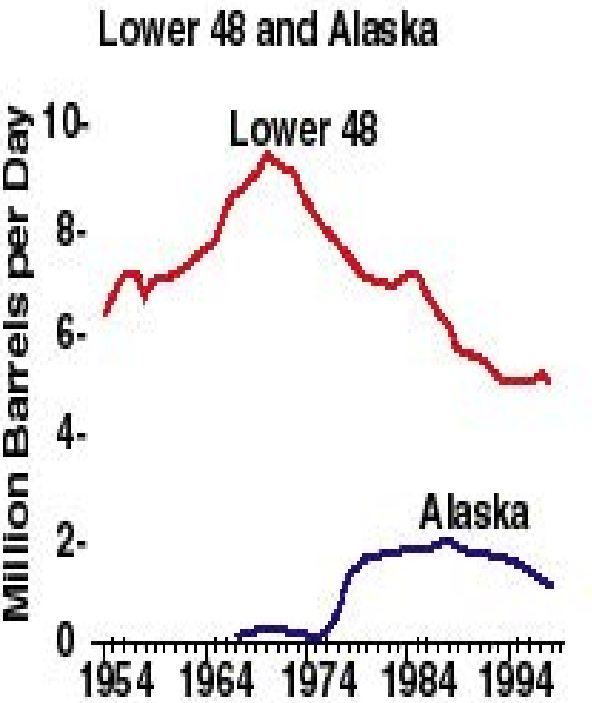

Specific Ages of Reservoir Rock in Assessment Units
Neog
Paleog-Neog
Paleog
Mz-Tert
Cret
Jur-Cret
Jur
Tri-Jur
(Undif. Mz)
PzMz
Carb-Perm
Dev-Carb
Sil-Dev
Cam-Ord
(Undif. Pz)
Pc-Pz
Pc
Mixed
Cenozoic
Mesozoic
Paleozoic
Precambrian
n=246
0
5
10
15
20
25
30
35
40
Number of Assessment Units

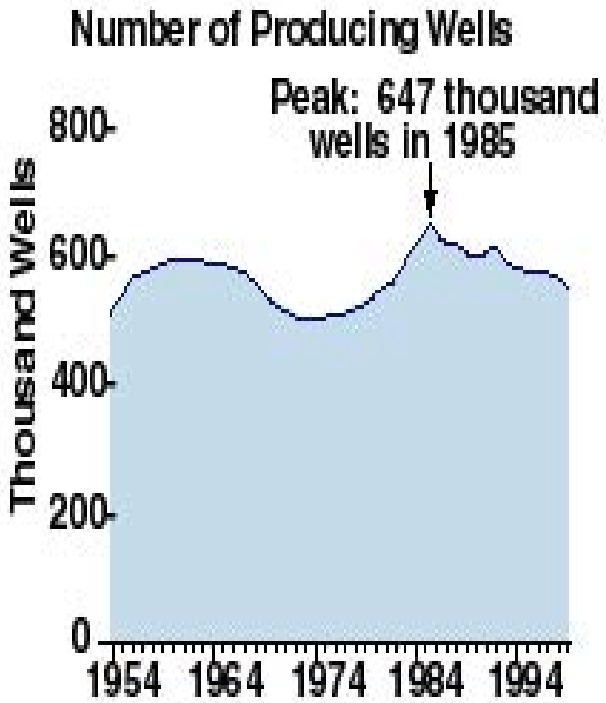

Mean Resource by Specific Age of Reservoir Rock
Neog
Paleog-Neog
Paleog
Mz-Tert
Cret
Jur-Cret
Jur
Tri-Jur
(Undif. Mz)
PzMz
Carb-Perm
Dev-Carb
Sil-Dev
Cam-Ord
(Undif. Pz)
Pc-Pz
Pc
Mixed
Cenozoic
Mesozoic
Paleozoic
Precambrian
Endowment
Undiscovered (mean estimate)
Known
Data from
246 AUs
0
5
10
15
20
25
30
35
40
BBOE

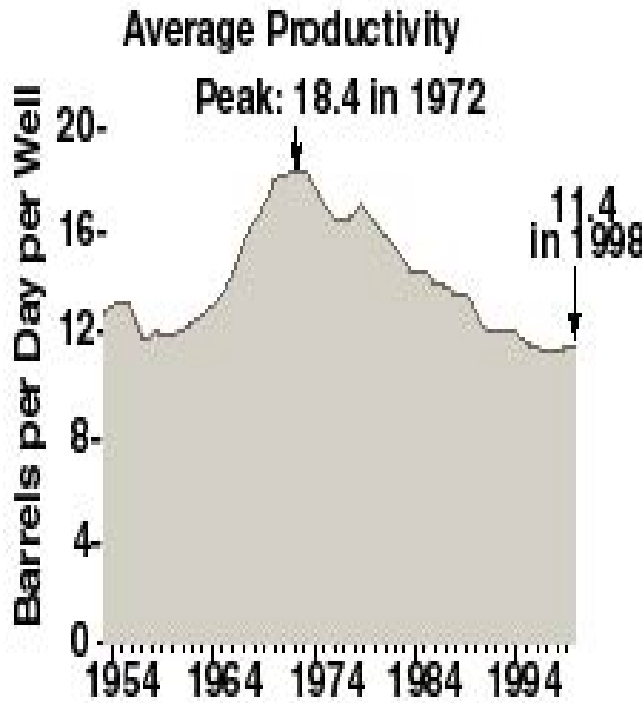

Energy Consumption in the United States, 1800-1998
Quadrillion Btu
70
60
50
40
30
20
10
0
1800
1850
1900
1950
2000
Petroleum & Natural Gas
Nuclear Electric Power
Hydroelctric Power
Coal
Wood Energy
(EIA, 1999)


Wells Drilled
Thousand Wells
45-
30-
15-
0
Oil Wells
Dry Holes
Gas Wells
1949 1954 1959 1964 1969 1974 1979 1984 1989 1994
Footage Drilled
Million Feet
180-
135-
90-
45-
0
Oil Wells
Dry Holes
Gas Wells
1949 1954 1959 1964 1969 1974 1979 1984 1989 1994
(EIA, 1999)

U.S. Oil Production

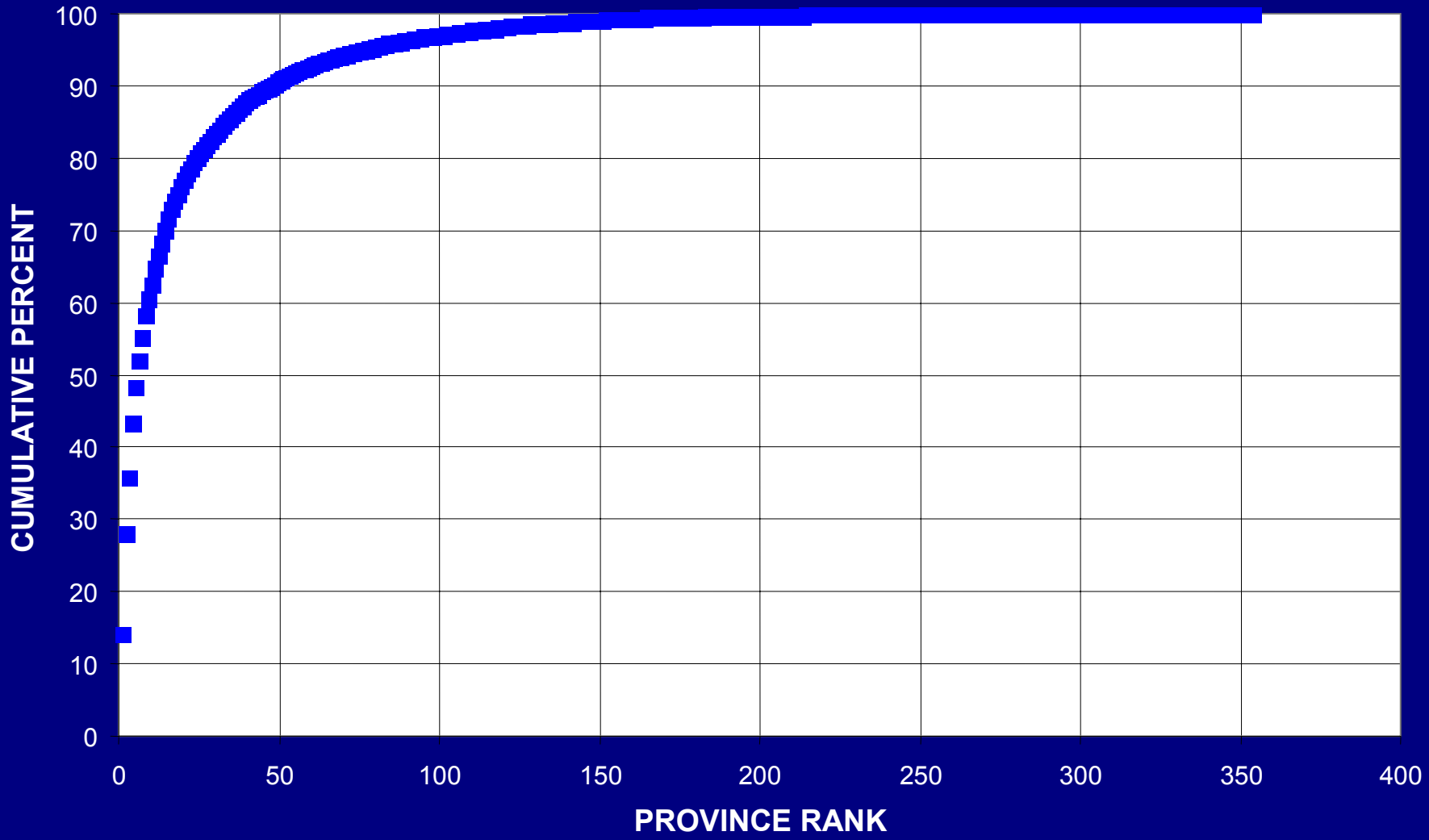






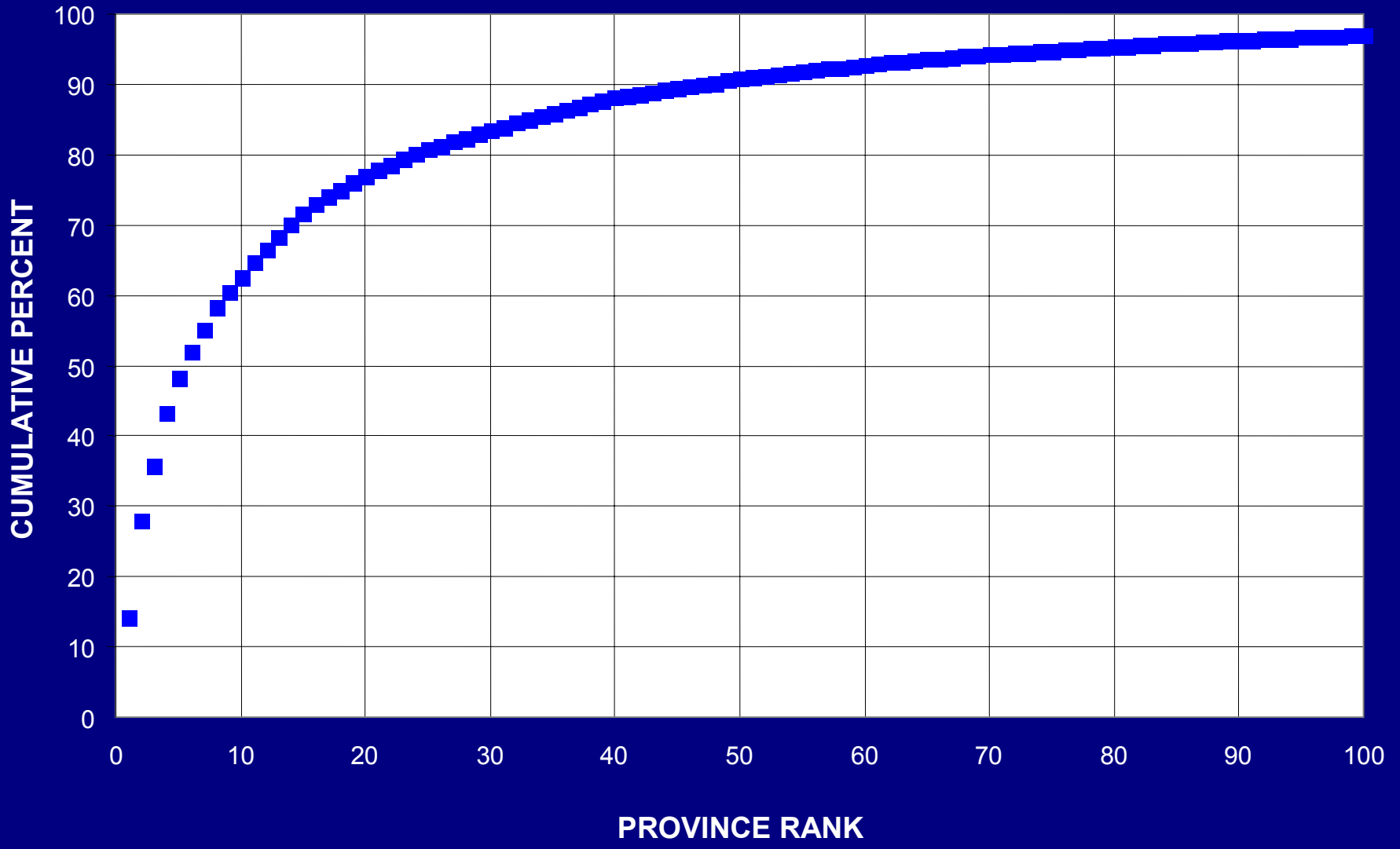
(EIA, 1999)

Cumulative Percent of World Known Petroleum Volume by Ranked Oil and Gas Provinces (Exclusive of the U.S.)



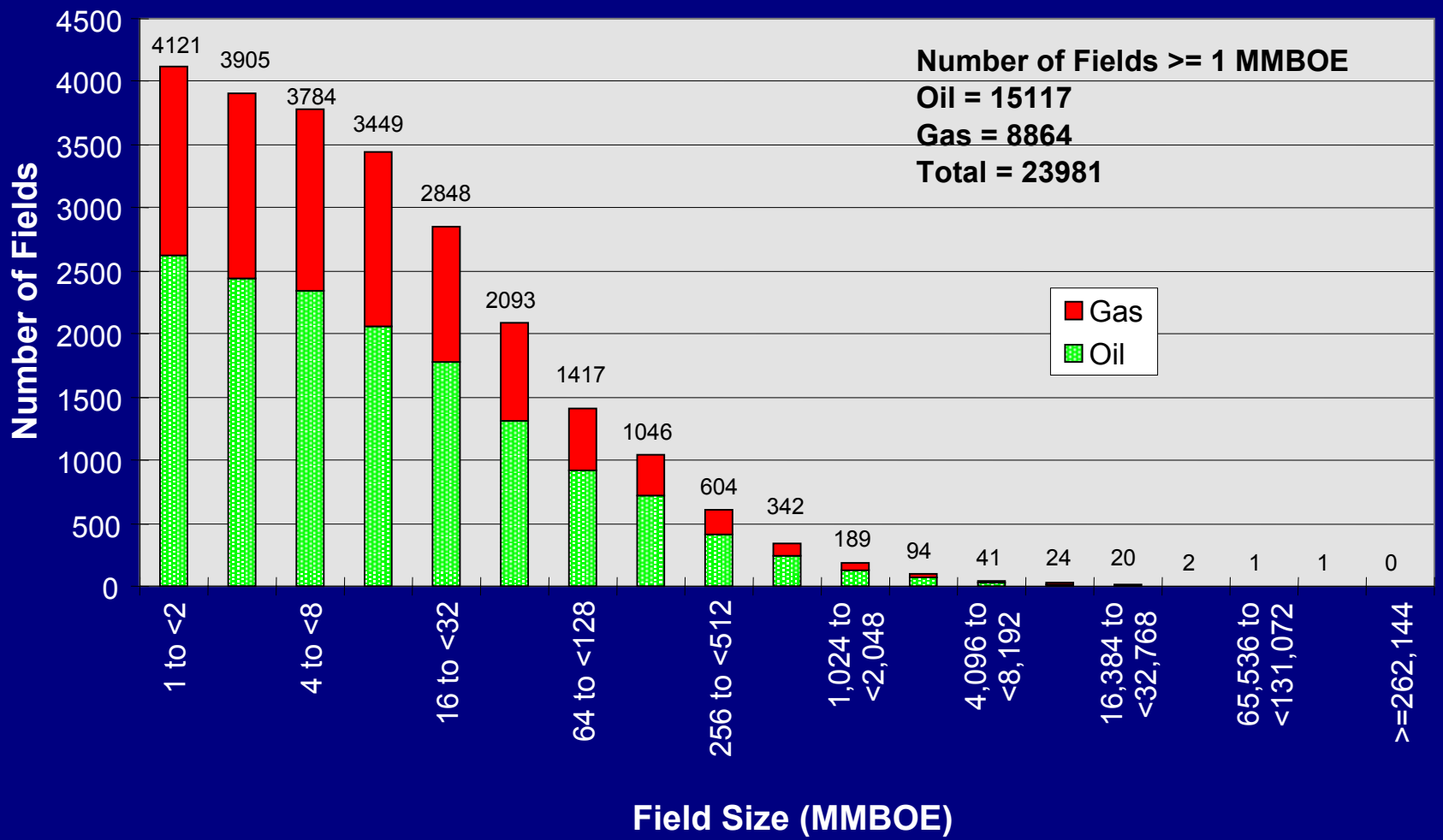
USGS

Cumulative Percent of World Known Petroleum Volume by Ranked Oil and Gas Provinces (Exclusive of the U.S.)



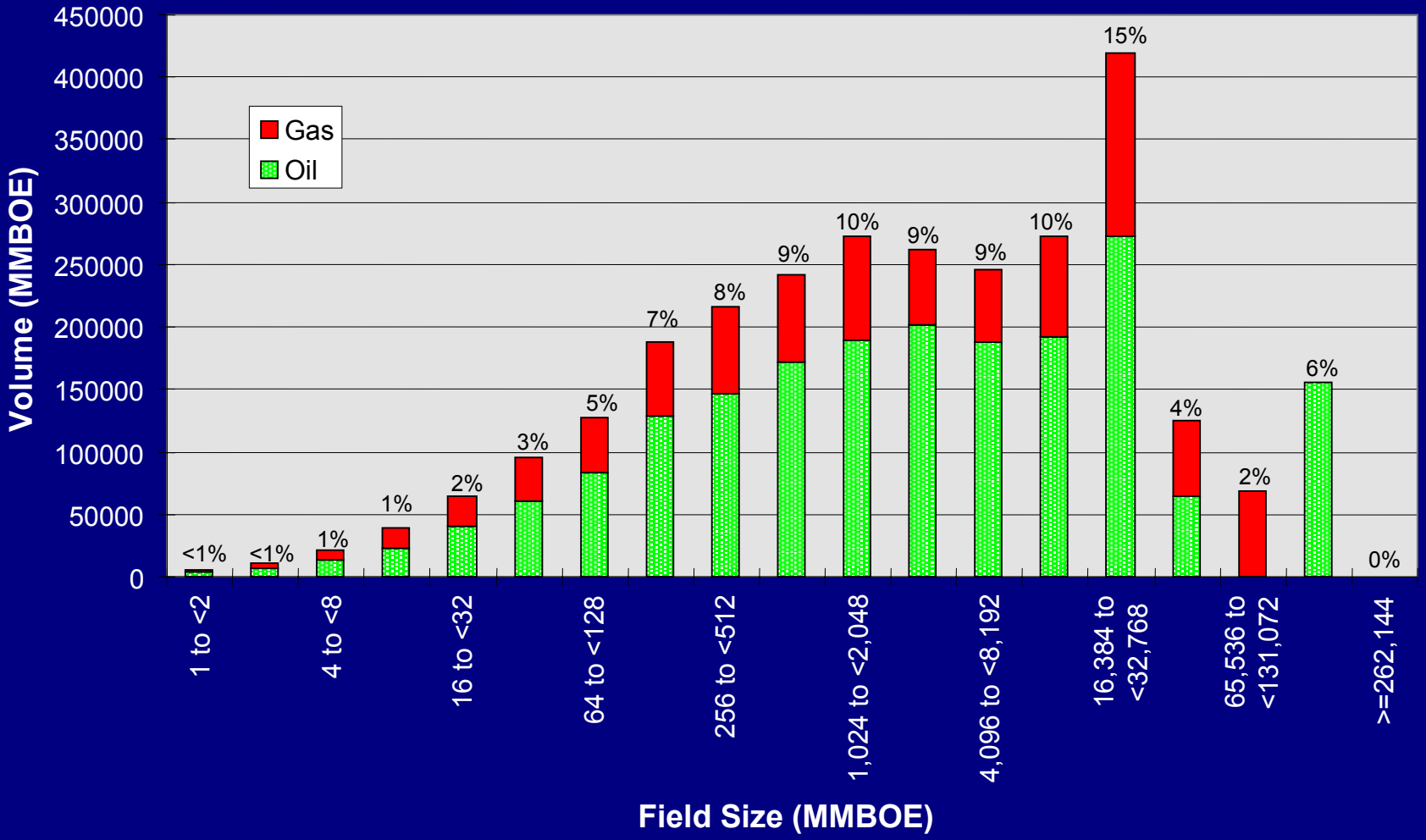
USGS

Number of Fields Per Size Class
The World



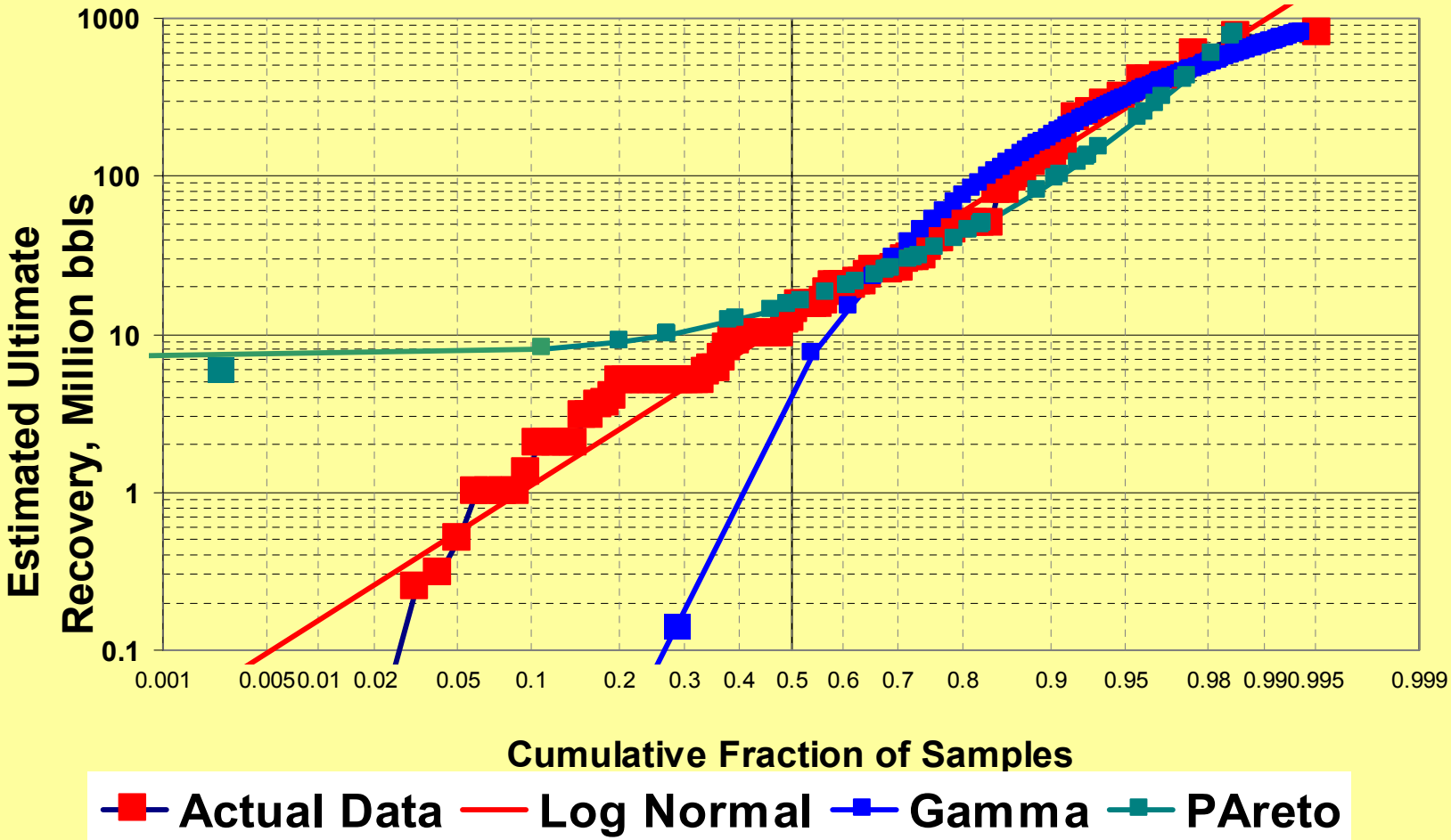
USGS

Known Volume Per Size Class
The World

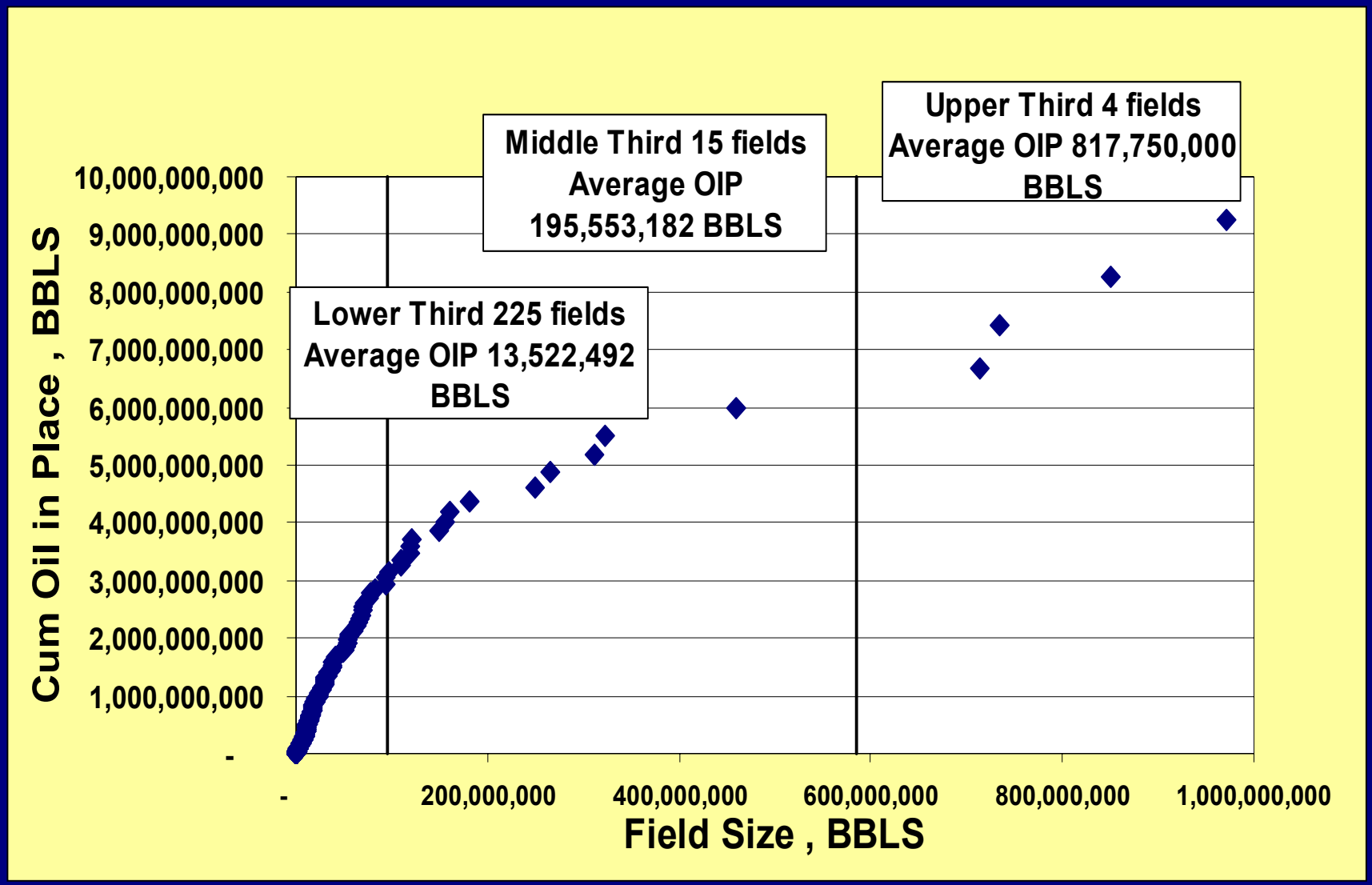


Trias-Ghadames

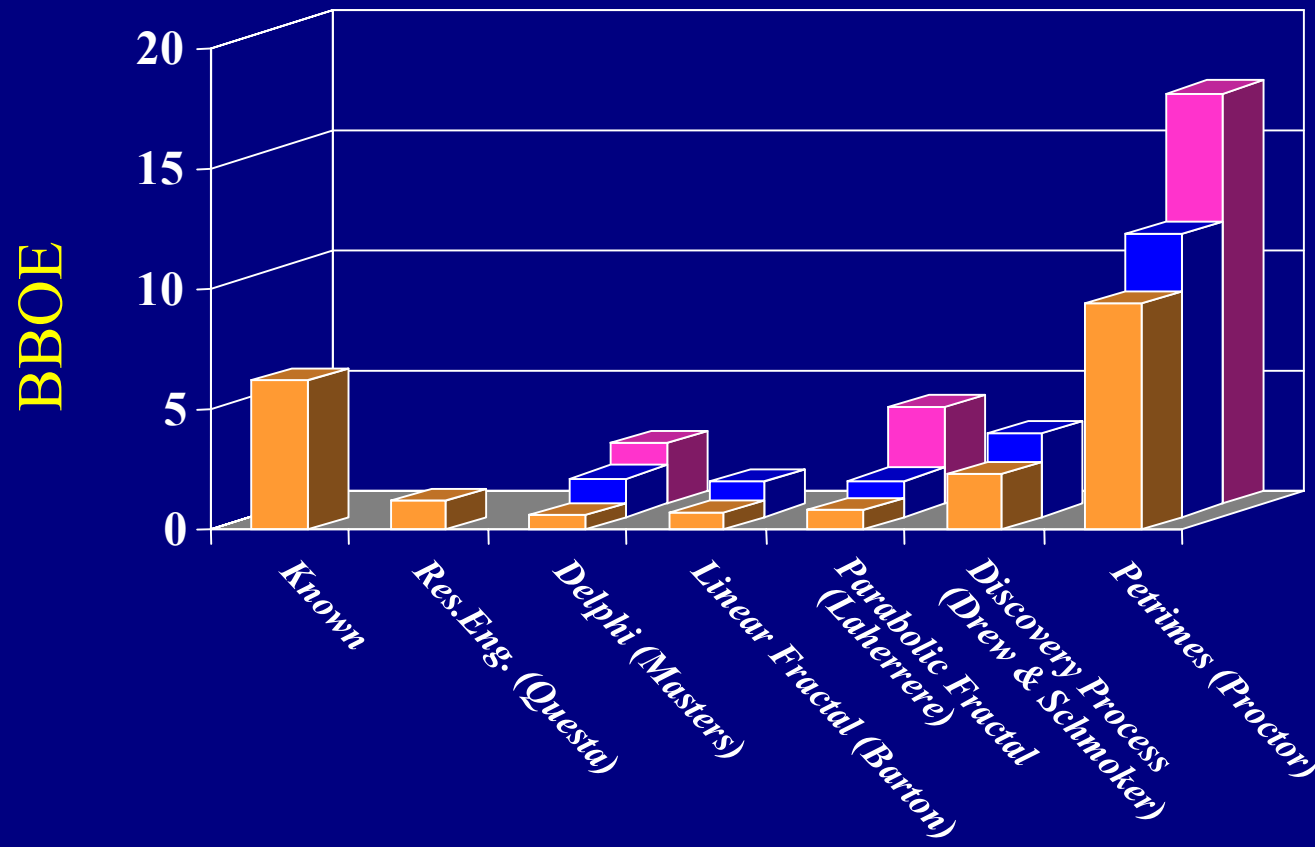
Best Fits with various Distributions



Neuquen Basin--Oil in Place



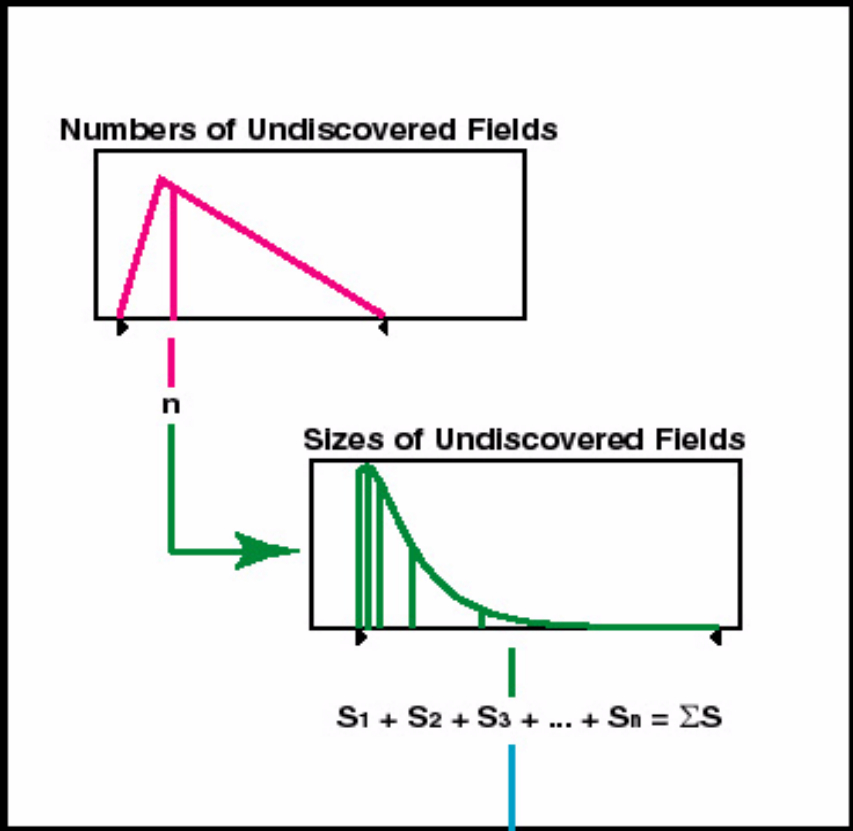
Neuquen Basin, Argentina
Comparison of Resource Estimates



Assessment Comparison 209 Fields>1 MBOE, 1,041 Wells, Petroconsultants, 1996, Rank 61st in World

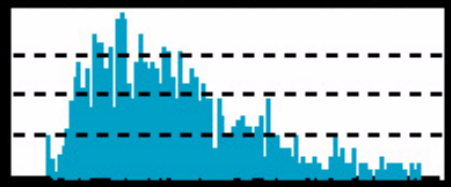
USGS

Monte Carlo Simulation for the Assessment of Undiscovered Resources



Repeat 50,000 Times

Forecast: Undiscovered Resource

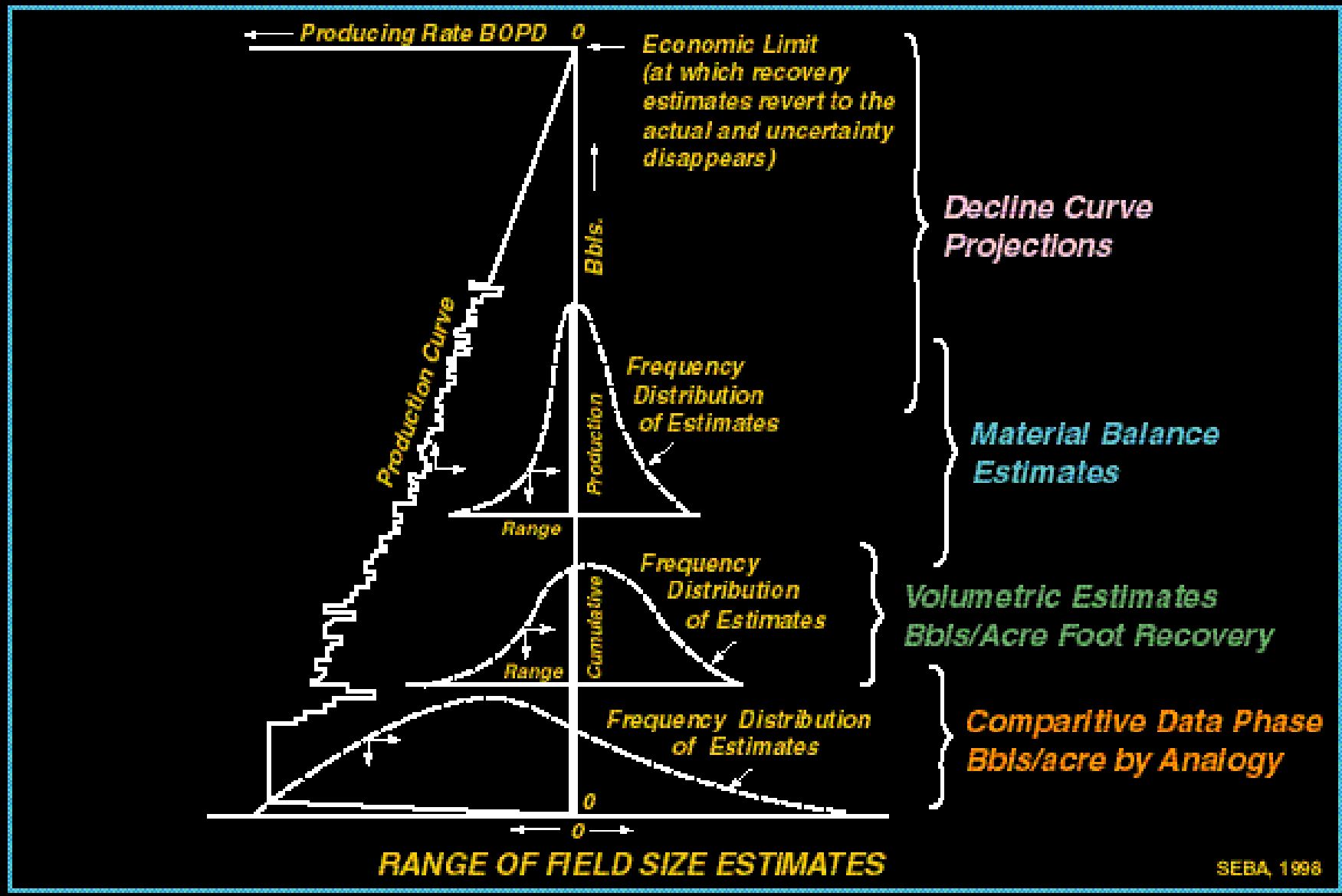


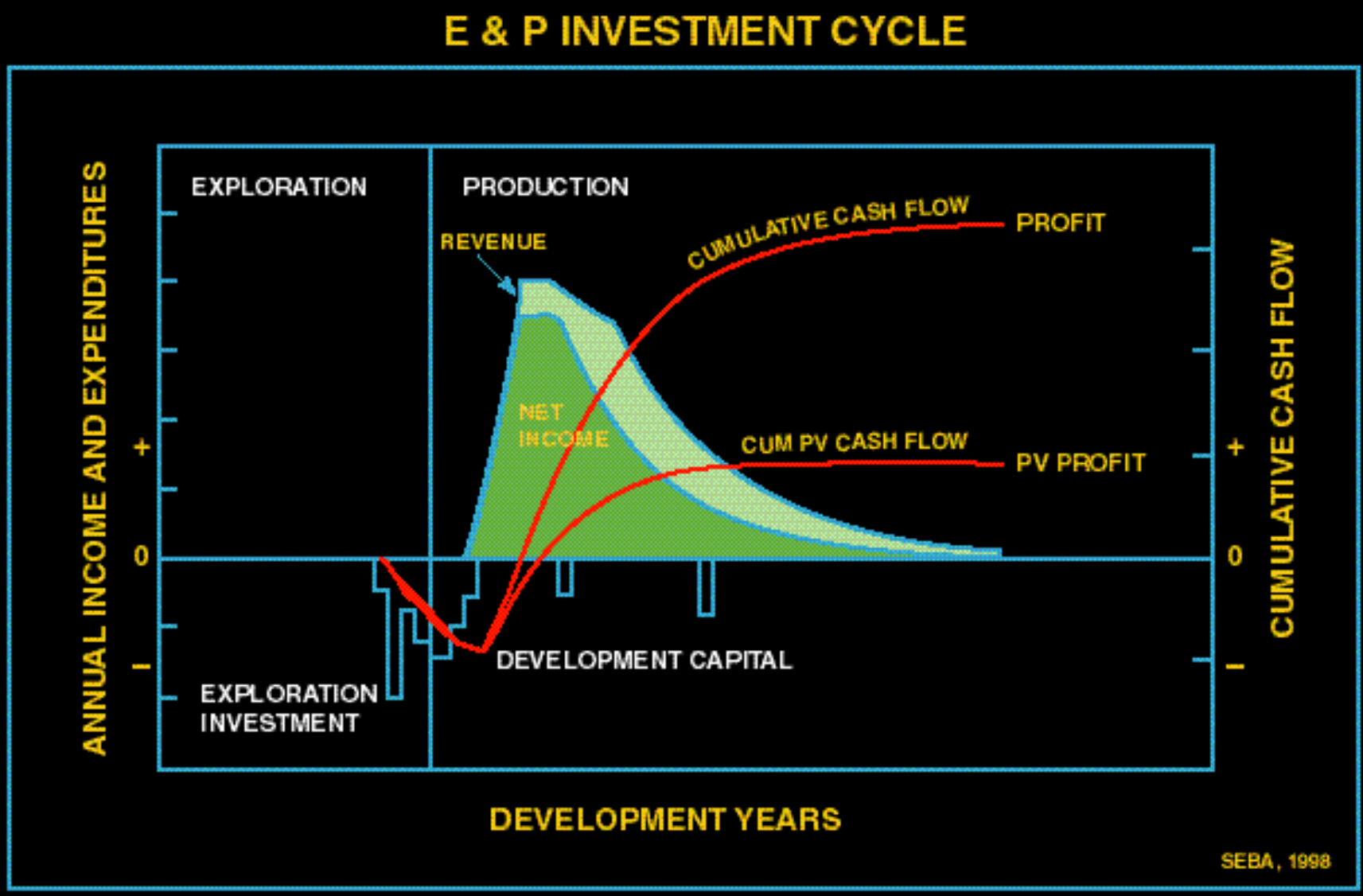
Production Profiles Probability vs. Functions

BEWARE:

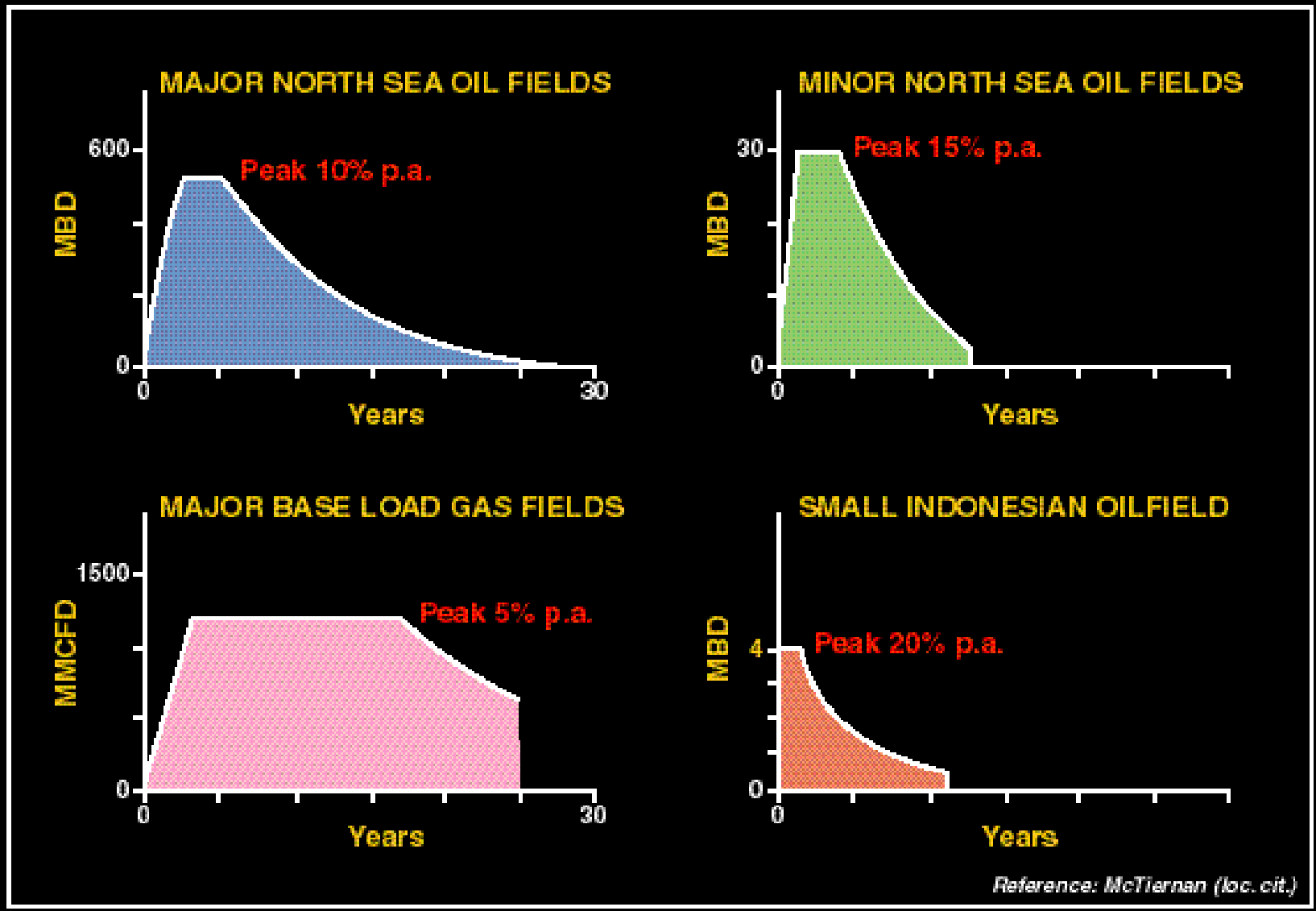
- We are NOT aggregating probability distributions (Central Limit Theorem)
- We ARE summing mathematical functions
- Production = f (time)
- Initially skewed distributions retain their skewness at successively higher aggregations

PROGRESSIVE REDUCTION IN UNCERTAINTY
CENTRAL LIMIT THEORUM

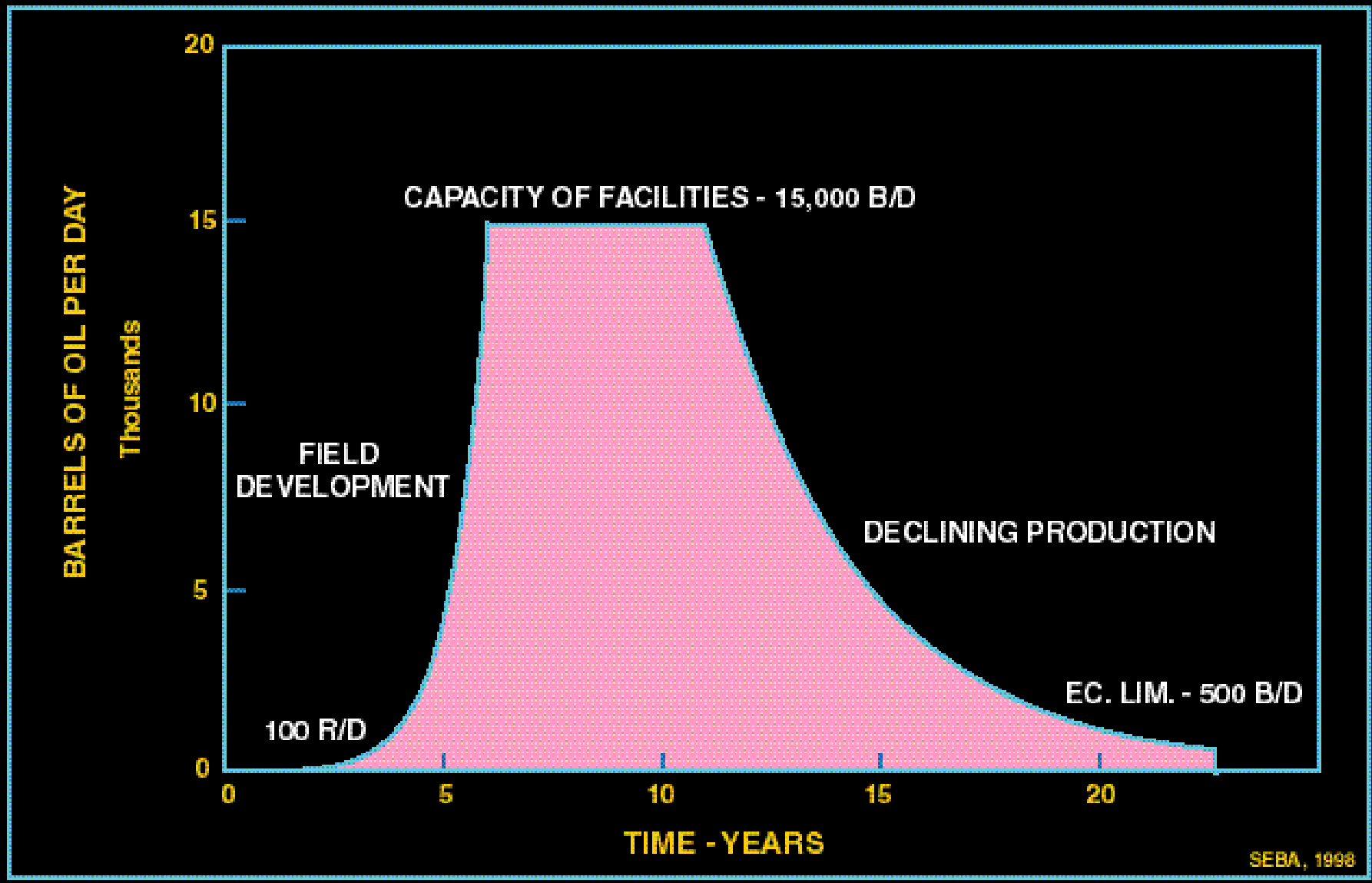


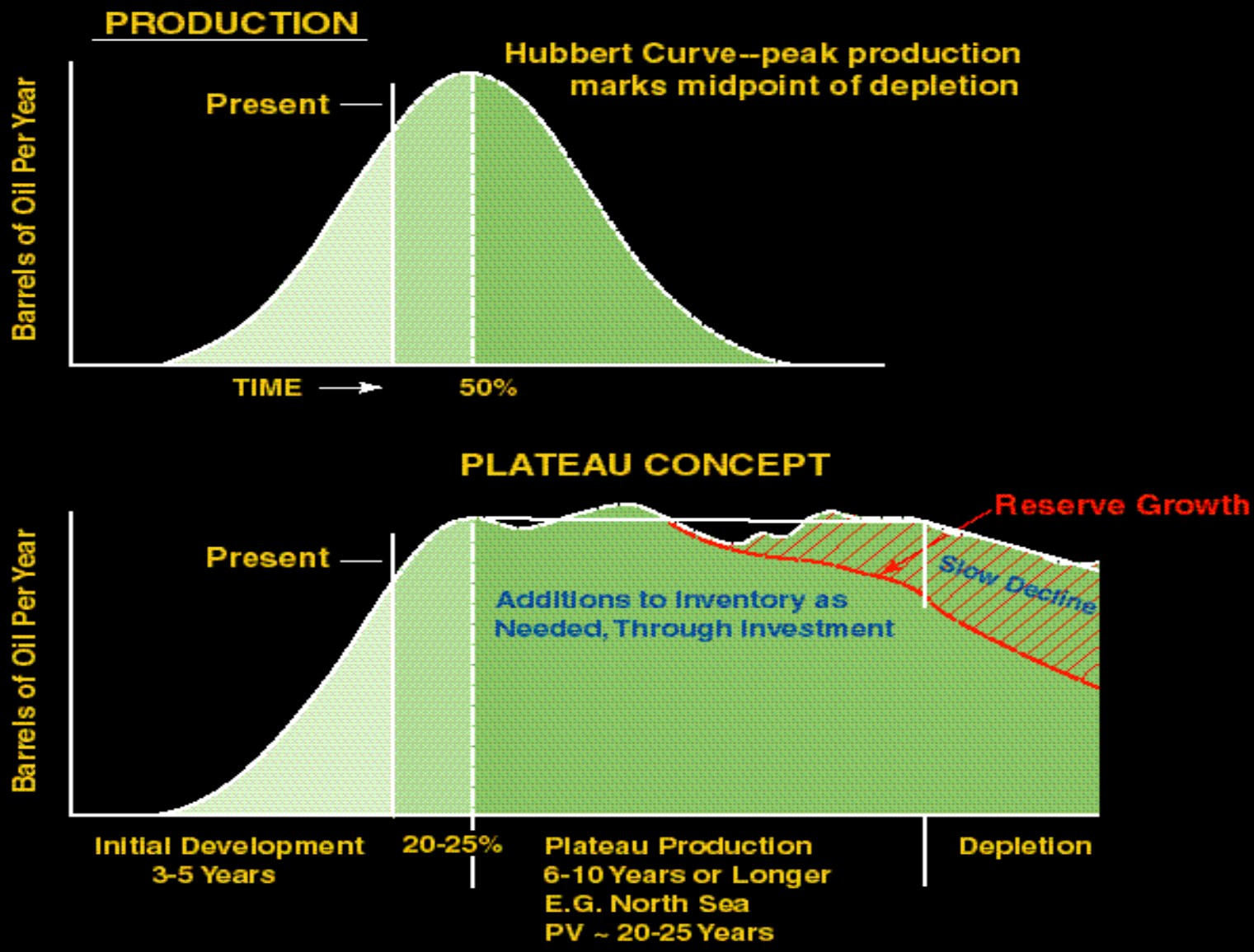

E & P INVESTMENT CYCLE
EXPLORATION
PRODUCTION
REVENUE
CUMULATIVE CASH FLOW
PROFIT
NET INCOME
CUM PV CASH FLOW
PV PROFIT
DEVELOPMENT CAPITAL
EXPLORATION INVESTMENT
ANNUAL INCOME AND EXPENDITURES
CUMULATIVE CASH FLOW
+
0
-
DEVELOPMENT YEARS
SEBA, 1998

PRODUCTION PROFILES

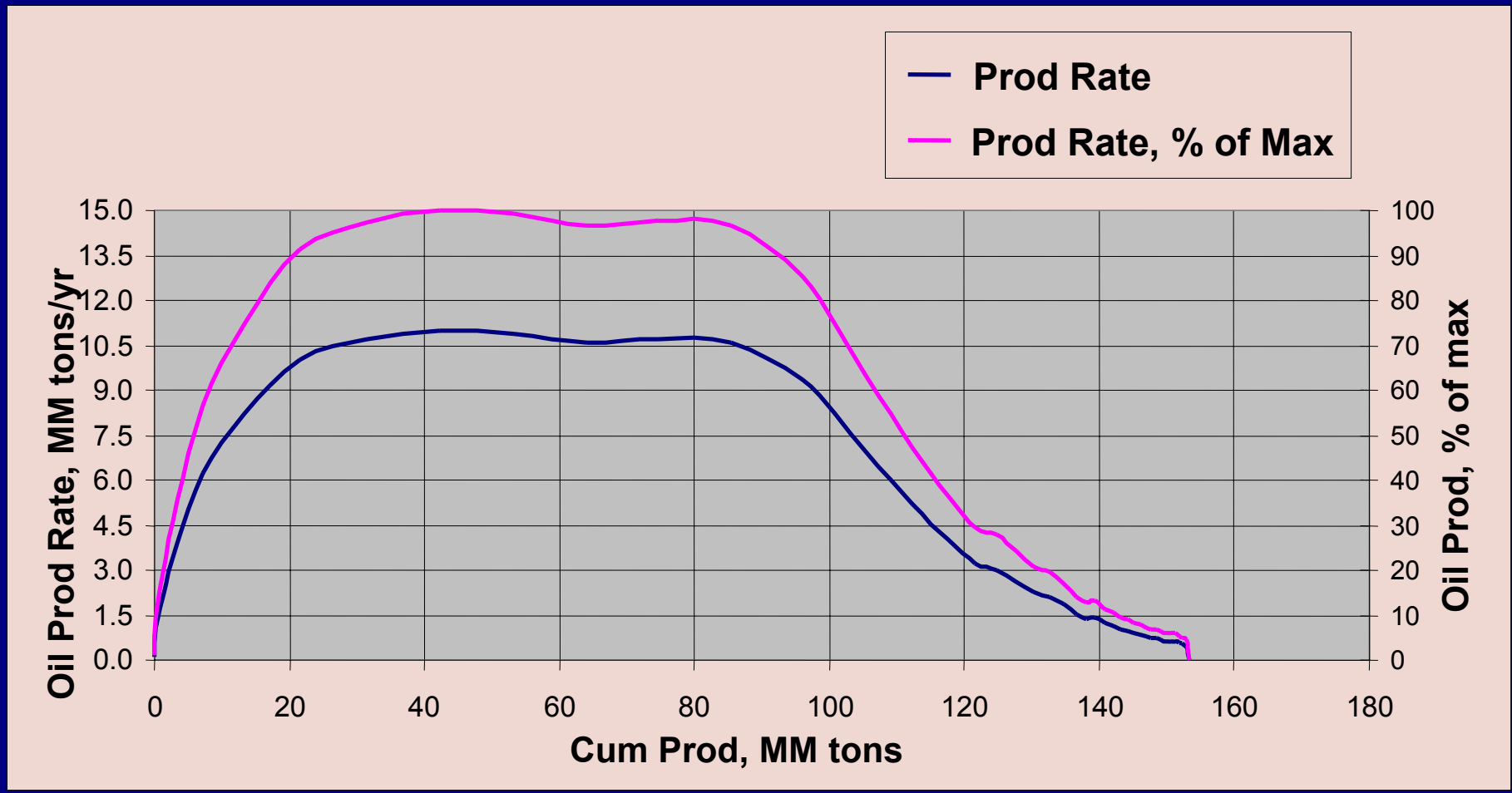


PRODUCTION FORECAST MODEL




PRODUCTION
Hubbert Curve--peak production marks midpoint of depletion
Present
Barrels of Oil Per Year
TIME
50%
PLATEAU CONCEPT
Reserve Growth
Present
Slow Decline
Additions to Inventory as Needed, Through Investment
Barrels of Oil Per Year
Initial Development 3-5 Years
20-25%
Plateau Production 6-10 Years or Longer E.G. North Sea PV ~ 20-25 Years
Depletion

Shkapov Oil Field (1.2 BBOE) Volga Ural Province, Russia



World and U.S. Oil And Natural Gas Supply

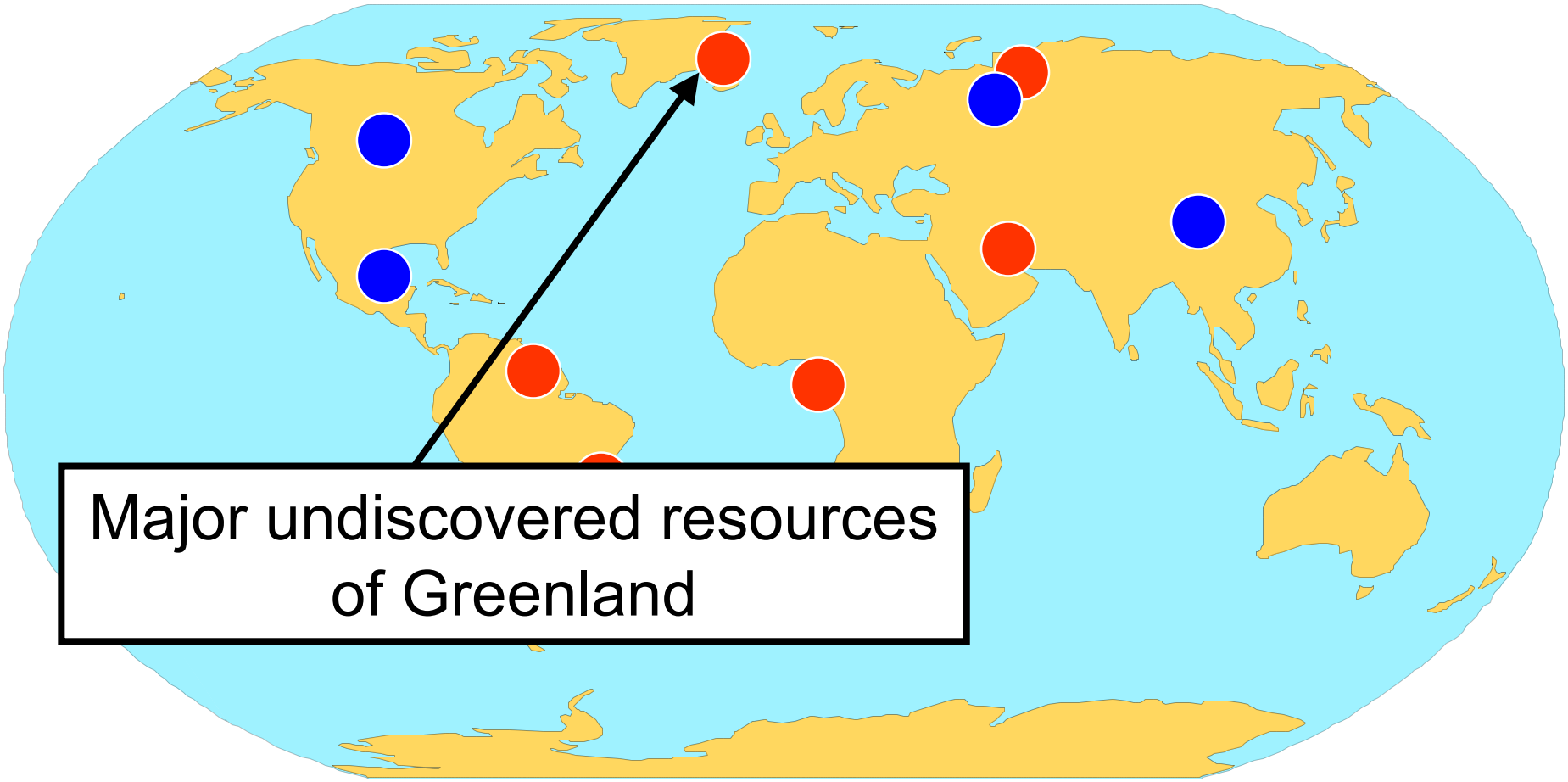
	World Oil*	U.S. Oil	U.S. %	World Gas*	U.S. Gas	U.S. %
Undiscovered	649	83	11	4669	621	12
Reserve growth	612	76	11	3305	390	11
Reserves	859	32	4	4621	167	3
Cumul production	539	171	24	898	854	49
TOTAL	2659	362	12	13493	2032	13
WORLD TOTALS	3021			15401		
	billion barrels			trillion cubic feet		

* Exclusive of U.S.

Sources: USGS (1996, 2000), MMS (2000), EIA (1999)

Oil and Gas Hot Spots and Cold Spots

New perspectives from the USGS World Petroleum Assessment 2000



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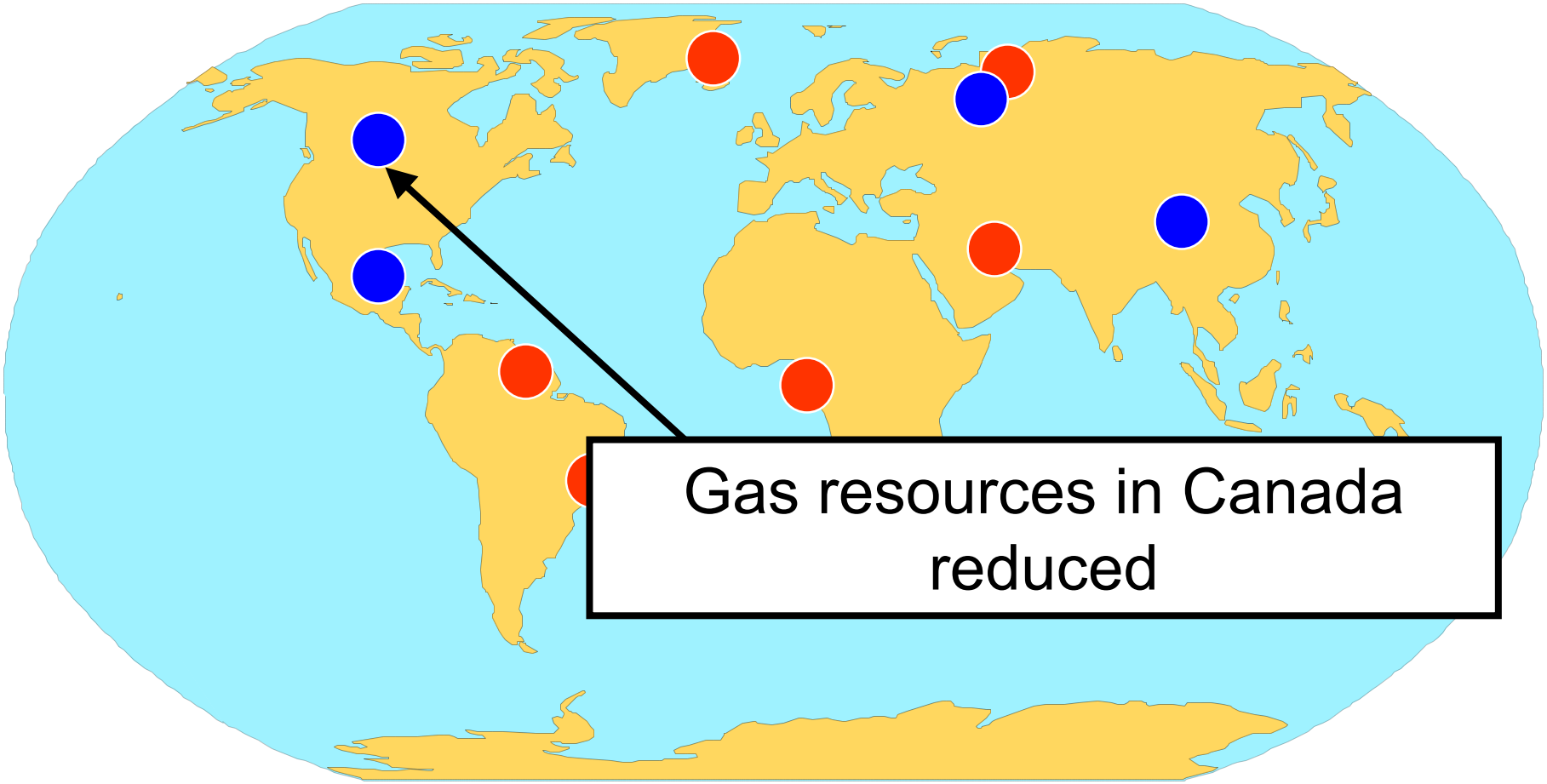

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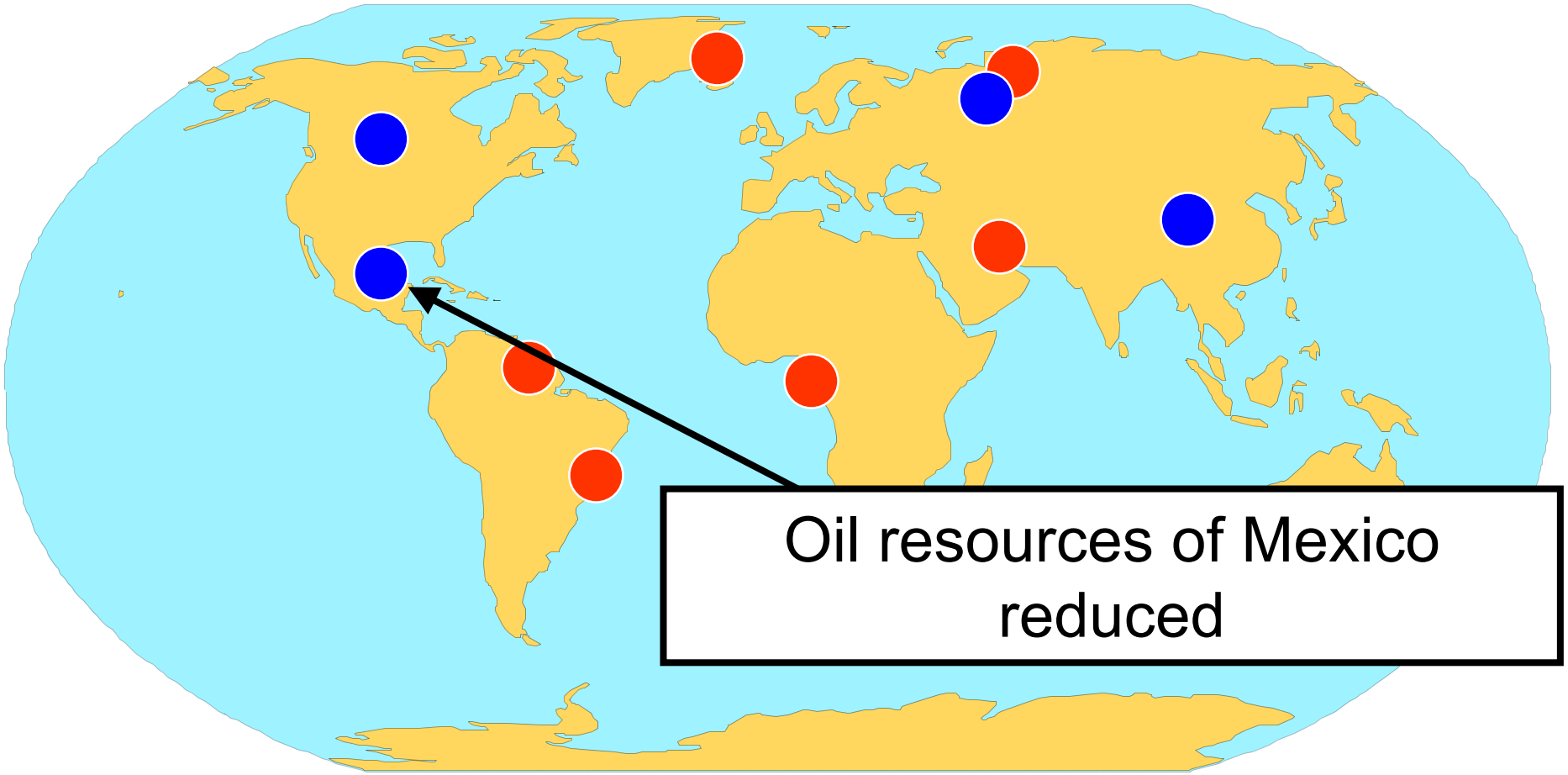

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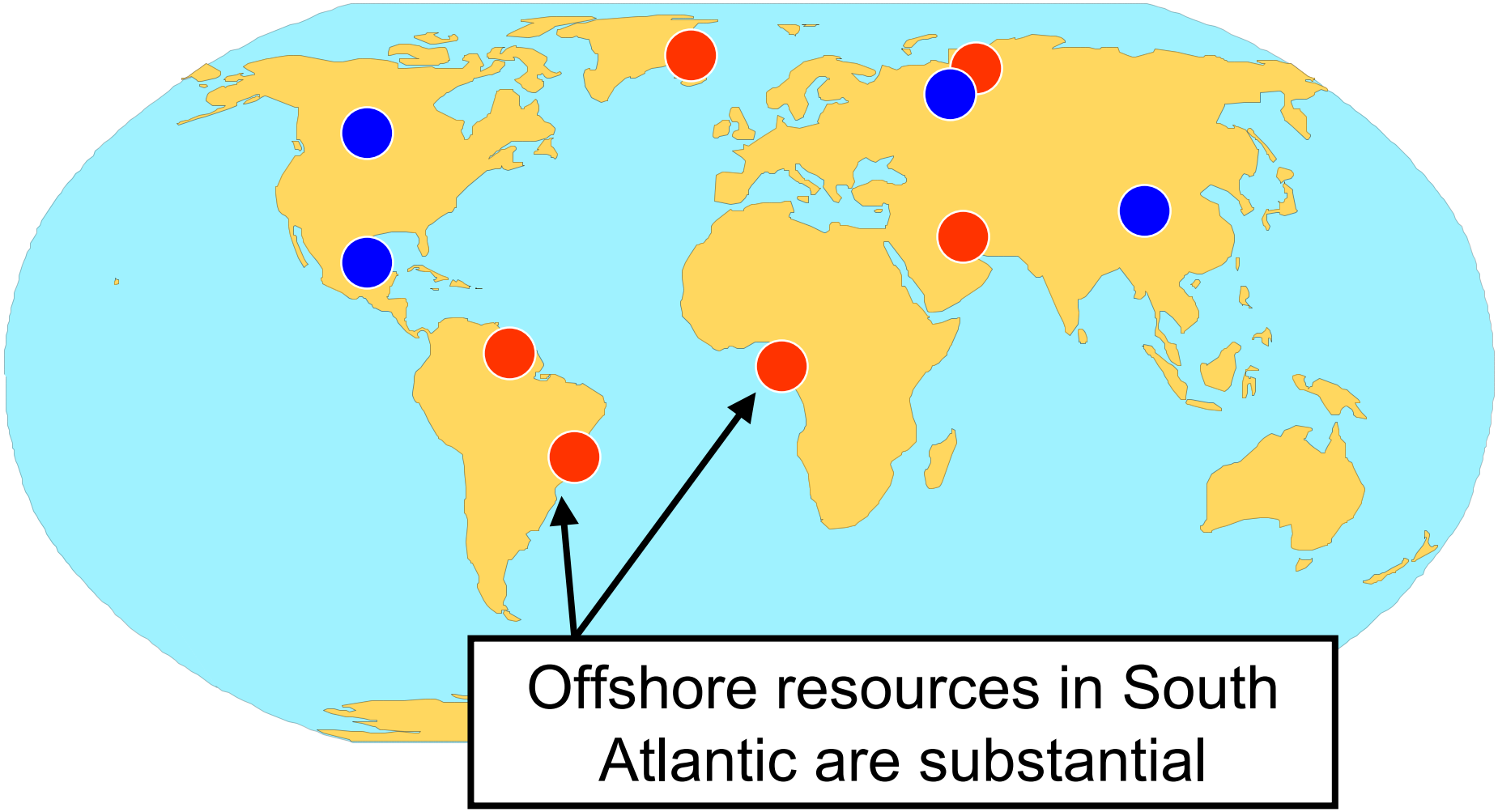

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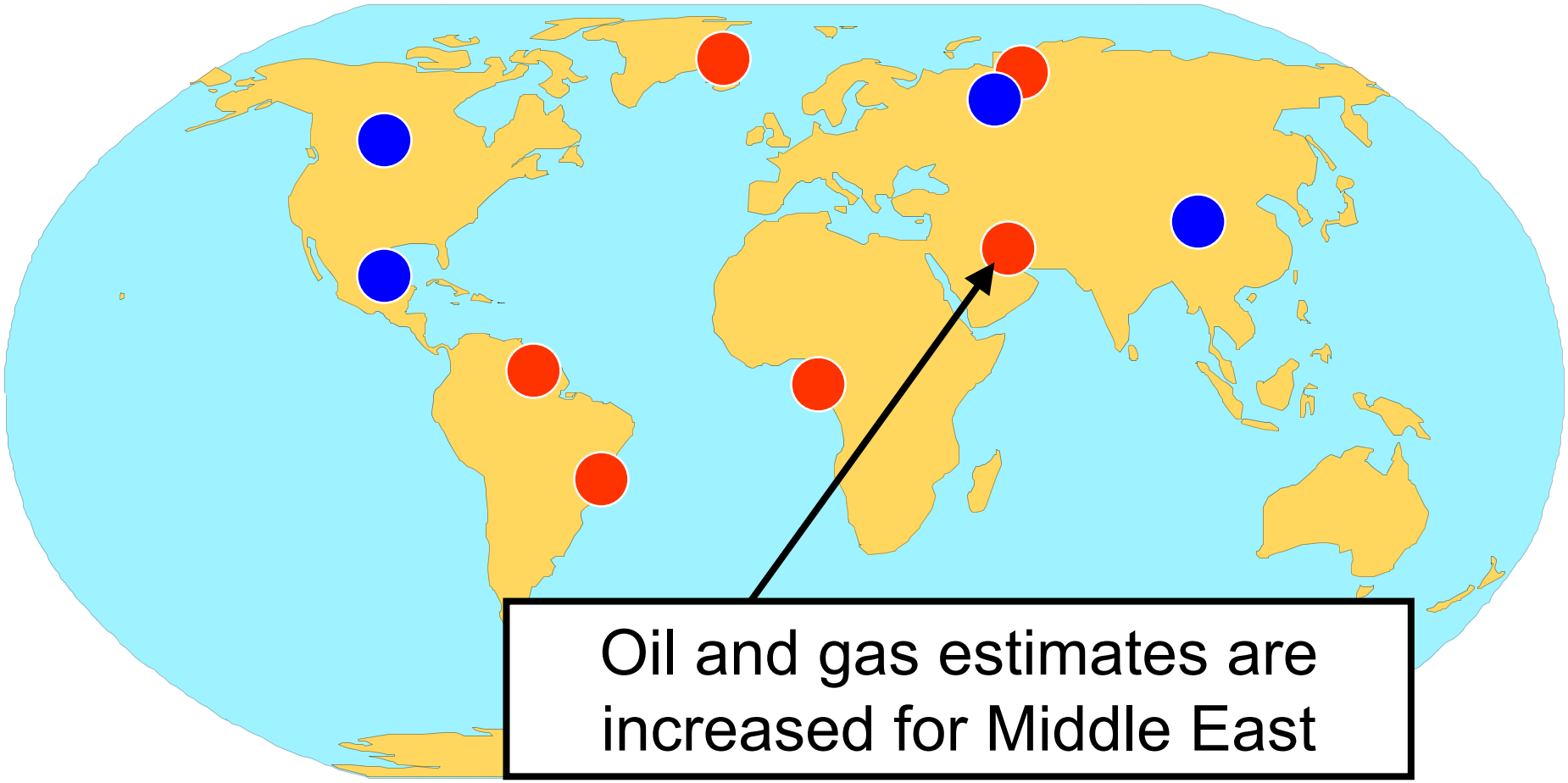

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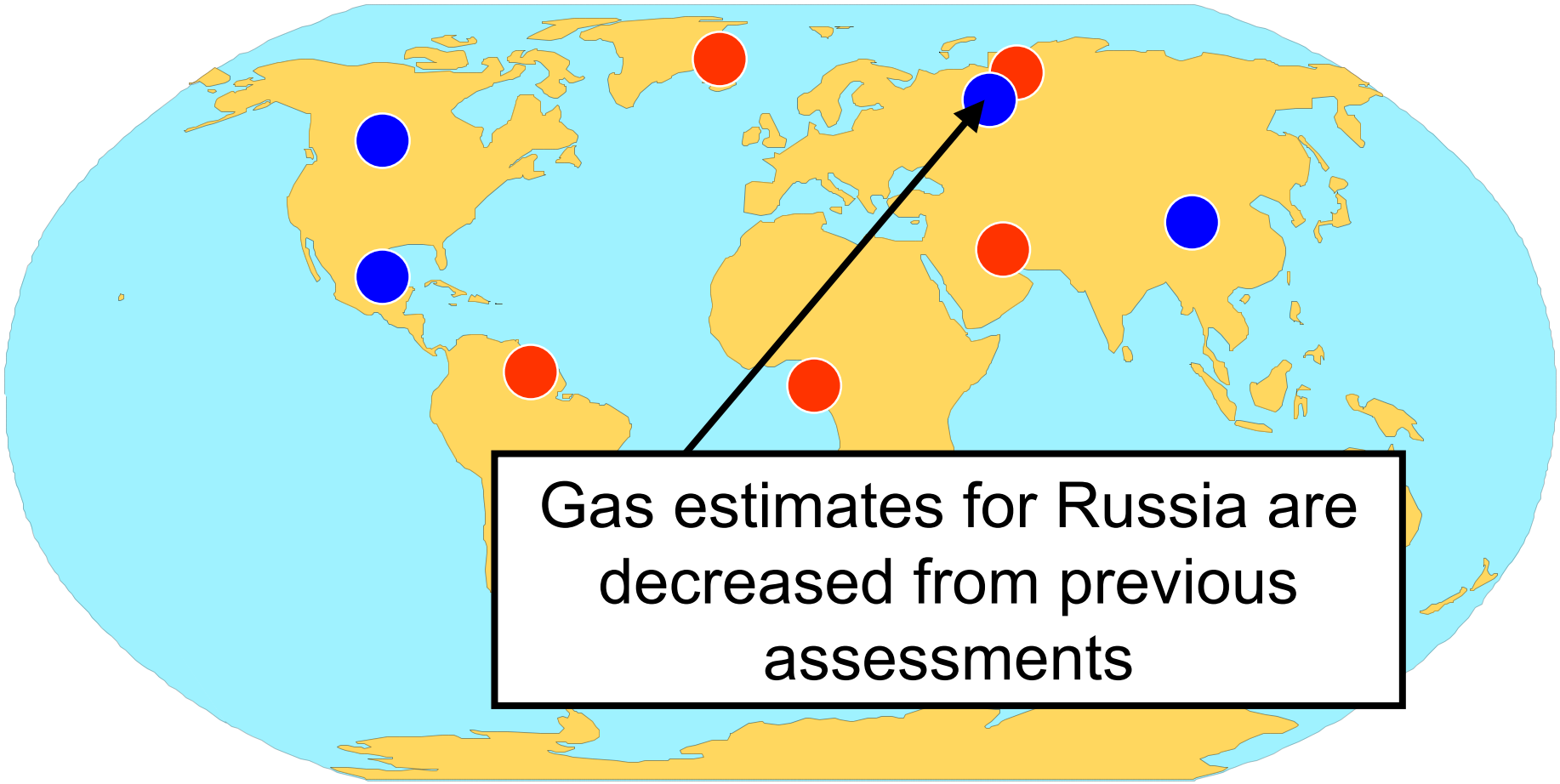

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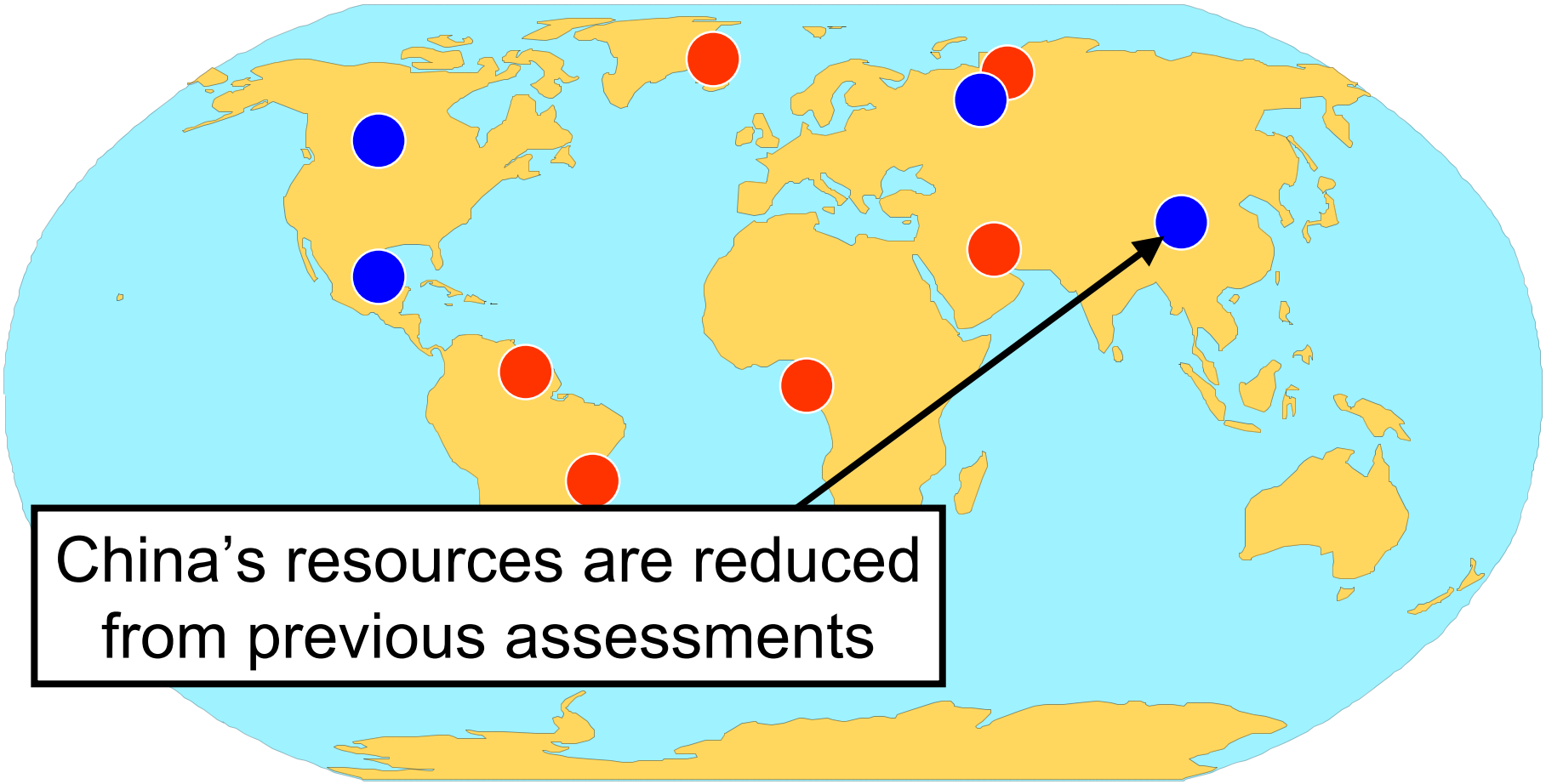

Summary

- Estimates (mean) of Undiscovered Petroleum are up (+9.5% overall; oil +24.3%, gas –10.4, NGL +104%) relative to 1994 USGS estimates
- Field Growth is significant (612 BBO, 3,305 TCF Gas at mean). Large growth potential in Iraq, Iran, Saudi Arabia, Volga Ural, West Siberia, Algeria as supported by detailed, proprietary studies
- OPEC undiscovered resources largely onshore, OECD and others largely offshore and undiscovered resources less concentrated in OPEC compared to previous estimates
- U.S. Reserves—surprising ~12% of world endowment, but troubling recent downturn
- Our understanding of petroleum systems is just beginning challenging our preconceptions and encouraging needed research into gas systems, unconventionals

Summary (2/2)

- Significant giant fields missing in database—East Siberian Basin
- Stranded gas; natural gas is underdeveloped and under-reported--many continuous occurrences
- Unconventional resources– 17 identified but not assessed; will be assessed in next phase. Heavy oil and abnormally pressured, low contrast/low resistivity (LC/LR) offer opportunities for current technologies (e.g. Algeria), many basin-center, coal bed methane, and gas hydrate deposits known
- Boutique province opportunities—2nd largest volume of estimated undiscovered oil assigned to Greenland. 52 such "boutique" provinces including India/Bangladesh, North Africa (Murzuk, Senegal)

Summary

- Total world endowment of oil is +20.5% above previous (1994) estimate
- Total world endowment of gas is -14.1% below previous estimate
- OPEC share of world petroleum endowment is down slightly
- 47% of undiscovered oil and 53% of undiscovered gas are offshore

USGS World Petroleum Assessment 2000

Summary

Reserve Growth

- First time assessed for world
- Nearly as much as undiscovered resources

Mean Estimates

- Oil Reserve Growth (612 BB)
- Natural Gas Reserve Growth (3,305 TCF)
- NGL Reserve Growth (42 BB)

World Energy Project

- ***General Project Overview***
- Project Planning
- Prioritization
- Teambuilding
- Internal Training
- Publications
- GIS protocols
- Data Security / Databases

- The "Assessment Bible"
  - 7th Approximation Form
  - Total Petroleum System Write-ups
  - Definitions/Procedures
- External Calibration
  - World Energy Consortium
  - AAPG Core Methodology Review
  - NRC Reviews
  - Intelligence Community
  - Media--"The Upcoming Crisis"

USGS World Petroleum Assessment Process

- GOAL: ASSESS TECHNICALLY RECOVERABLE CONVENTIONAL OIL AND GAS RESOURCES OF THE WORLD EXCLUDING U.S.

- 5 YEAR PROJECT--1995-2000

- METHODOLOGY AND RESULTS THOROUGHLY REVIEWED BY CONSORTIUM PARTNERS (industry, government, associations)

USGS World Petroleum Assessment Process

- USE GEOLOGIC BASIS (PROVINCES, TOTAL PETROLEUM SYSTEM AND ASSESSMENT UNIT)

- ESTIMATES OF "UNDISCOVERED" RESOURCES BASED ON UNDERSTANDING OF PETROLEUM FORMATION PROCESSES

- ESTIMATES BASED ON "BEST-AVAILABLE" DATA: SNAPSHOT IN TIME

- RESULTS ALLOCATED TO COUNTRIES, ONSHORE / OFFSHORE, OPEC, OECD, OTHER

USGS WORLD ENERGY PROJECT

- 5 YEAR PROJECT--1995-2000
- EXTENSIVELY REVIEWED
- ASSESS RECOVERABLE UNDISCOVERED CONVENTIONAL OIL AND GAS RESOURCES OF THE WORLD
- 30 YEAR TIME FRAME (1995-2025)
- GEOLOGICALLY BASED ASSESSMENT
- ALLOCATION TO COUNTRIES, ONSHORE / OFFSHORE, OPEC, OECD, OTHER
- *RESERVE (FIELD) GROWTH ESTIMATES (30 Year Forecast)*
- ALL INFORMATION IS DIGITAL http://energy.usgs.gov

Provinces

- 1st step, ranking of provinces; 2nd step, identifying and mapping petroleum systems; 3rd step, assessing total petroleum systems.
- 954 Geologic Provinces—prepared digital maps of comparable geologic attributes at scale of 1:2.5M or 1:5M and released on CD-ROM (over 50,000 distributed in Open-File Series 97-450)
- Allocation of 32,695 oil and gas fields (Petroconsultants, 1996; Nehring, 1996) to 409 petroleum provinces
- 76 Priority Provinces—contain 95% of known petroleum reserves (exclusive of U.S.)--14,185 fields (U.S. Provinces from 1995 USGS assessment)
- 52 Boutique Provinces—expensive places to look, but you can get some nice surprises

TOPICS

- World Energy Assessment (U.S.G.S. National Assessment Link; Free CD's)--Conventional (EMC^2), FORSPAN Unconventional.
- Many unconventional opportunities in the World--e.g. LC/LR Algeria, basin center gas--Barents, NW Shelf Australia, China; heavy oil-- E. Siberia, Orinoco, self sourced oil--Domanik (Devonian), Knieper Donets, Timan-Pechora
- Technologies utilized in the U.S. are well suited for unconventional gas (Paleozoic--Middle East, China, South America) and oil (Devonian--Volga-Ural, Algeria)
- Conventional Resources--field growth, new discoveries

Assessment Issues

- Region 5 estimate is down (Canada, Mexico—assessments down)
- Total oil is up due to South Atlantic deepwater and higher assessments in Middle East
- Total gas is down due to lower assessments in Barents, West Siberian Basin, China
- Total NGL up because co-products were not previously assessed
- Overall undiscovered volumes are reasonably close to previous assessments

Assessment Issues (Cont.)

- Natural gas issues—database, lack of development
- Although reserve (field) growth adds considerable resources, the World is basically fairly mature
  - 75% of our oil endowment is known
  - 66% of our natural gas endowment is known

Unresolved Issues

- Is there an impending oil crisis due to lack of discoveries?
- Virtually every preconceived notion we held regarding petroleum systems was challenged by our work (We'll look at the components to demonstrate)
- Our understanding of the origin, migration and accumulation of petroleum resources is immature-particularly for natural gas
  - Conventional / unconventional gas linkage
  - Isotopic fractionation, long term preservation
  - Unknown processes—Amu Darya, South Caspian

Unresolved Issues (cont.)

- Many unconventional opportunities in the World,e.g.--
  - -LC/LR Algeria
  - -Basin center gas--Barents, NW Shelf Australia, China
  - -Heavy oil--E. Siberia, Orinoco,
  - -Self sourced oil--Domanik (Devonian), Knieper Donets, Timan-Pechora

- Technologies utilized in the U.S. are well suited for unconventional gas (Paleozoic--Middle East, China, South America) and oil (Devonian--Volga-Ural, Algeria)

- Conventional resources--field growth (more detailed region and province level work), new major discoveries are increasing not decreasing

Future World Energy Studies

- Plan for subsequent project
  - Continuous accumulations--GERC cooperation
  - Deltas
  - Deepwater sediments
  - Natural gas
  - Field growth--detailed petroleum engineering studies

Questions for the Future of Energy:

1. How much of the world's substantial oil and gas resources are economically recoverable?

2. How much of South American and African offshore resources will be developed? Greenland? When?

3. Who will develop those huge offshore resources, especially in hostile environments? Will ocean production rules change?

4. How will the U.S. meet its natural gas demand? What role will Canada play?

5. How will unconventional resources evolve and develop?