The Quest for Energy

Rewarding Careers in Petroleum Exploration

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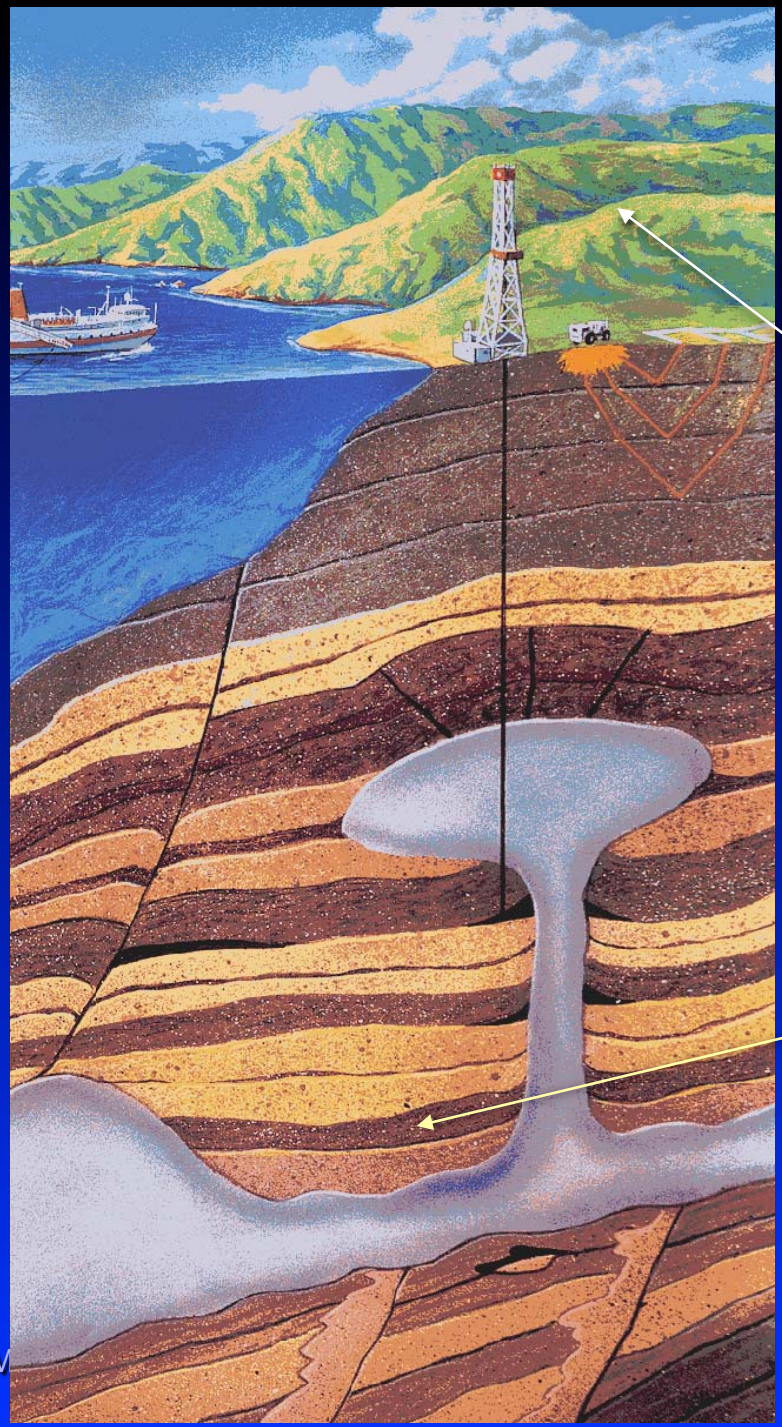


Petroleum Exploration's Challenge

Interpreting the Unseen

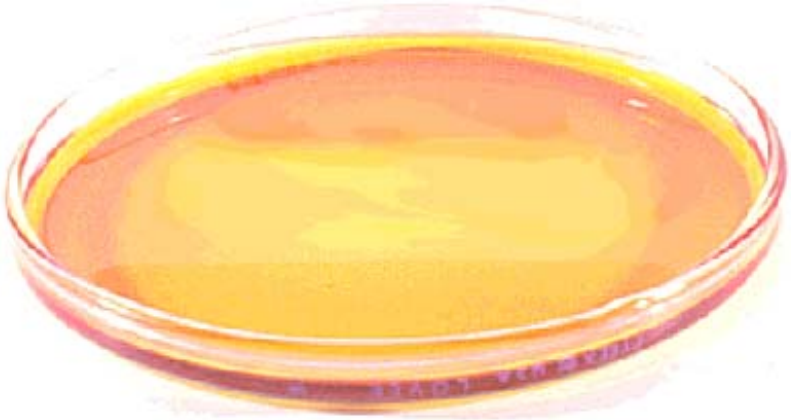
- Surface Geology
  - Aerial photos
  - Geologic maps

- Subsurface Analysis
  - Gravity
  - Magnetics
  - Seismic reflection
  - Wells

The Goal - ‘Black Gold’

Petroleum Supplies our Energy Needs

Light Texas Crude
Palo Pinto Field
North Texas



Heavy Texas Crude
Humble Oil Field
Southwest Texas

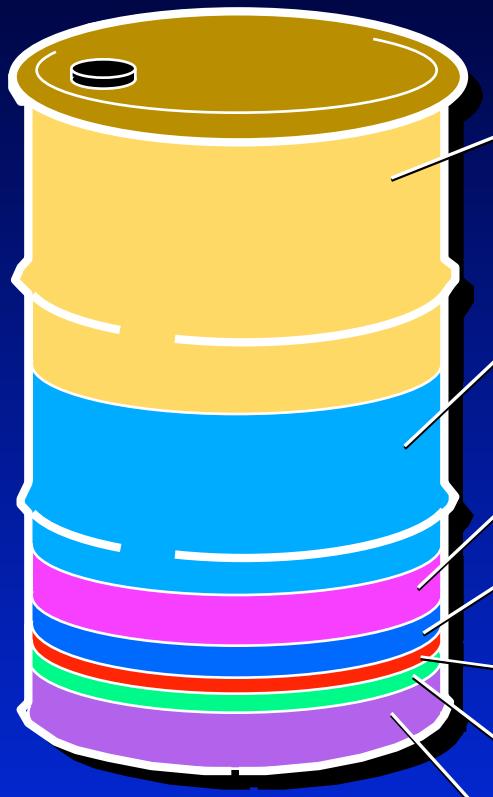
What is Petroleum?

- Petroleum: a natural yellow-to-black flammable liquid hydrocarbon found beneath the earth's surface
- Hydrocarbon: an organic compound made up of carbon and hydrogen atoms

Petroleum Products

A Barrel of Crude Oil Provides:

One Barrel =
42 gallons



Gasoline - 19.5 gallons

Fuel Oil - 9.2 gallons

Jet Fuel - 4.1 gallons

Asphalt - 2.3 gallons

Kerosene - 0.2 gallons

Lubricants - 0.5 gallons

Petrochemicals,
other products - 6.2 gallons

American Petroleum Institute, 1999

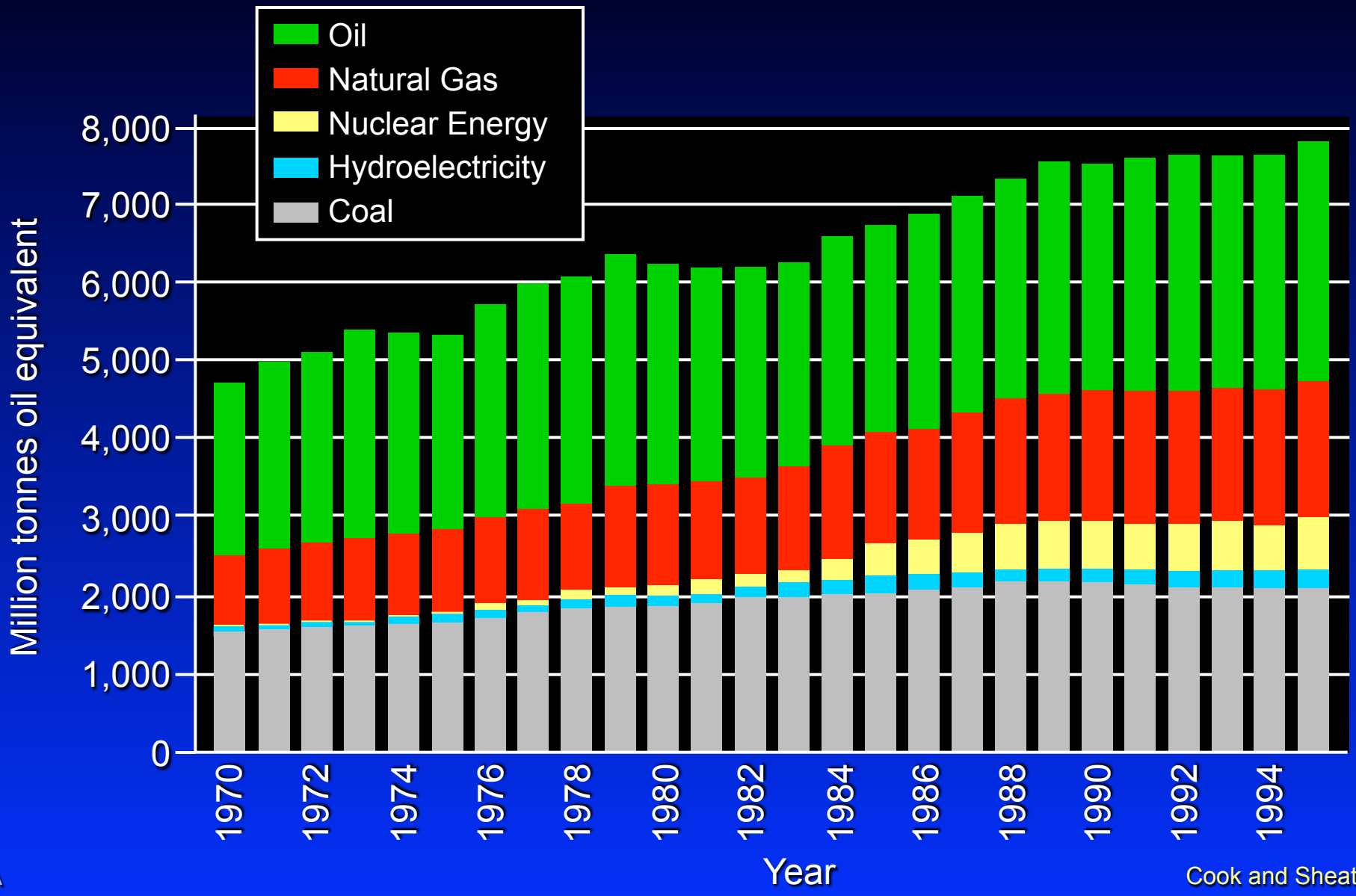
Petrochemical Products

More Than 3,000 Products

- Detergents - Cosmetics
- Fertilizers - Weed Killers
- Medicine - Antiseptics - Anesthetics
- Plastics - Synthetic Fibers
- Synthetic Rubber
- Rust Preventatives
- Liquid Petroleum Gas

American Petroleum Institute, 1999

World Fuel Consumption: 1970-1994



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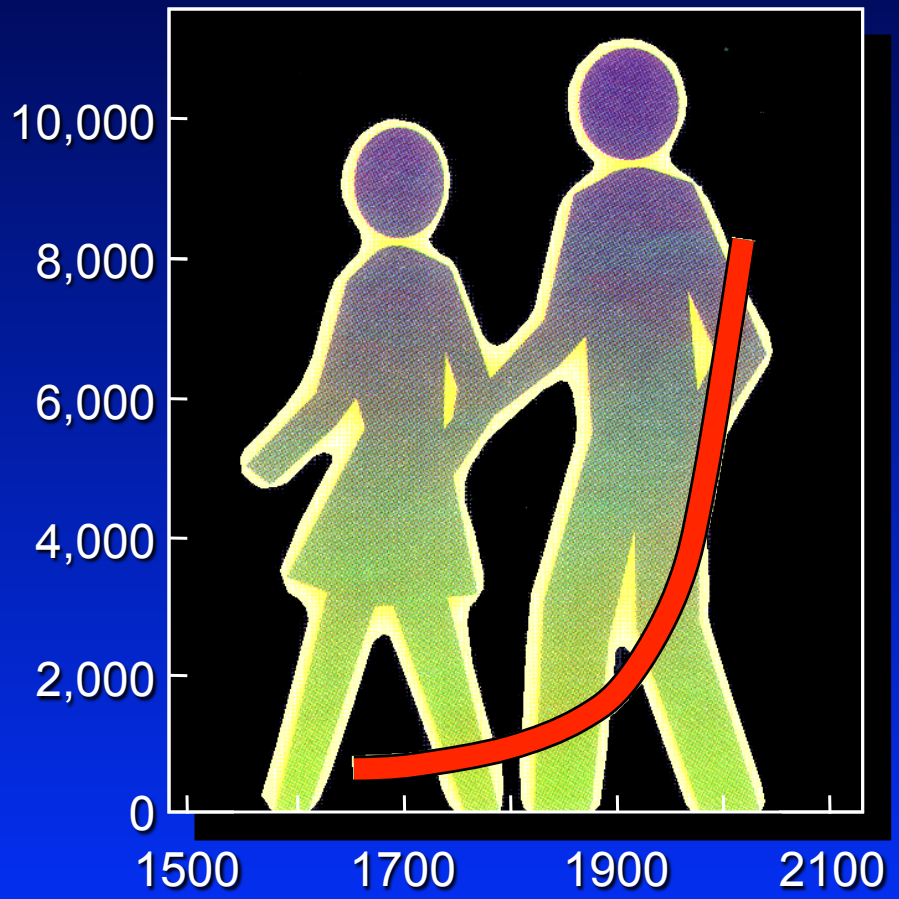
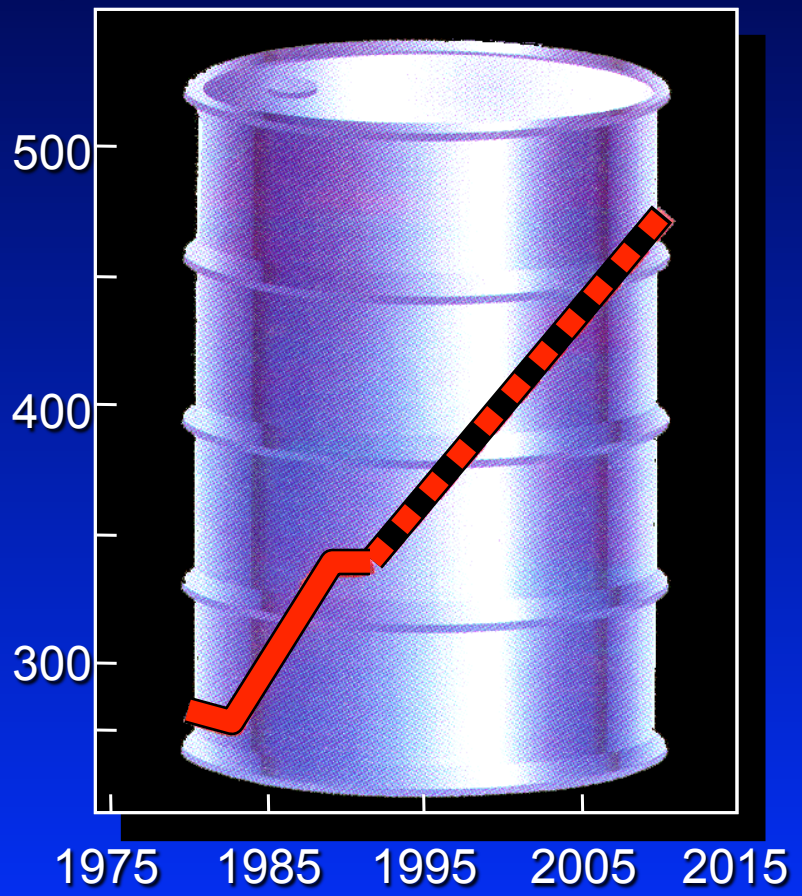
Cook and Sheath, 1997

Population-Driven Energy Demand

World Population
(Millions)



World Primary Energy Consumption
(Quadrillion BTU)



AAPG Explorer, 8/95

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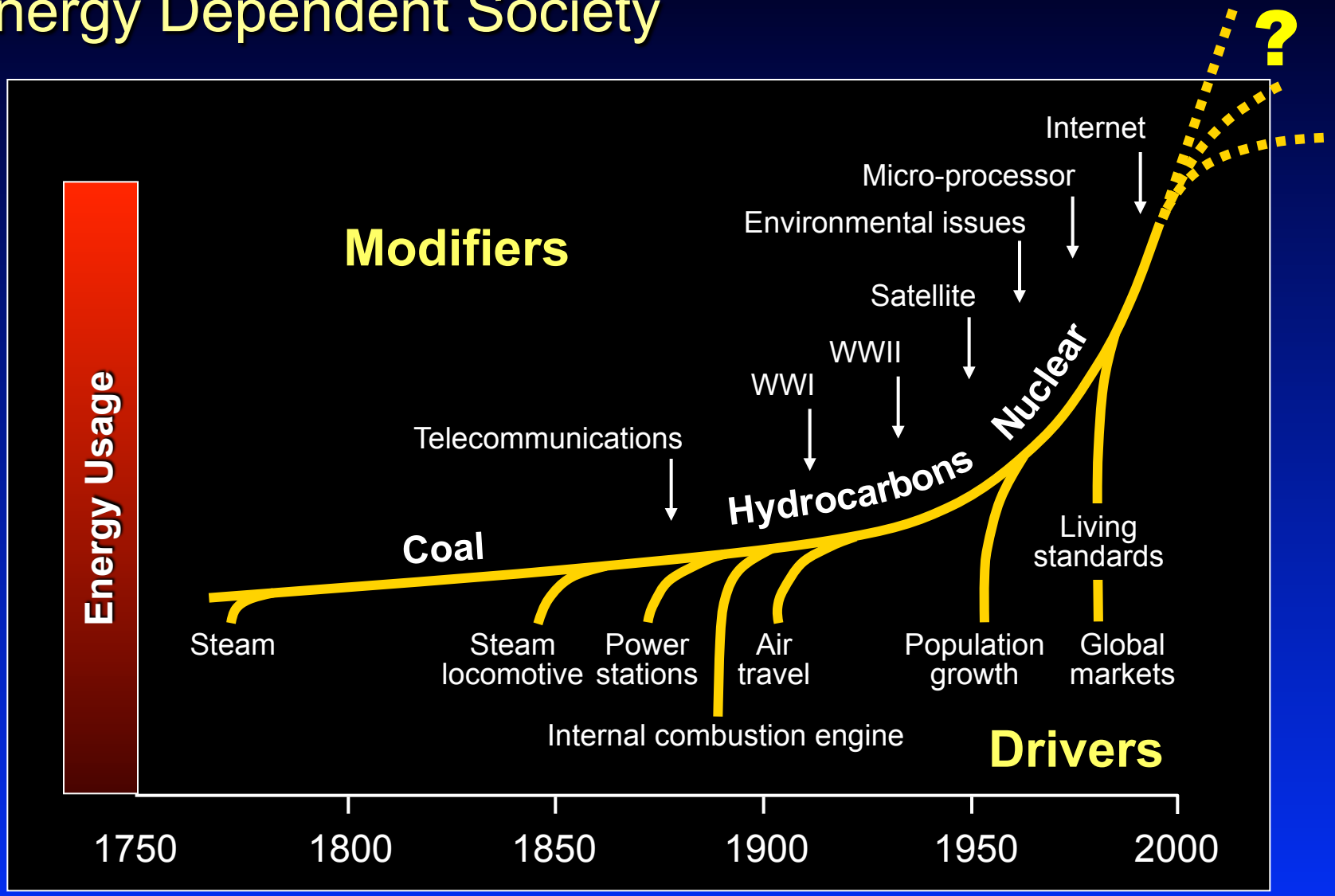
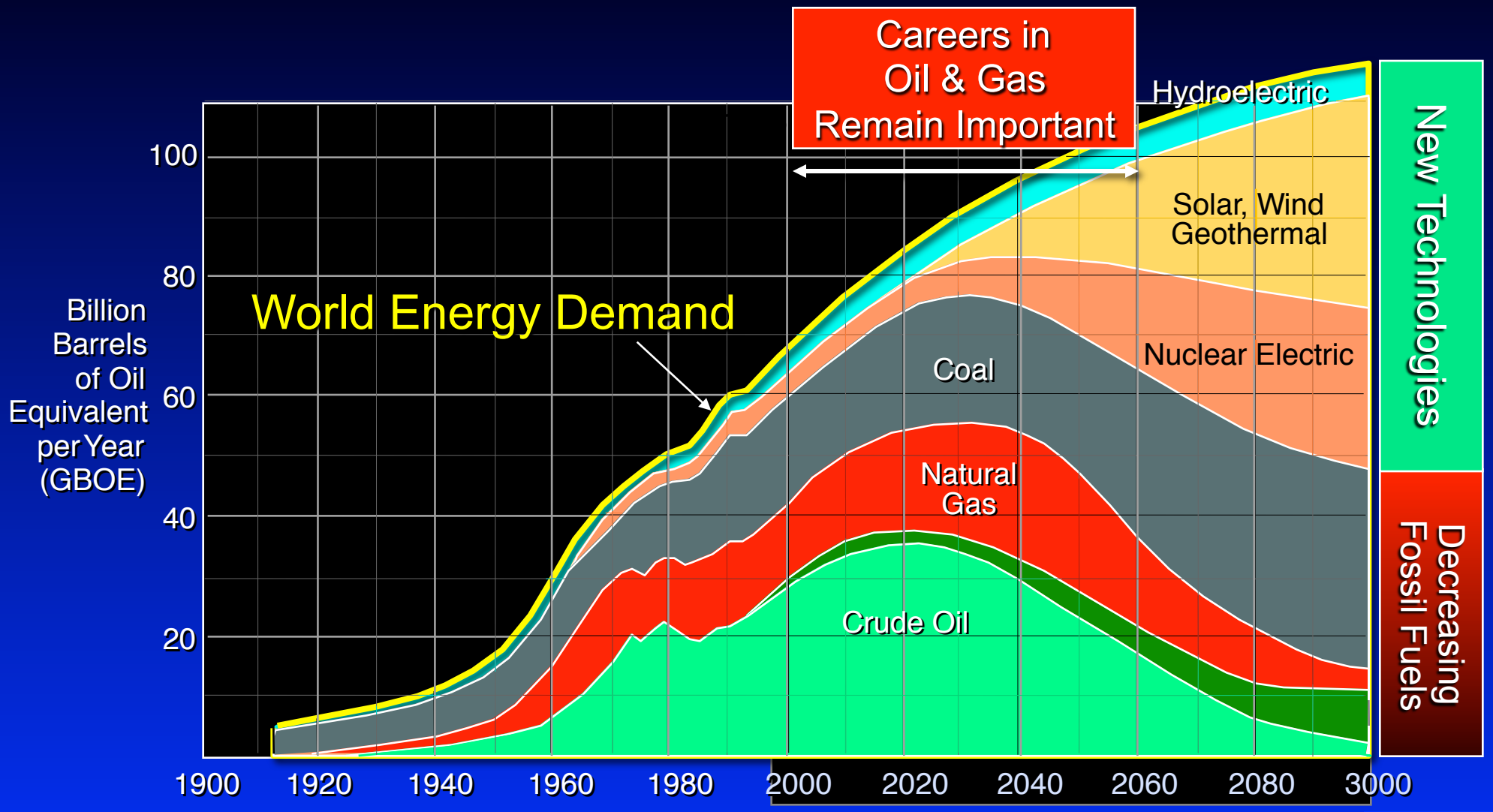
Energy Usage: 1750-2000

An Energy Dependent Society



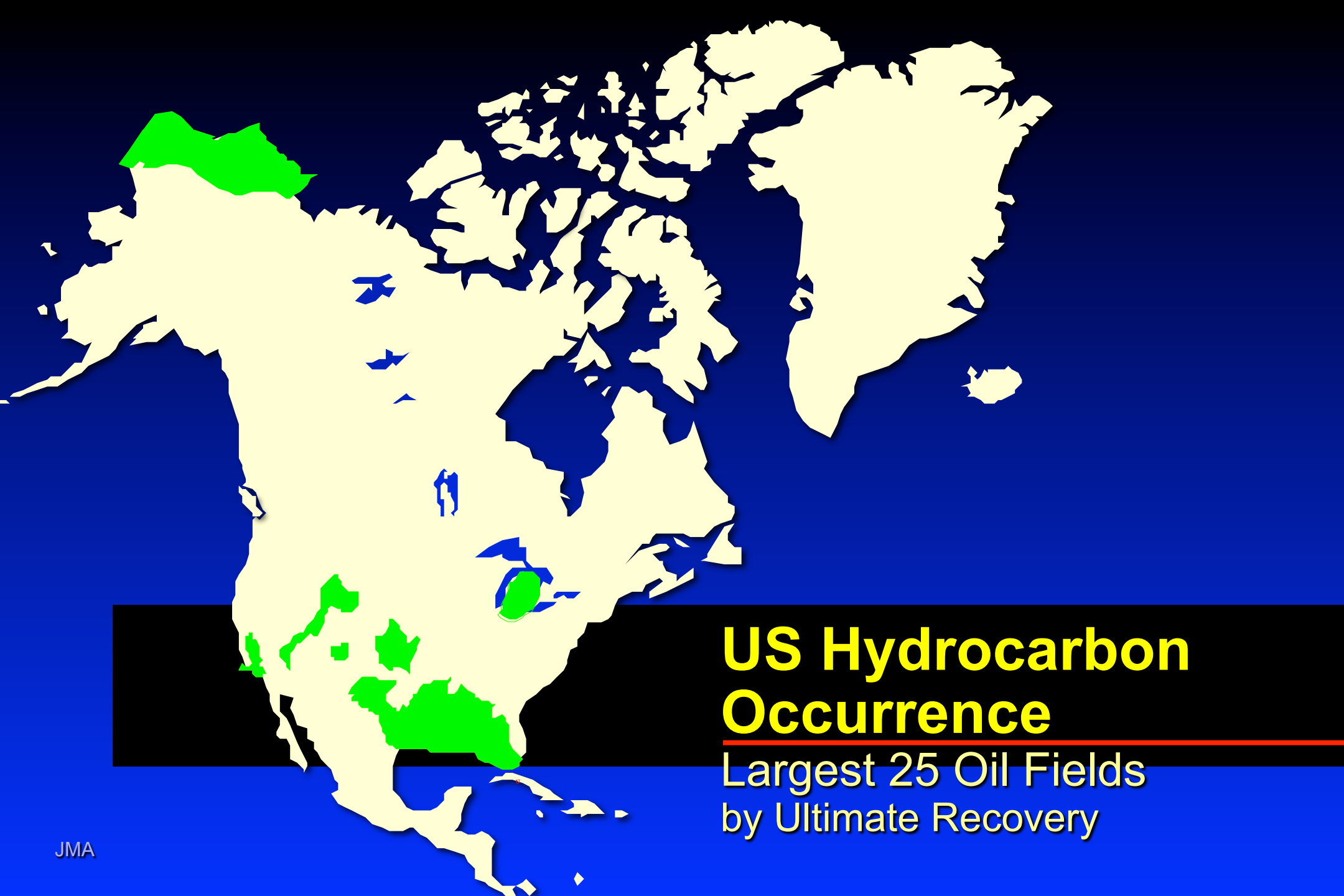
Cook and Sheath, 1997

Projected World Energy Supplies



after Edwards,
AAPG 8/97

Global Oil and Gas Fields


US Hydrocarbon Occurrence
Largest 25 Oil Fields
by Ultimate Recovery
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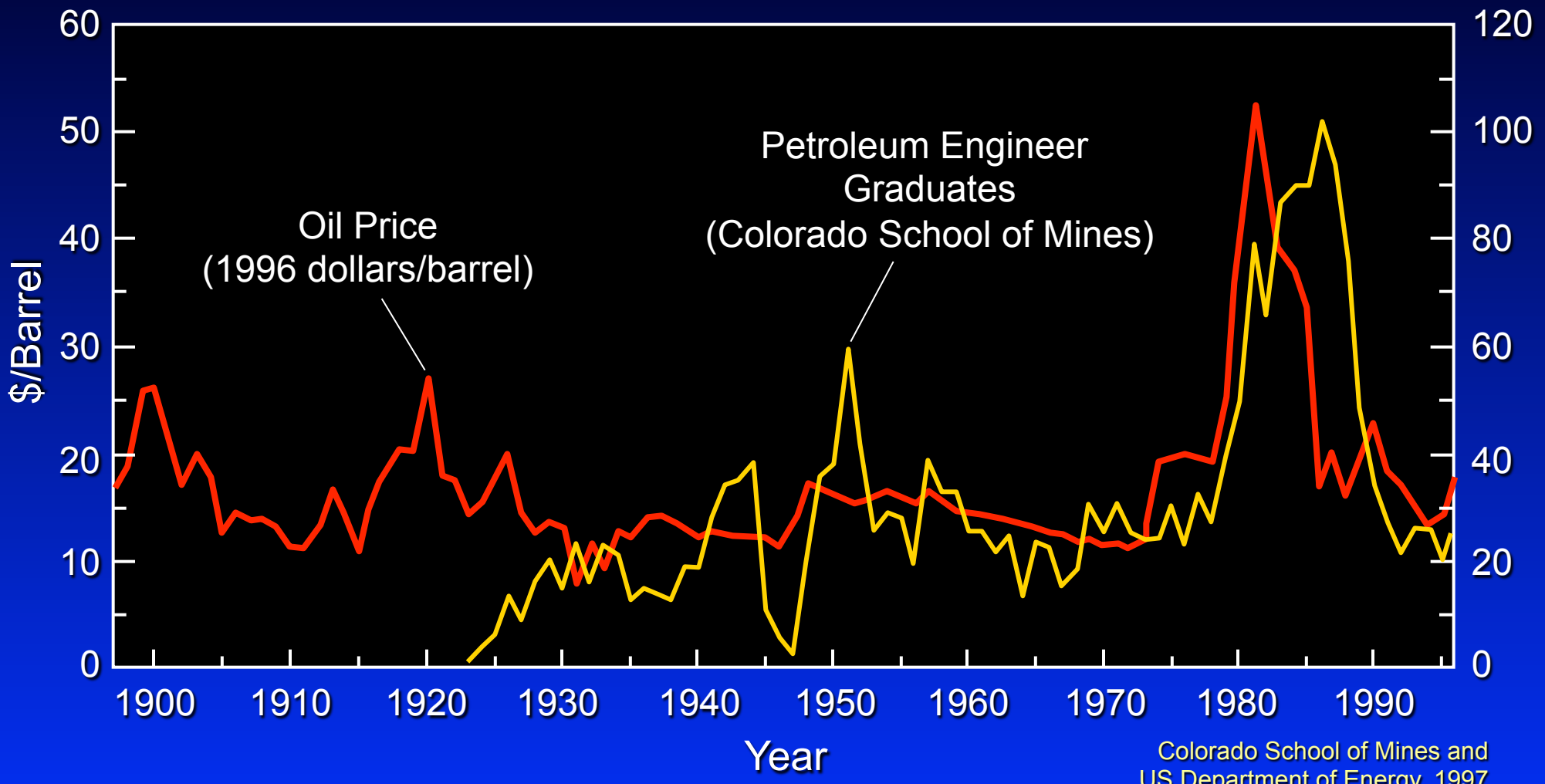
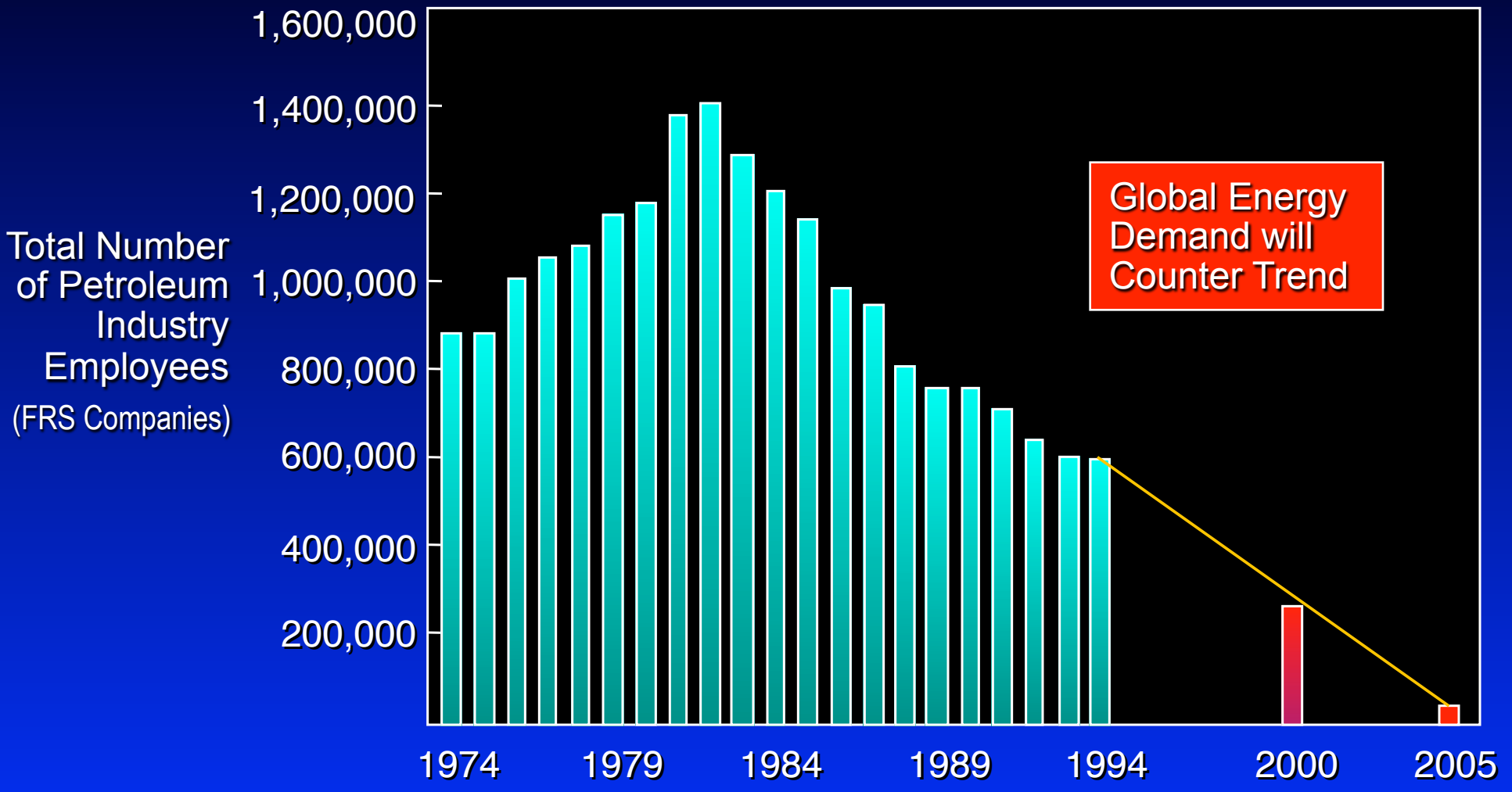
Impact on Students

Linkage of Petroleum Industry and Geoscience Students



Colorado School of Mines and
US Department of Energy, 1997

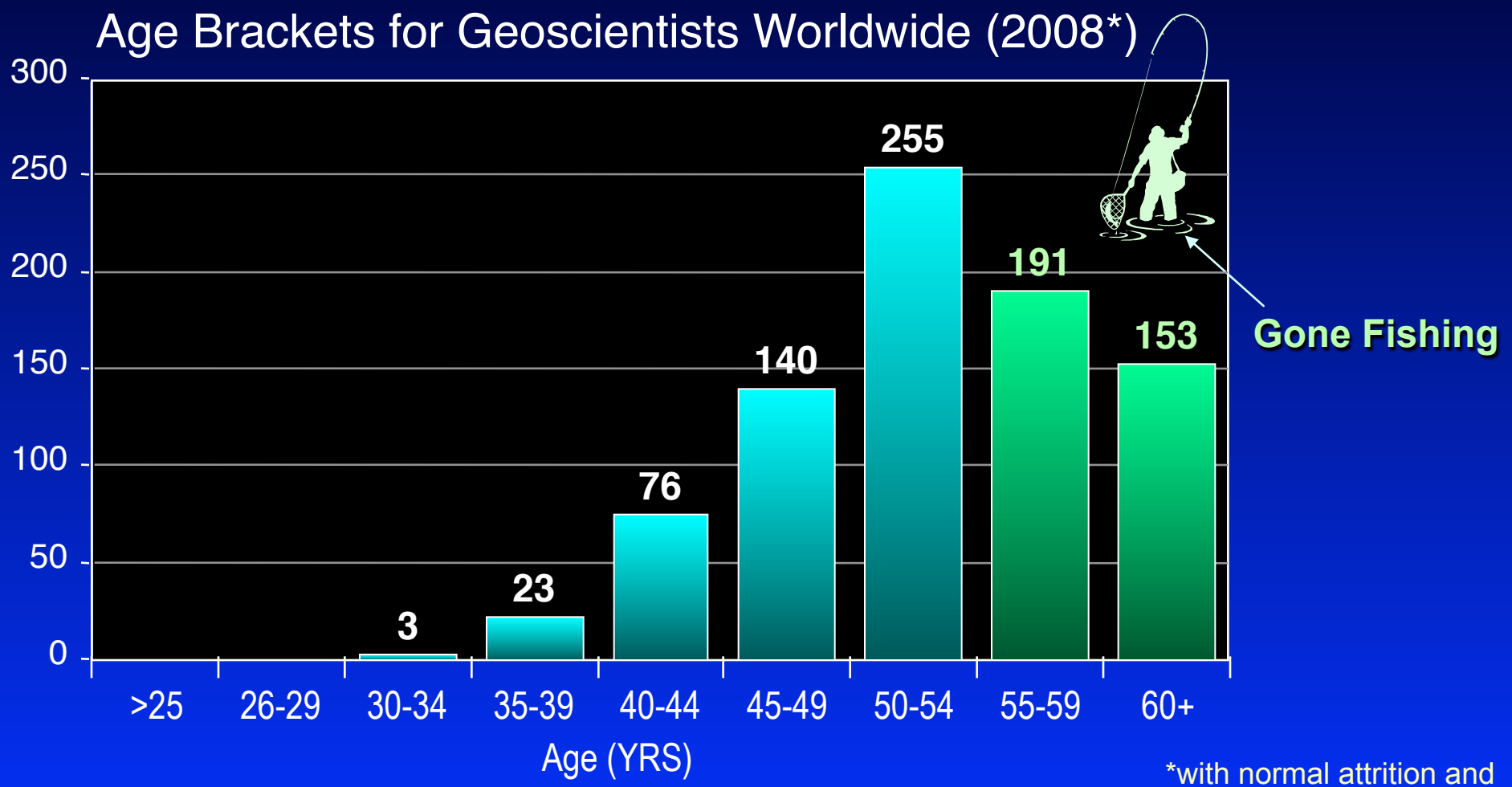
Worst Case Employment Scenario



Arthur L. Smith, CFA - Abilene, Texas, 1996

Geoscience Demographics

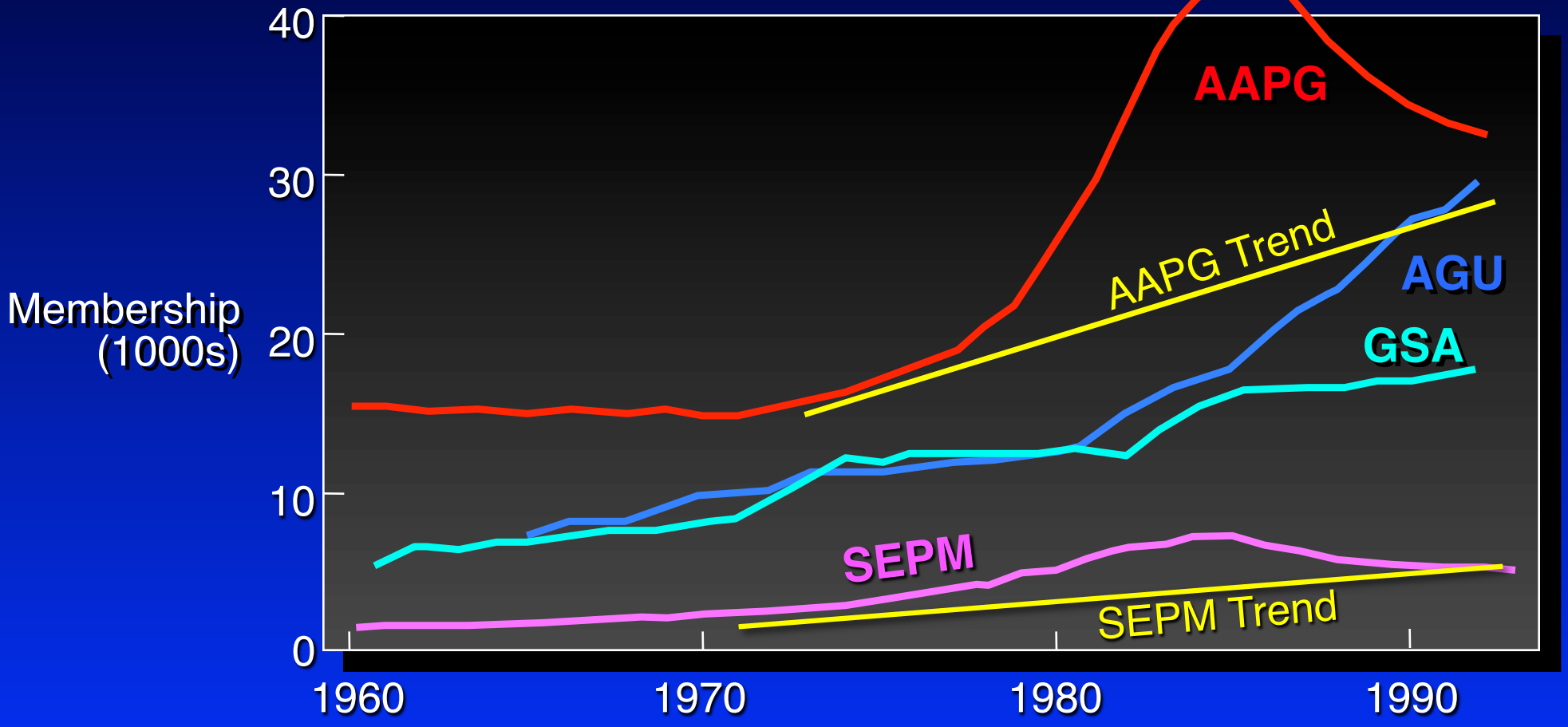
For a Typical Major Oil Company



*with normal attrition and no replenishment

Optimistic Long-range Trends for Geoscience Employment

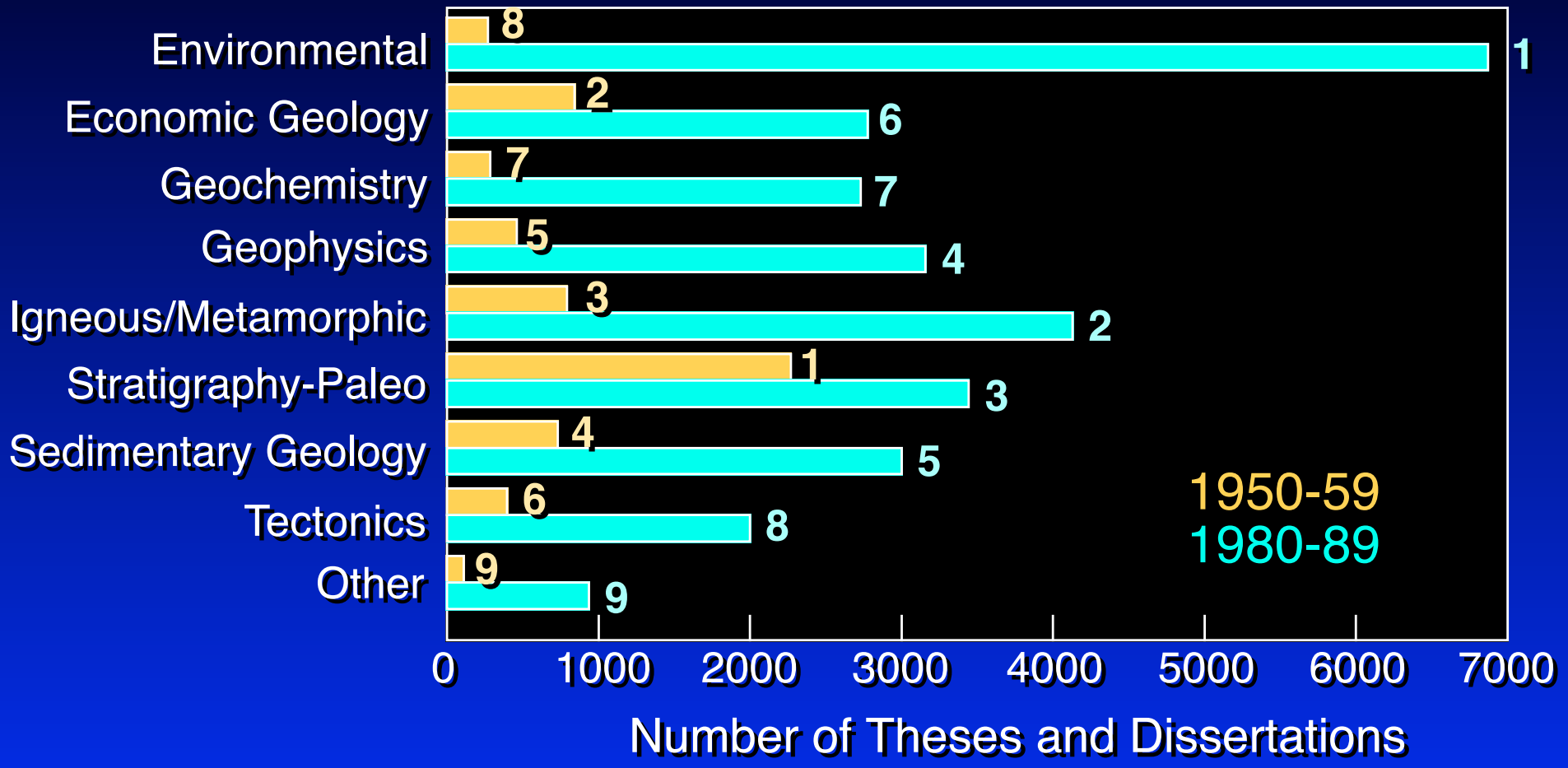
Total Employment Continues to Grow



after Marcus Milling - AGI, 1995

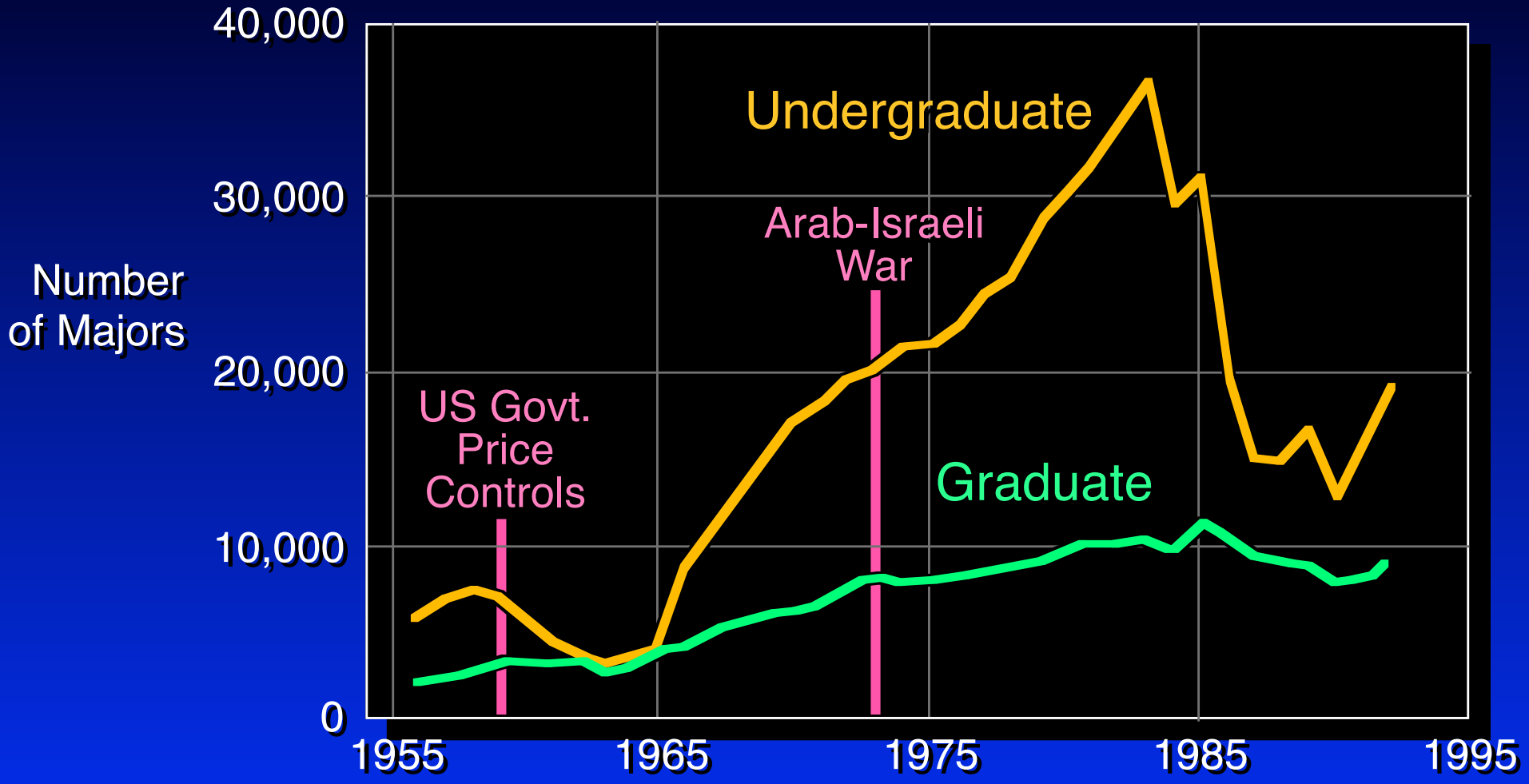
Geoscience Theses and Dissertation Topics

1950s versus 1980s



Marcus Milling
AGI, 1996

US Geoscience Student Enrollment



Marcus Milling
AGI, 1993

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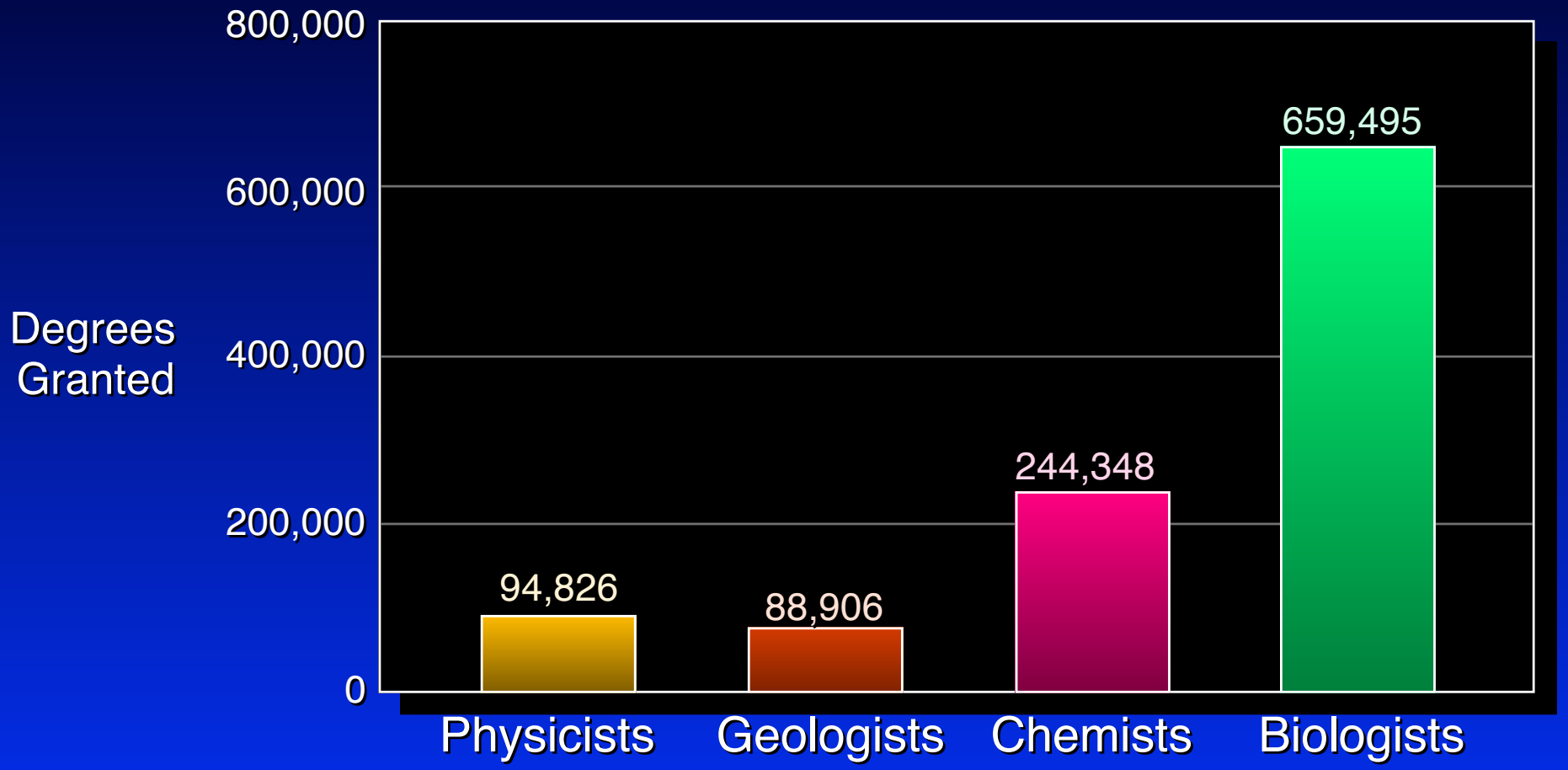
Supply

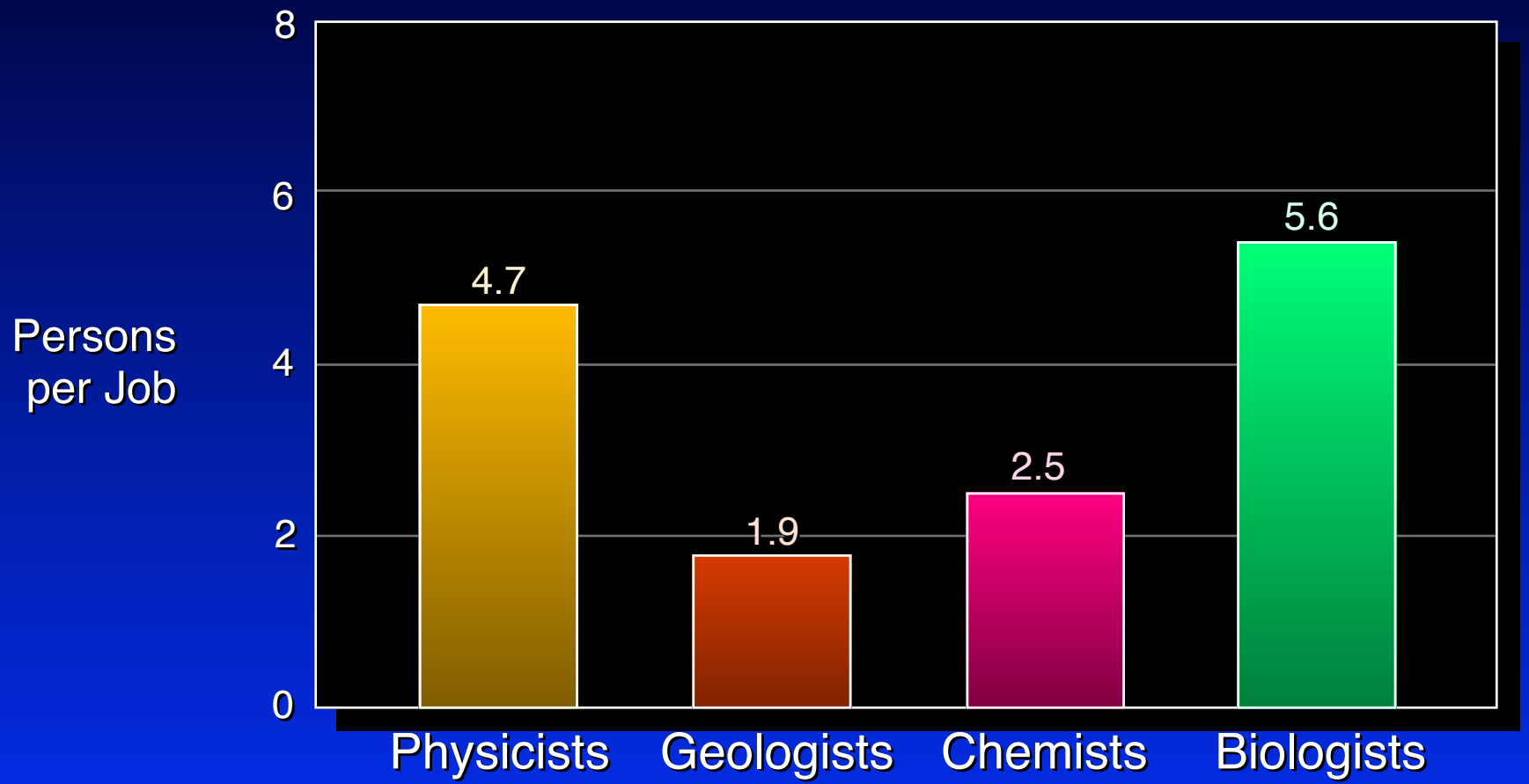
Bachelor's Degrees, 1970-1994



John Holbrook, *Palaios,* Dec. 1997 | Occupational Outlook Handbook, US Bureau of Labor Statistics

Job Competitiveness

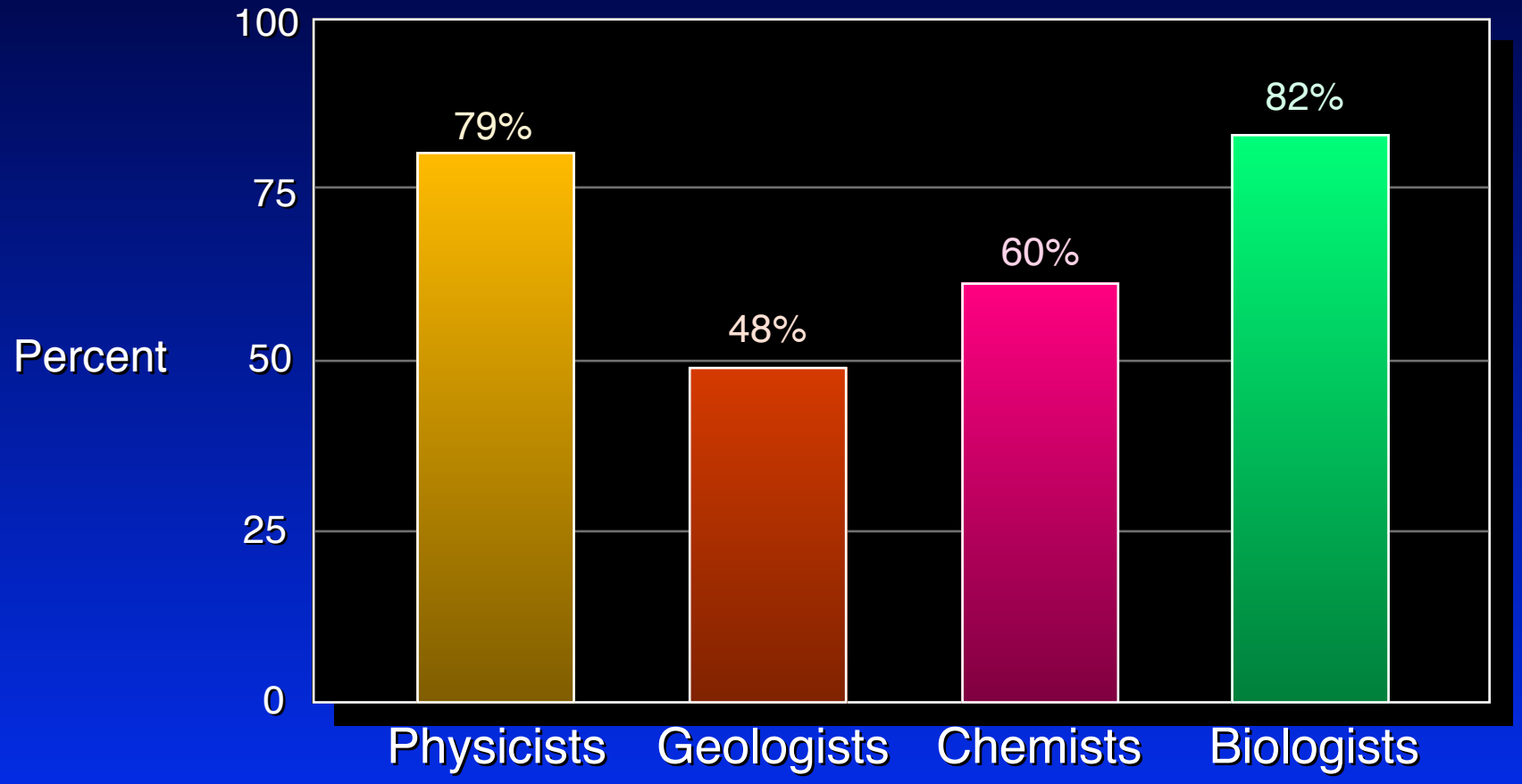
1970-1997 BS Degrees/1997 Jobs



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

Employed Outside Initial Discipline

1970-1997 BS Degrees/1997 Jobs



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

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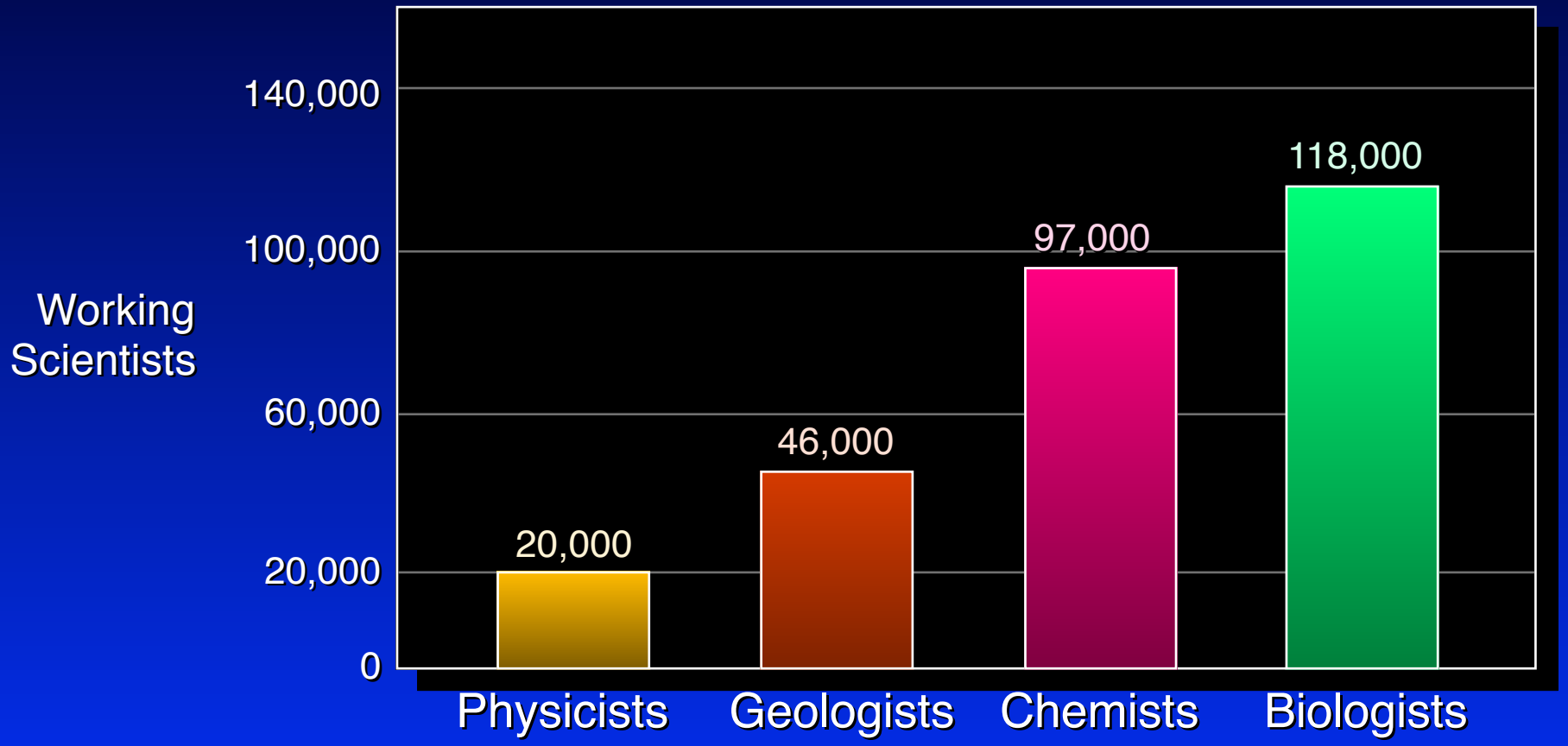
Demand

Employed Natural Scientists, 1997, USA



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

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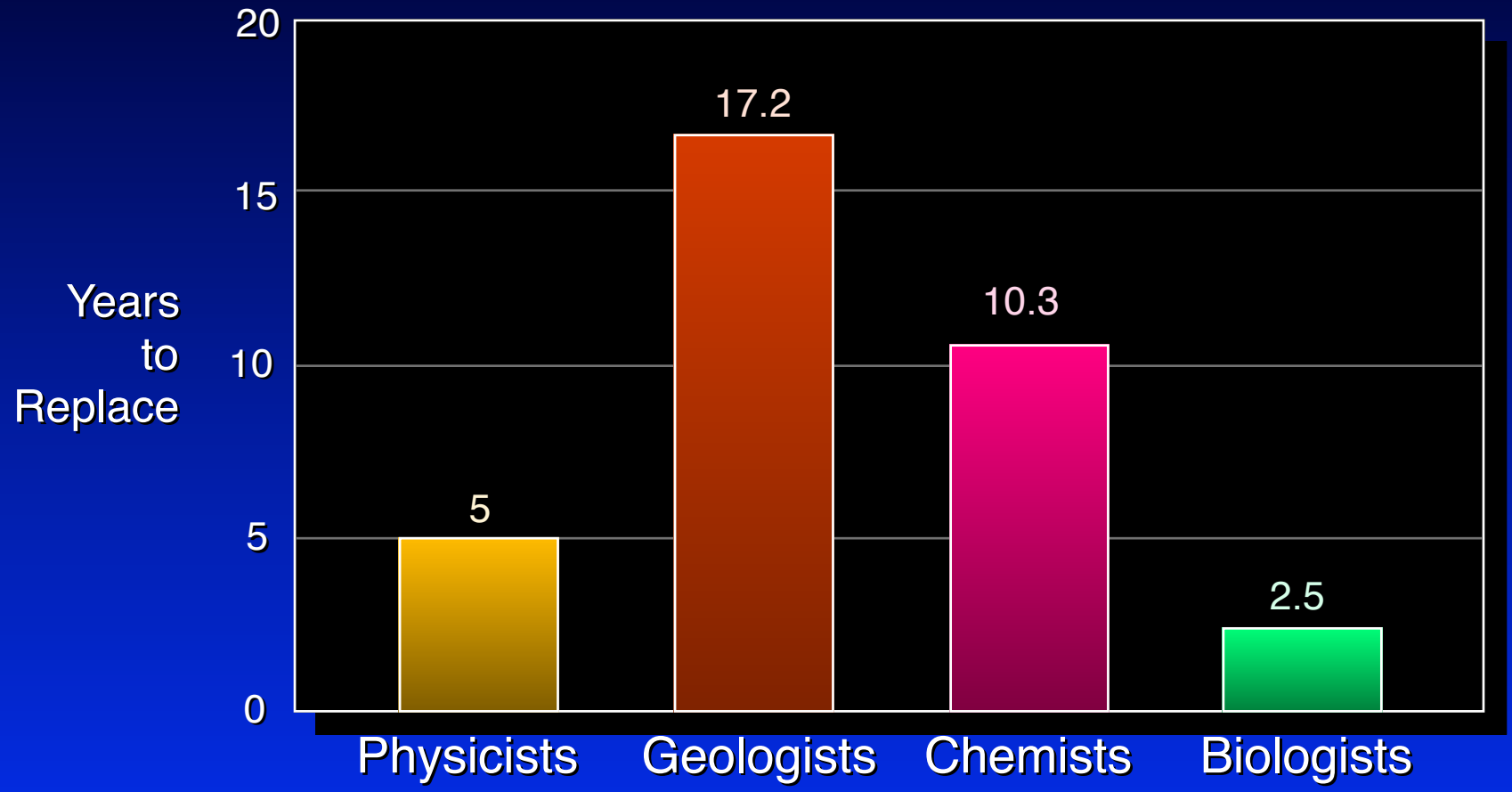
Job Competitiveness

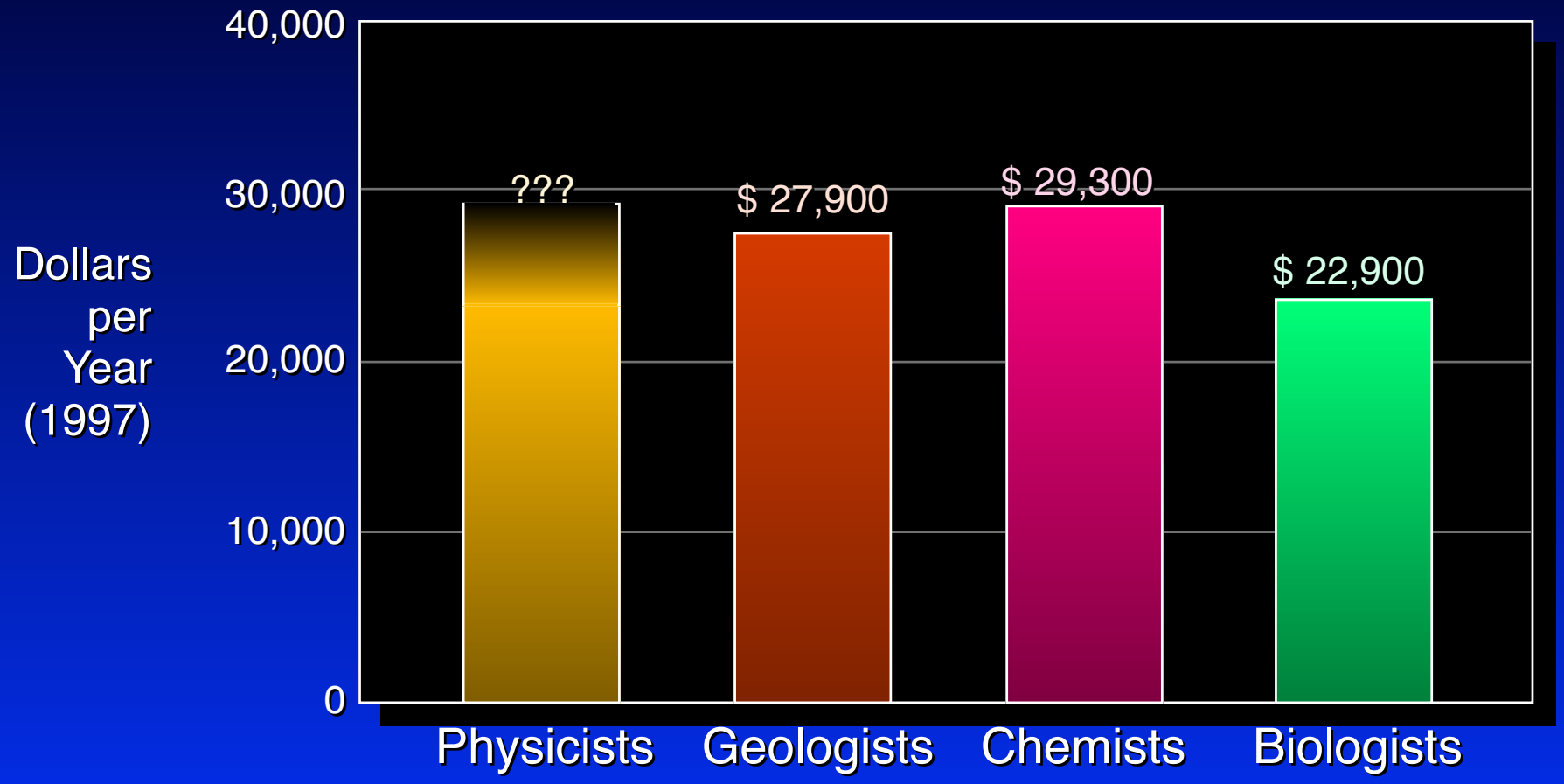
Years to Replace Currently Employed Scientists



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

Compensation

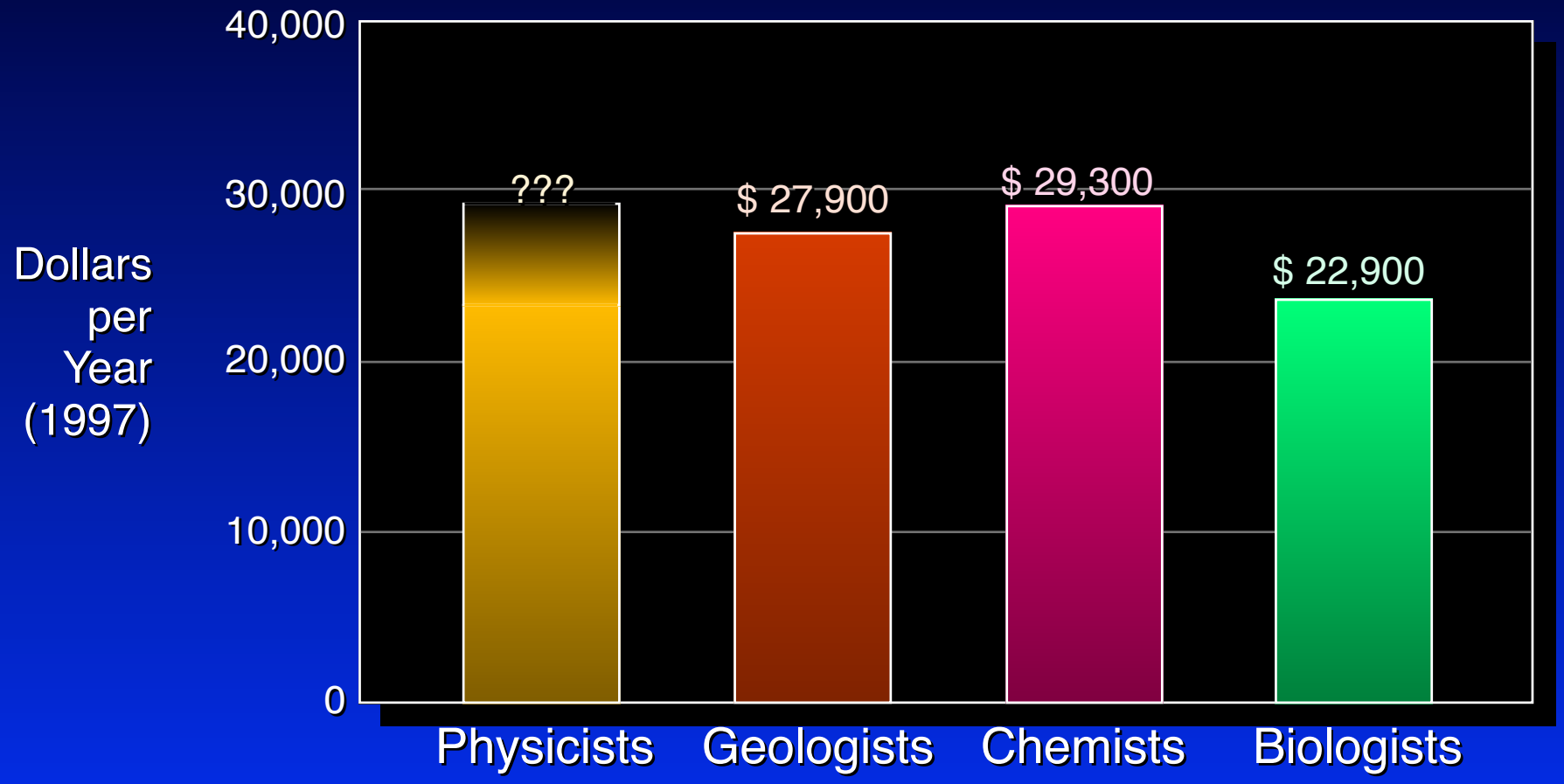
Average Salary – Bachelor's Degree, USA



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

Compensation

Average Salary – Bachelor's Degree, USA



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

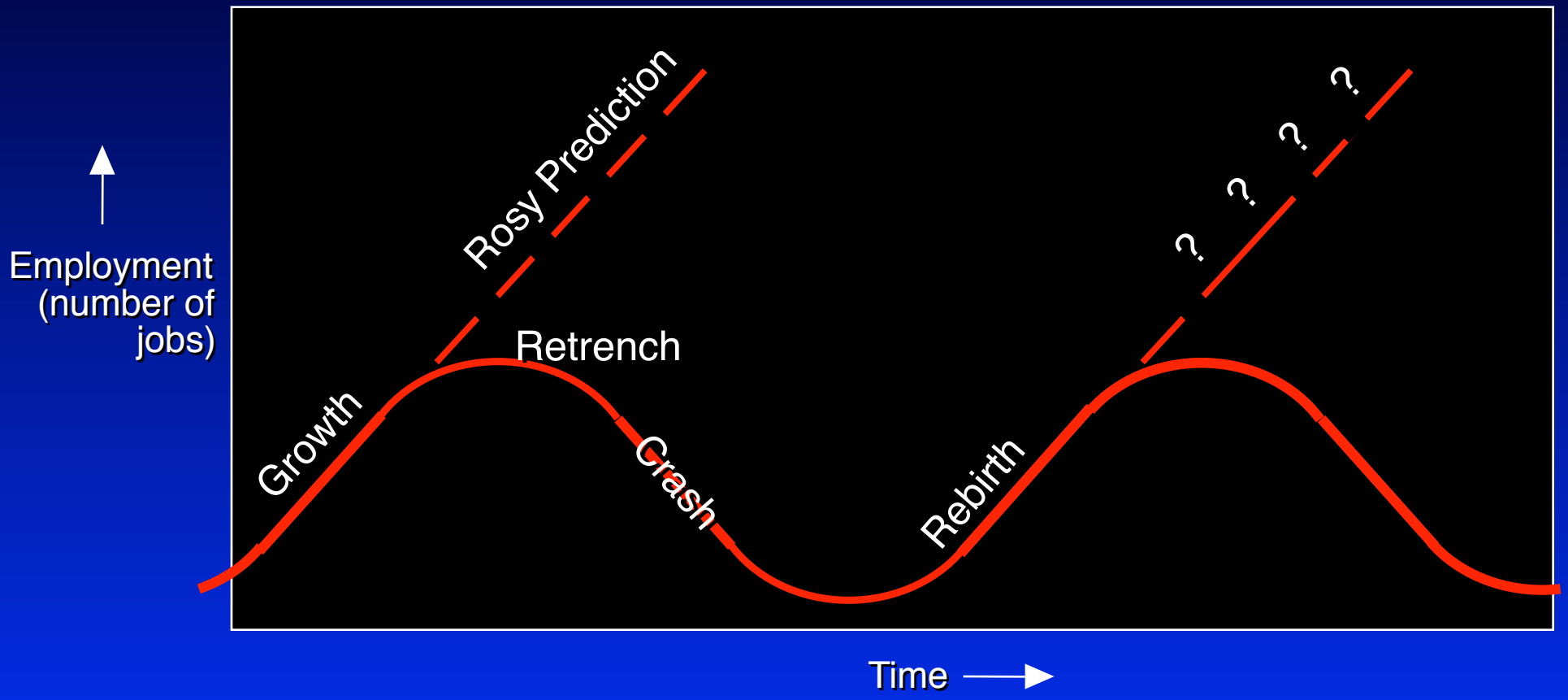
Geoscience Careers

Survival Training

- Strong basic-discipline training
- Constant updating and expansion of skills and knowledge
- Competitive-edge in several skills
  - Quantitative
  - Workstation (computer)
- Excellent communication skills
  - Oral, written, graphical

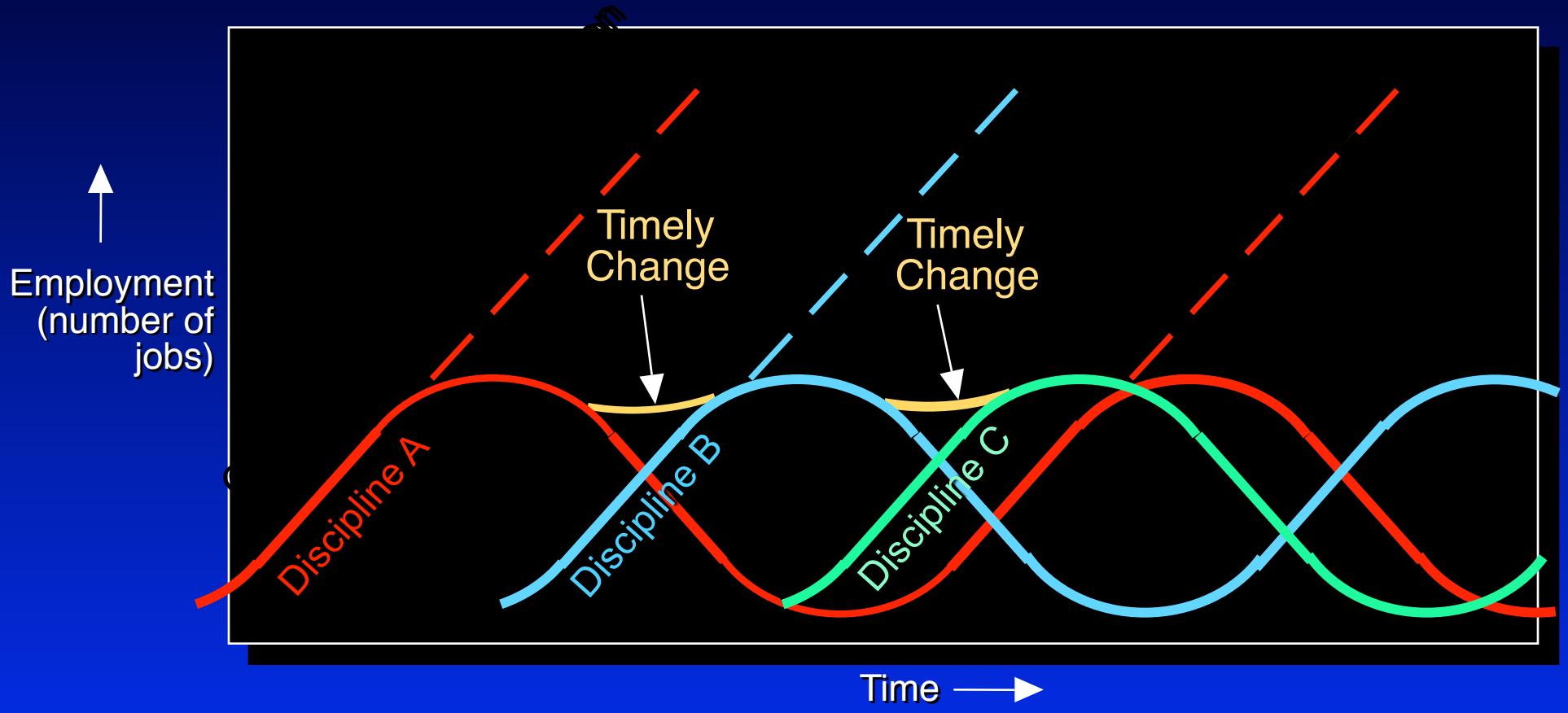
Cyclic Job Market

Typical of Today's Global Industries



Cyclic Job Market

Continuous Learning Facilitates Timely Changes



Geologic Mapping and Sampling

- Gravity
- Magnetics
- Seismic Reflection
- Geologic Mapping

American Petroleum Institute, 1986

Career Pa

Management/
Technical

Domestic/
Overseas

Exploration/
Producing

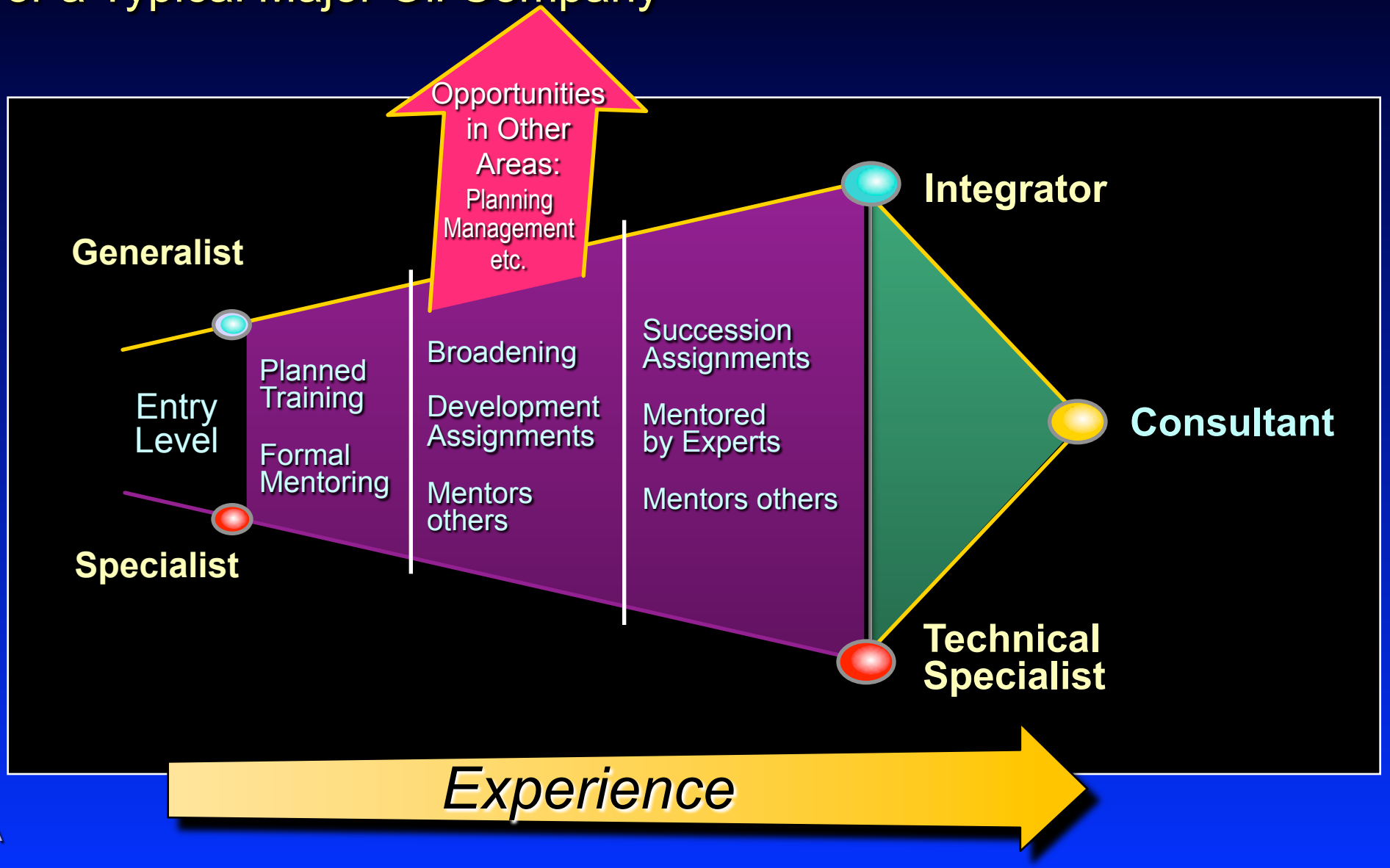
Research/
Operations

Transfers/
One Site

Lateral Mobility

Geoscience Professional Development

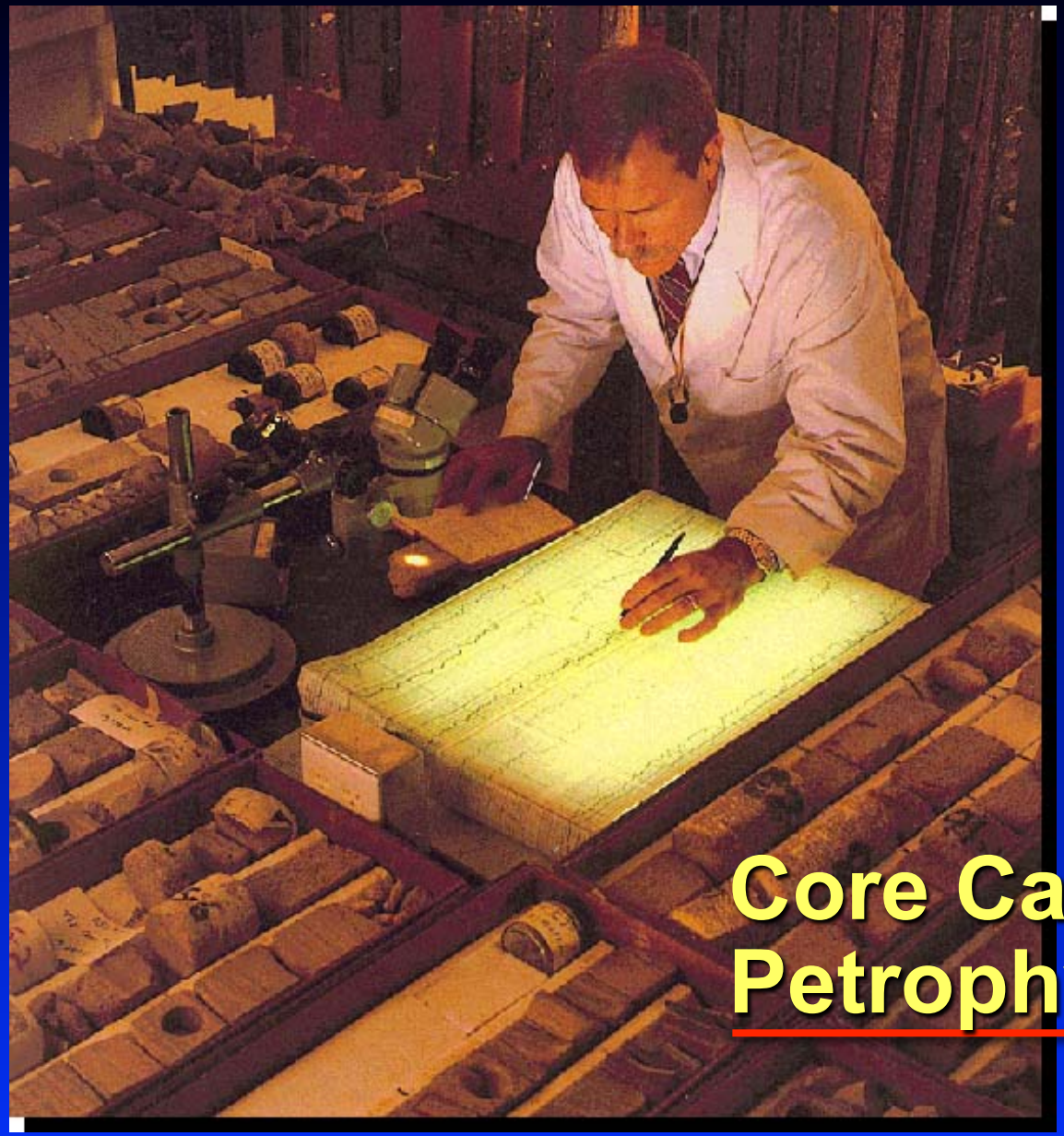
For a Typical Major Oil Company



Geologic Data Analysis

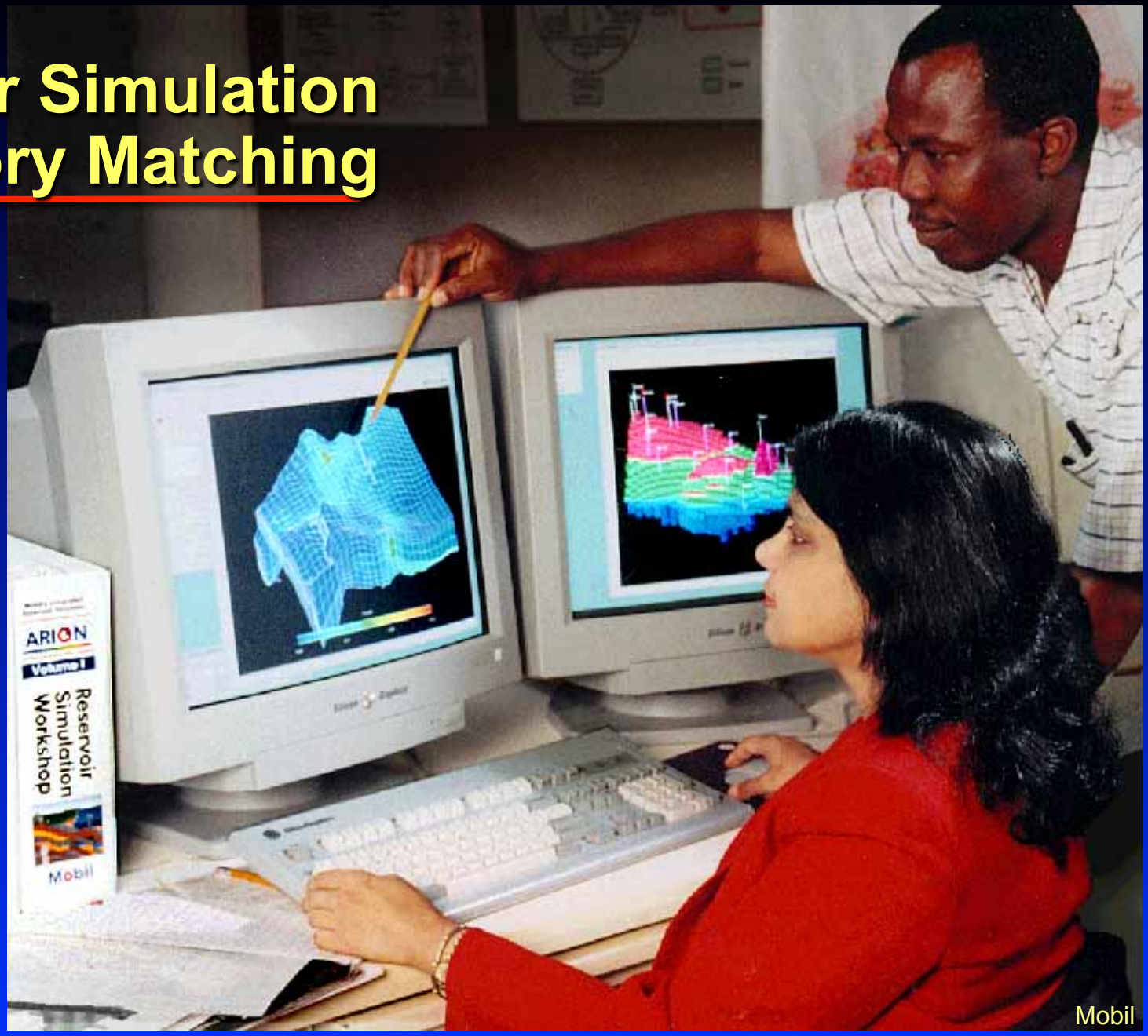
The Petroleum Geologist - A Detective

- Predicts where oil and gas occurs by ‘remote sensing’
- Uses tools to gather data - gravity and magnetics
  rock distribution and properties
  geophysical imaging
  computer processing
  & visualization
- Uses concepts to develop models:
  Anticlinal theory and petroleum systems
- Makes economic analysis and recommends drilling



Core Calibration for Petrophysical Analysis

Computer Simulation and History Matching



Mobil

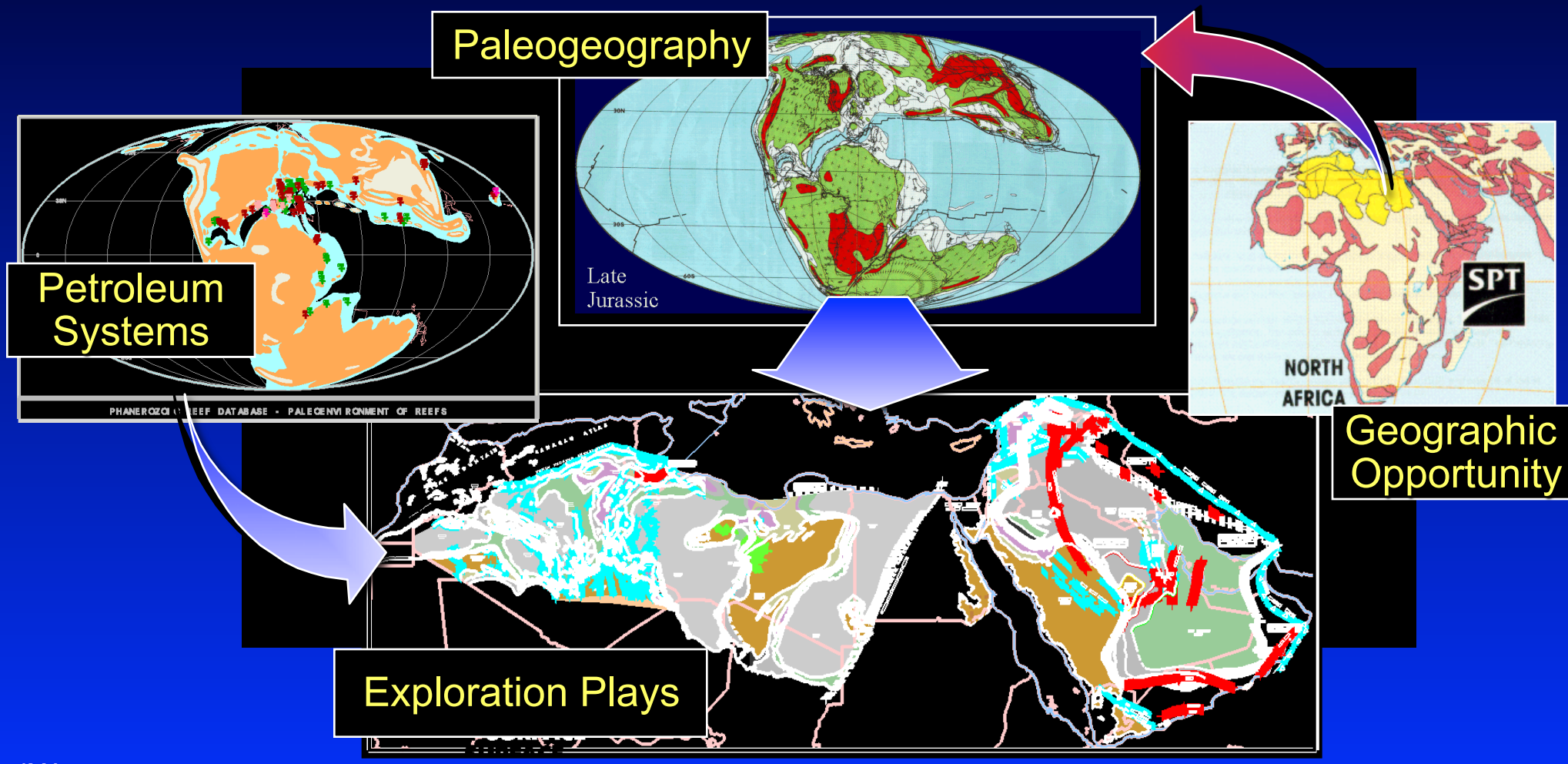
Industry Geoscience Careers: Exploration and Producing

- **Geophysics**
  - Provides an image of the subsurface and data useful for predicting rock type and the occurrence of petroleum.
- **Regional Geology**
  - Provides an understanding of which areas are productive, why they are productive, and where else we should look.
- **Basin Modeling**
  - Quantitative integrated models of the petroleum system: source, reservoir, seal, hydrocarbon charge.
- **Structural Geology**
  - Provides an understanding of the process of deformation of the subsurface due to external forces.
- **Stratigraphy**
  - Provides an understanding of processes creating sedimentary units.
- **Geochemistry**
  - Chemistry of petroleum and its sources to characterize the type, history and origin of petroleum.
- **Reservoir Characterization**
  - Describes the flow characteristics and attributes of subsurface reservoirs for enhanced exploitation.

Regional Geology:

Field Mapping and Literature Distillation
Computer Modeling of Paleogeography

Regional effort is focused on identifying
potentially effective petroleum systems



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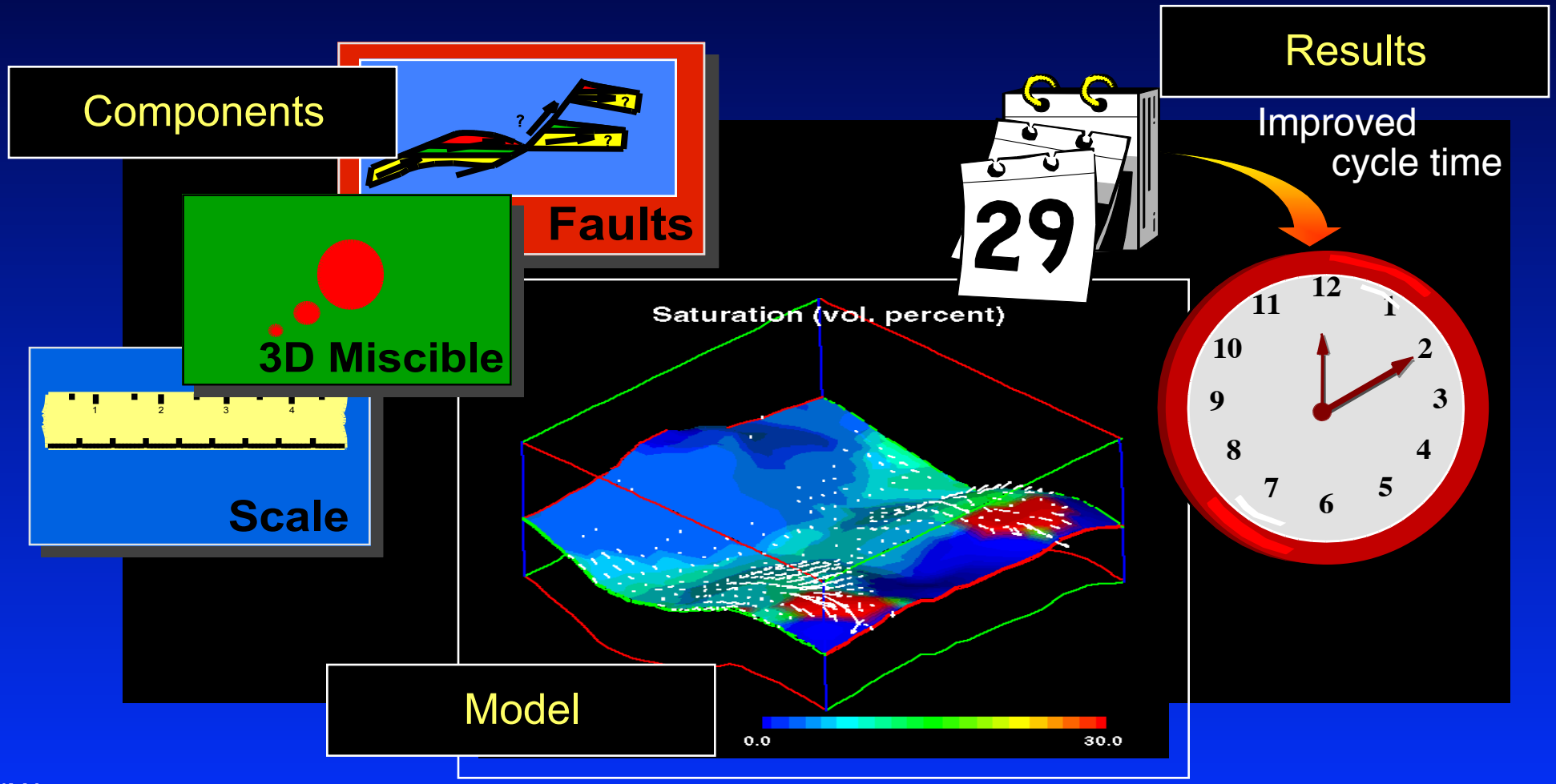
Basin Modeling:

Regional Geology
Fluid Flow and Geochemical Kinematics

Basin Modeling is a key component in understanding Petroleum Systems



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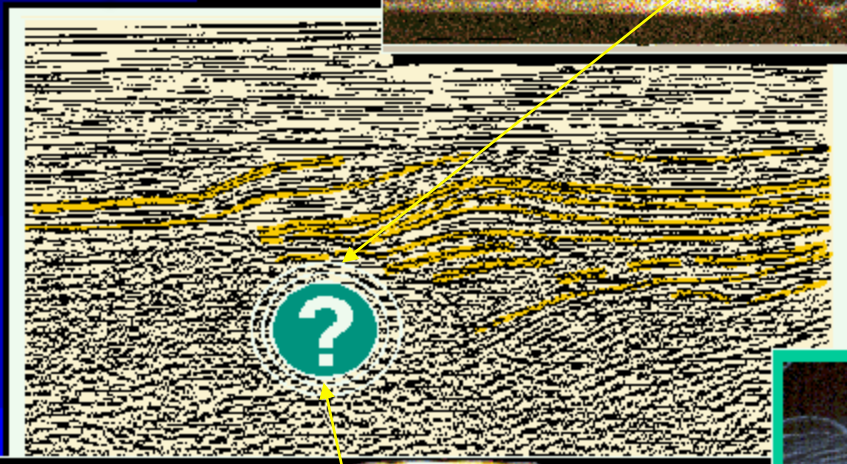
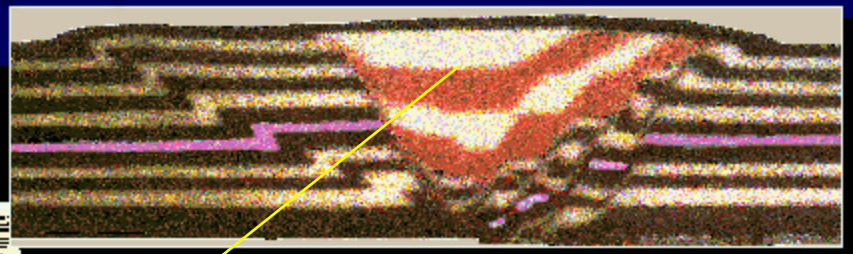
Structural Geology:

Case Histories: Outcrop and Seismic Modeling: Physical and Computer Stratigraphic Consequences

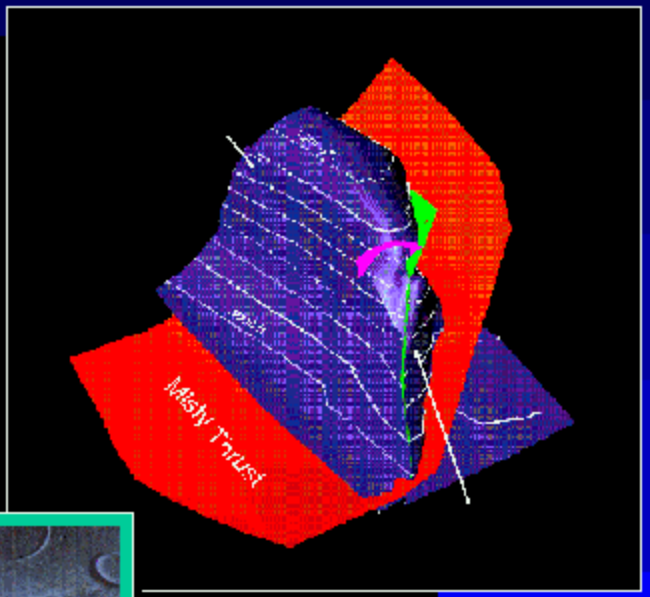
Understanding the process of deformation of the subsurface due to external forces

Seismic Interpretation

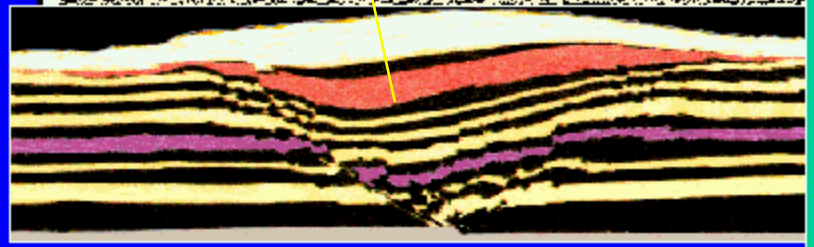




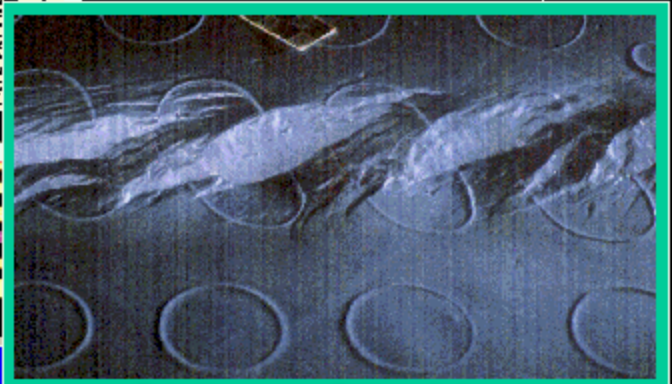
Physical Models



3D Kinematic Model Building



Physical Models as Guides to Interpretation



Oblique Slip Model

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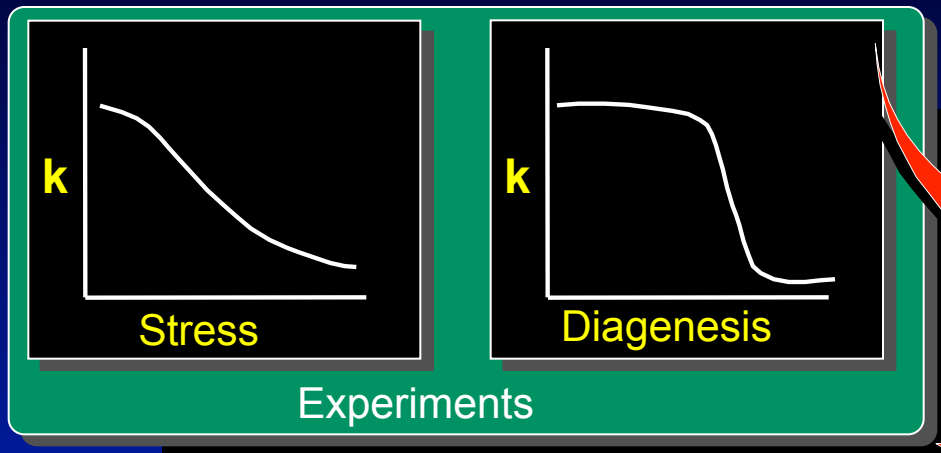
Faults as Seals and Conduits:

Seeking an understanding of petroleum migration

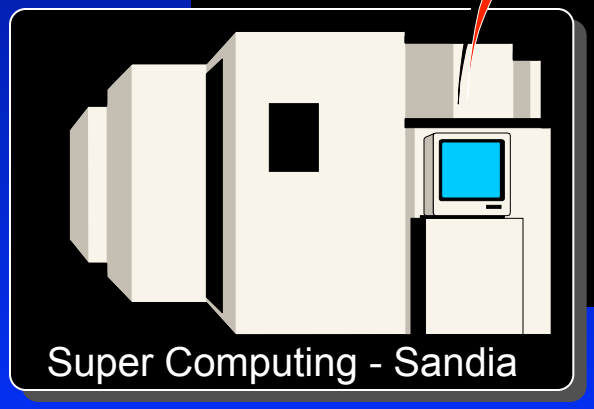
Structural Geology
Fluid Flow

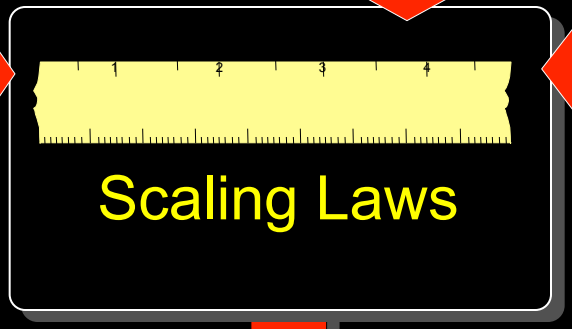


Model
$k = f(\sigma, T, X)$

k

Stress Fields





Modeling Algorithm

Field Test

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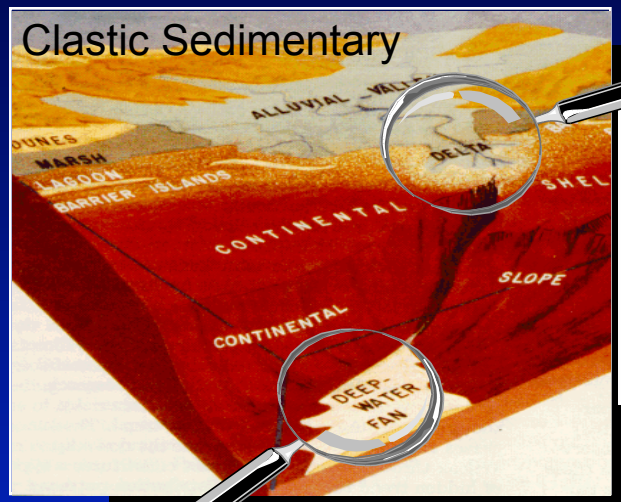
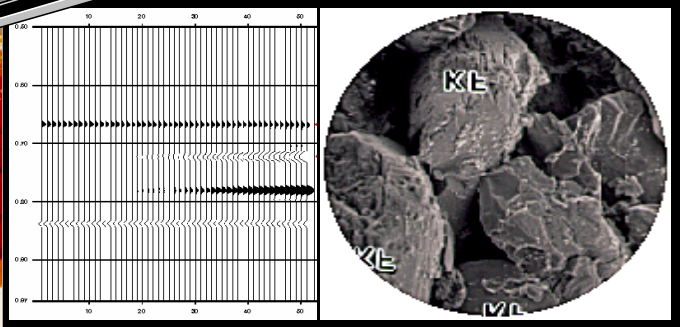
Stratigraphy:

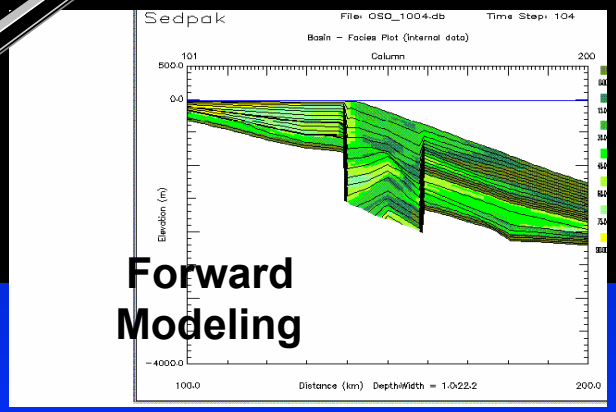
Depositional Systems
Sequence Stratigraphy
Petrophysics and Paleontology

Understanding the processes creating sedimentary units

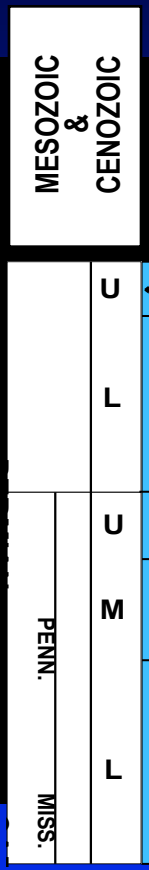




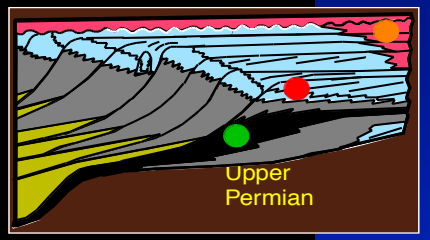
Rock Physics

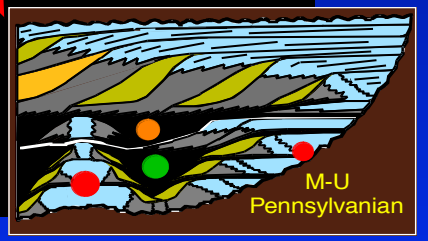


Sedimentary Modeling



Record missing due to erosion:
Must reconstruct history from regional data





Carbonate Analogues

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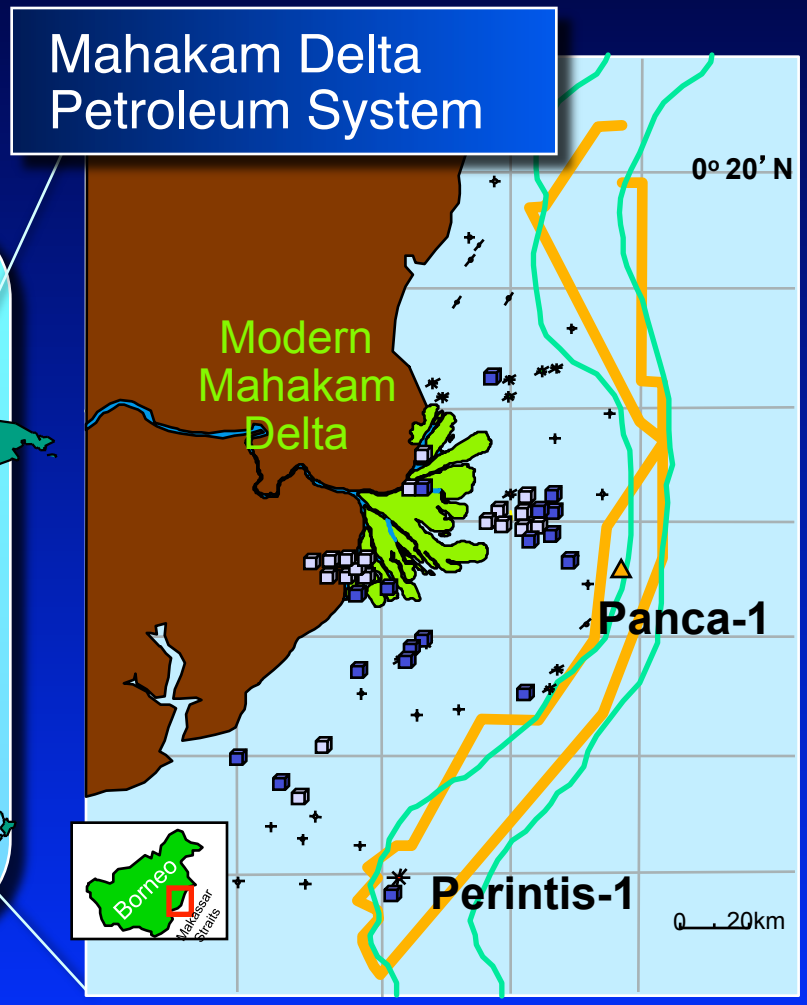
Clastics:

Paleogeography and Biological Systems
Depositional Systems and Stratigraphy Source
Reservoir, Seal and Burial History

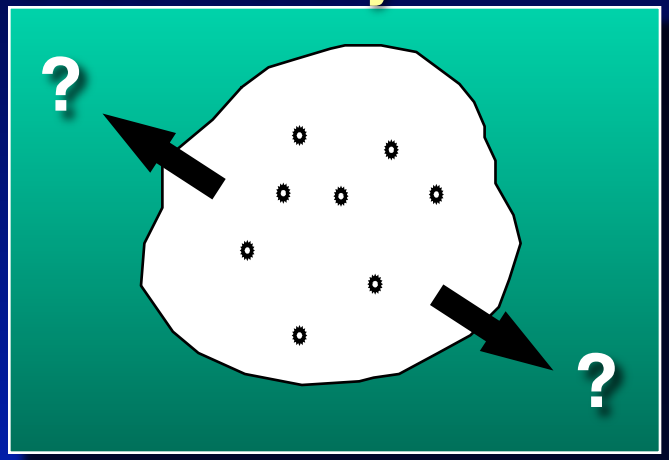
Example: Coaly Source Rock Predictions



Carbonates:

Sedimentology and Diagenesis
Fluid Flow
Computer Simulation

Case History

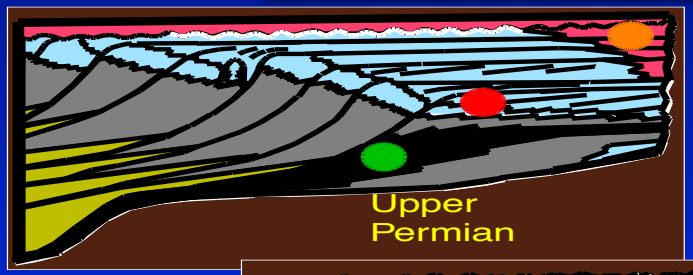


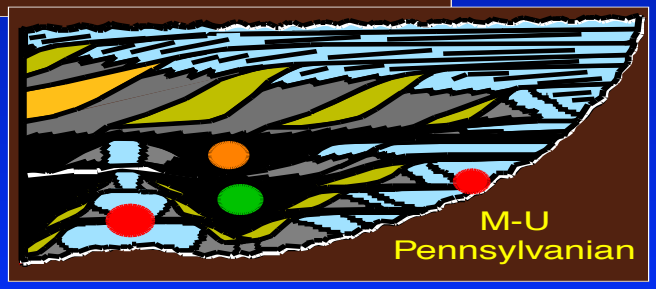
Future Opportunities

Middle East

Former Soviet Union

Pacific Rim



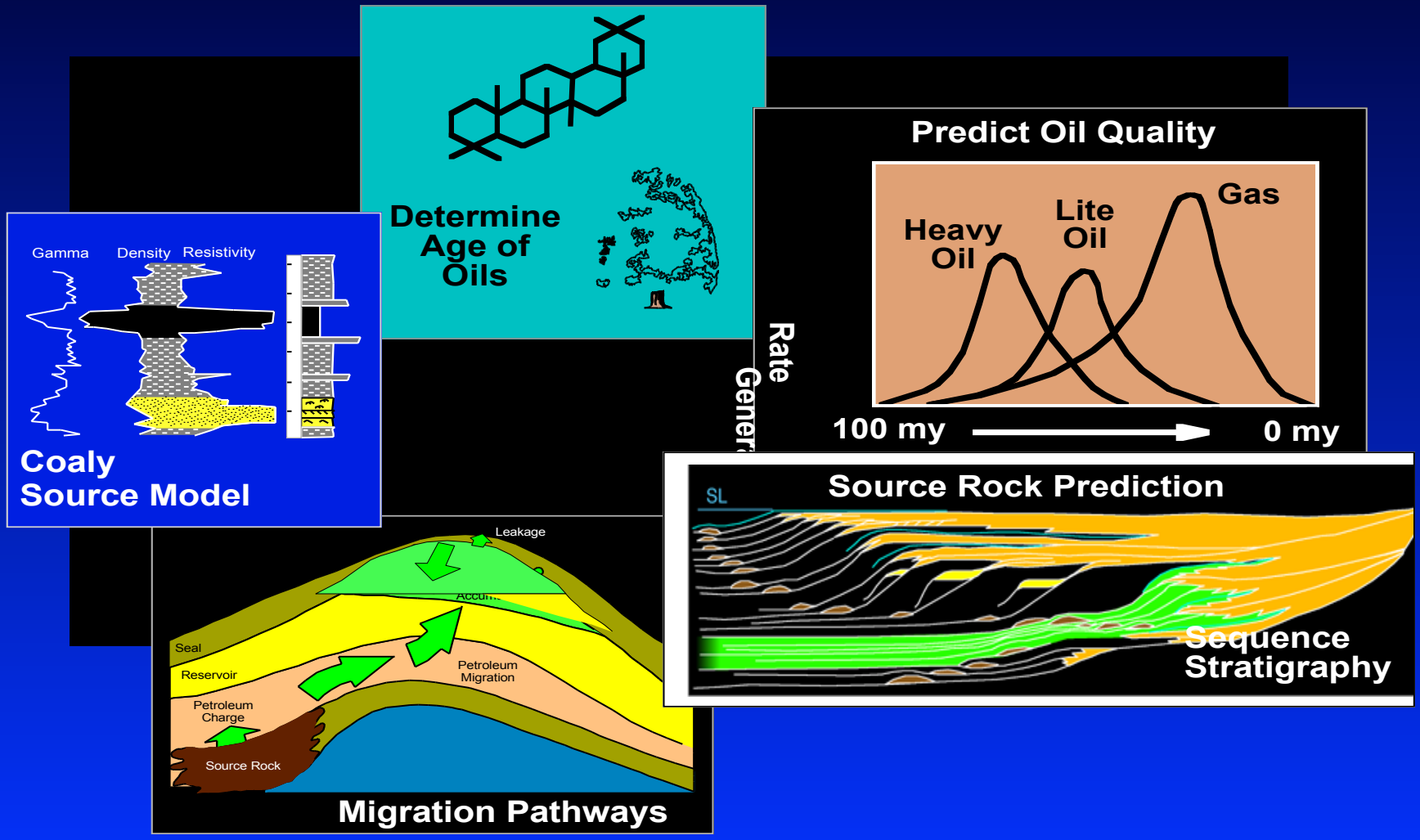


- Age Based Models
- Hierarchy of Stratigraphic Scales

Exploration Geochemistry:

Inorganic and Organic Sedimentology

Characterizing the type, history and origin of petroleum



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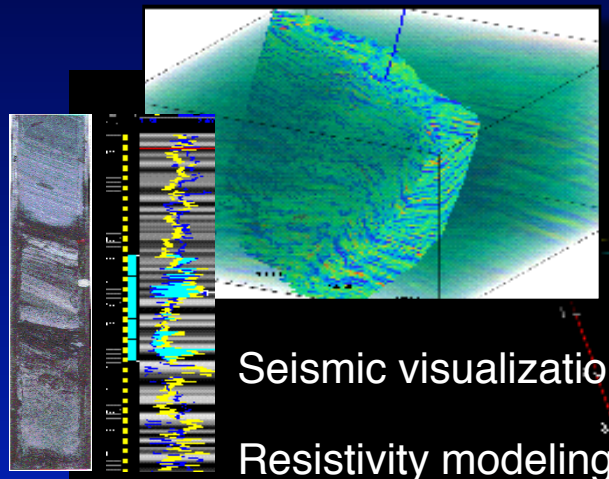
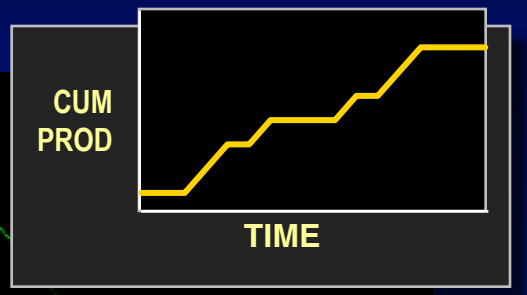
Reservoir Characterization:

Sedimentology
Fluid Flow
Computer Simulation

Reservoir Characterization focuses on data integration to model reservoir architecture and flow properties





Seismic visualization

Resistivity modeling

Outcrop studies

Geostatistics

Upscaling

Interpretation aids

Fracture characterization

Production data inversion

Optimization

QUANTIFIED UNCERTAINTY

Volumetric and reserve estimation

Geosteering

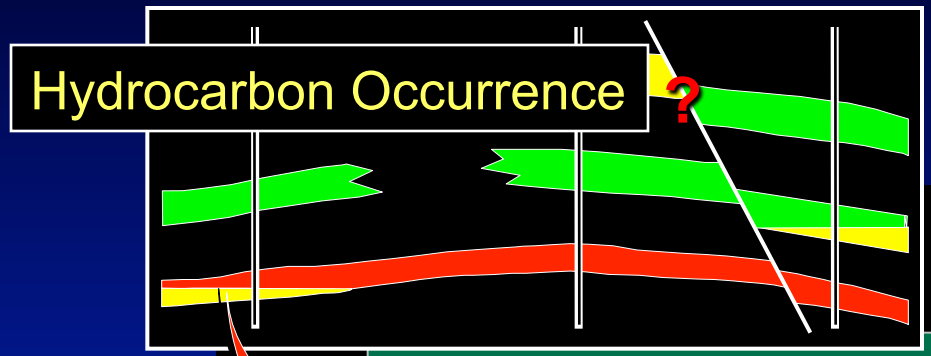
Reservoir simulation

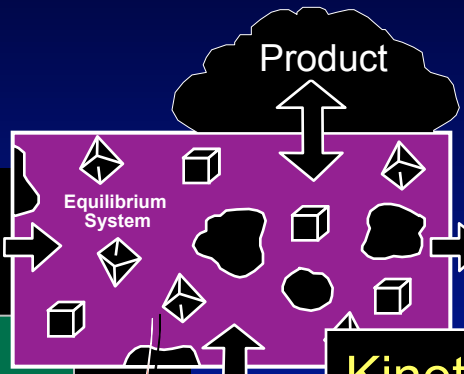
JMA

Producing Geochemistry:

Geochemistry of Hydrocarbons, Fluid Flow, Sedimentology

Correlation of hydrocarbon types to define reservoir connectivity

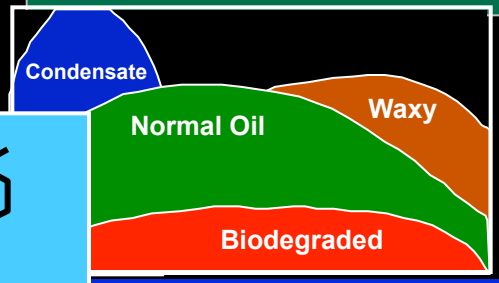


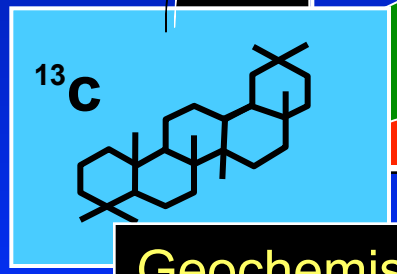


Kinetic Models

Project Goals:

- ✓ Predicting Reservoir Continuity
- ✓ Predicting HC Quality
- ✓ Modeling Frac & Remediation
- ✓ Training





Geochemistry

Applications:

- ★ Exploitation / Development
- ★ Producing

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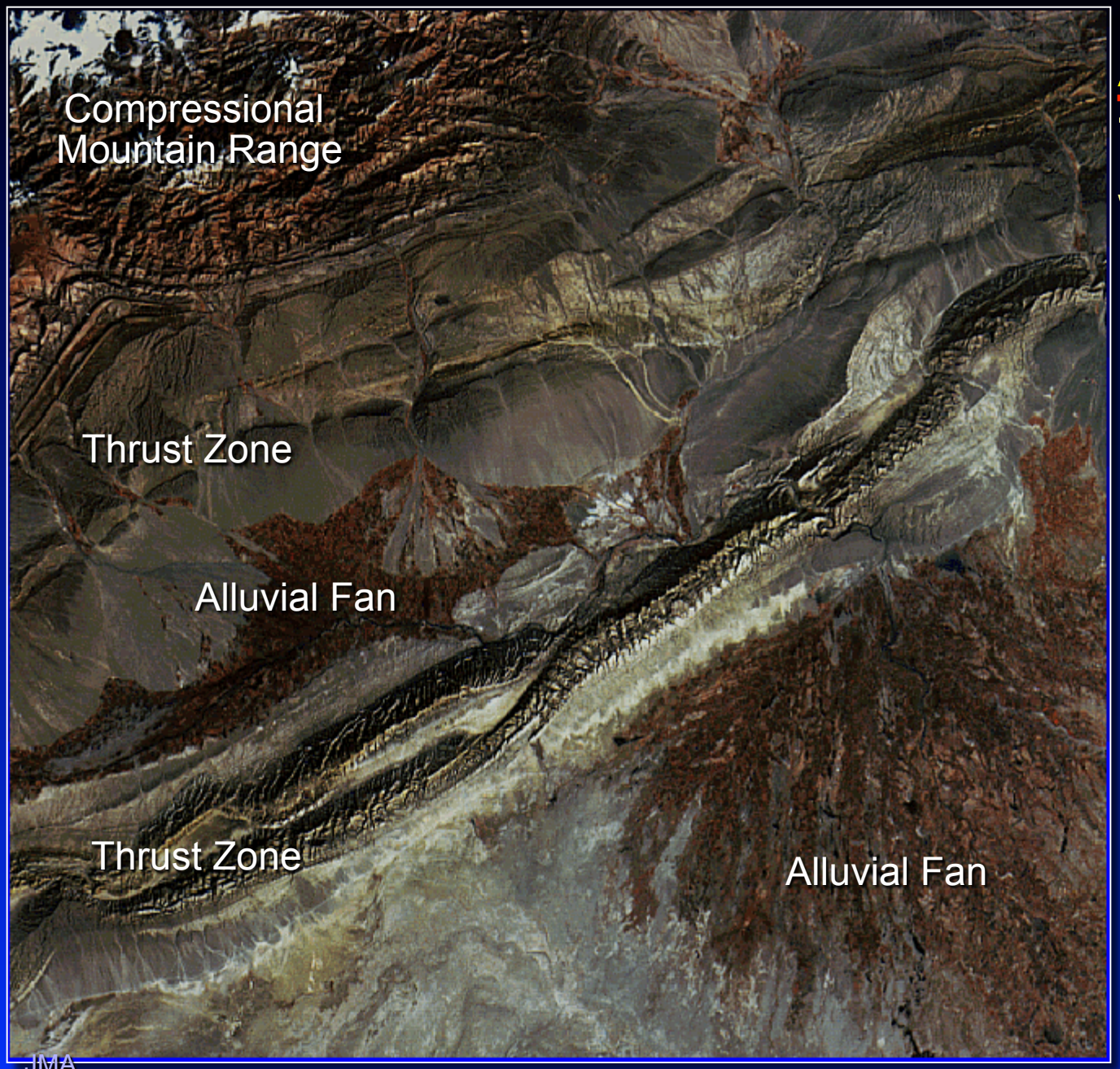


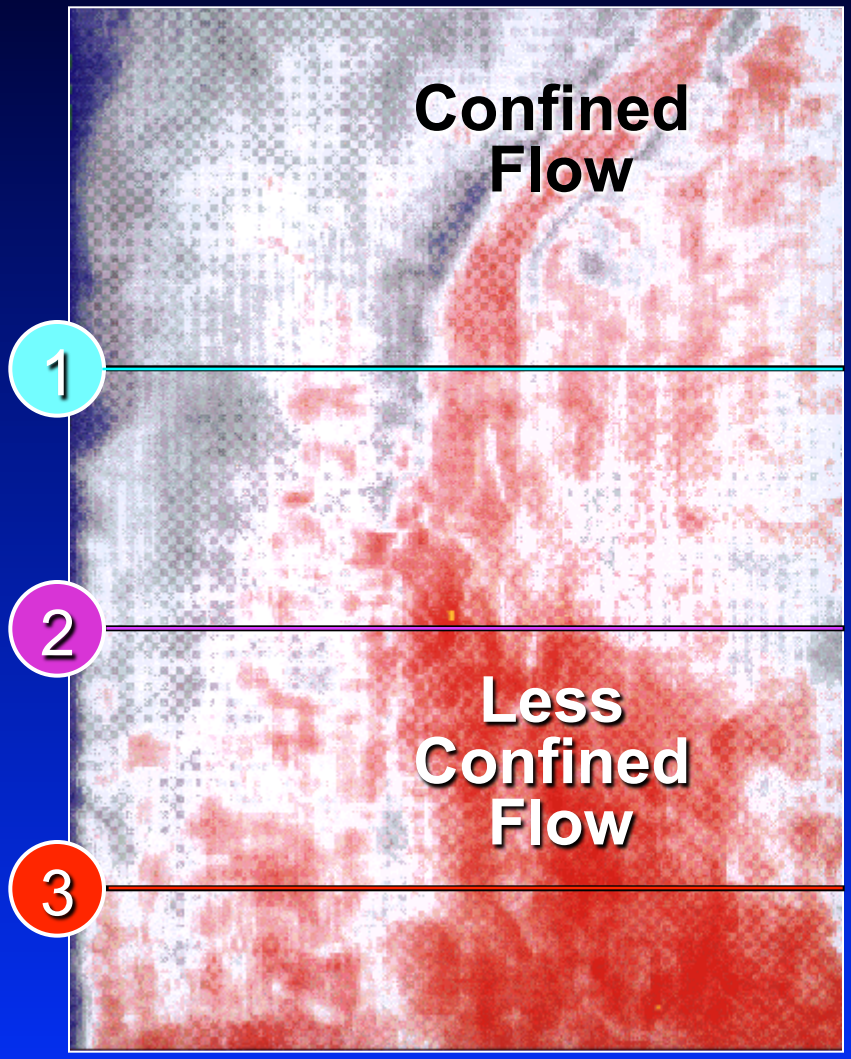
Aerial Photo

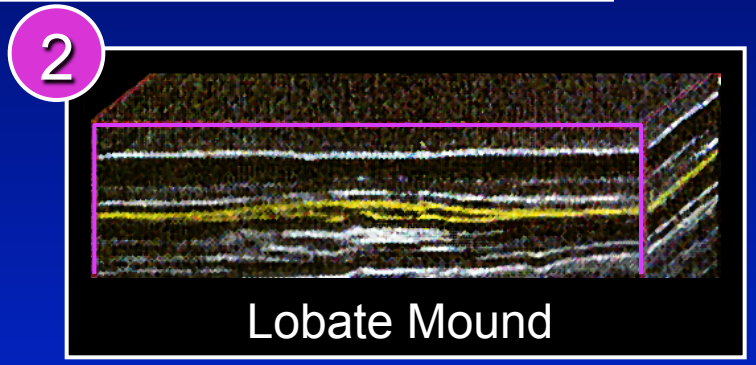
Traditional Tool with Improved Resolution

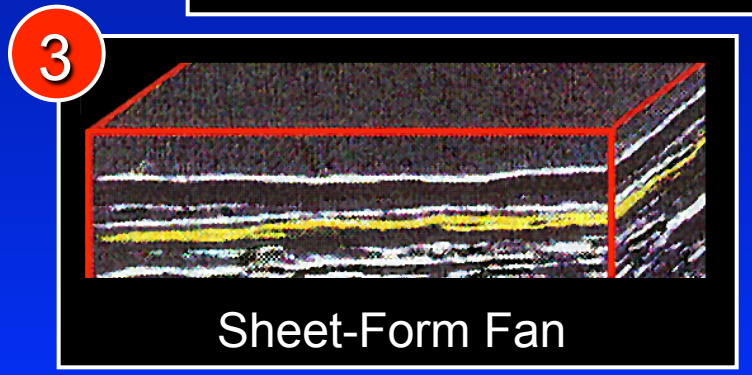
- Aerial photo for mapping patterns
- Field check for geological detail

3D Seismic Image - Submarine Fan

New Tools → Better Data → Improved Understanding



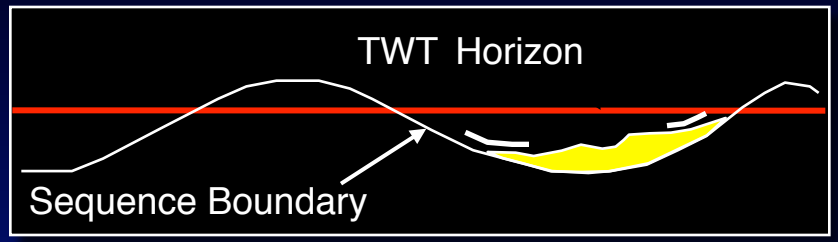


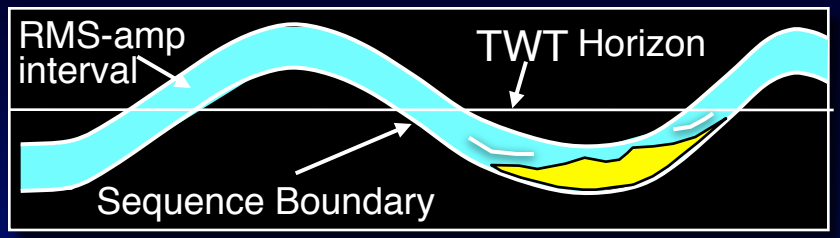


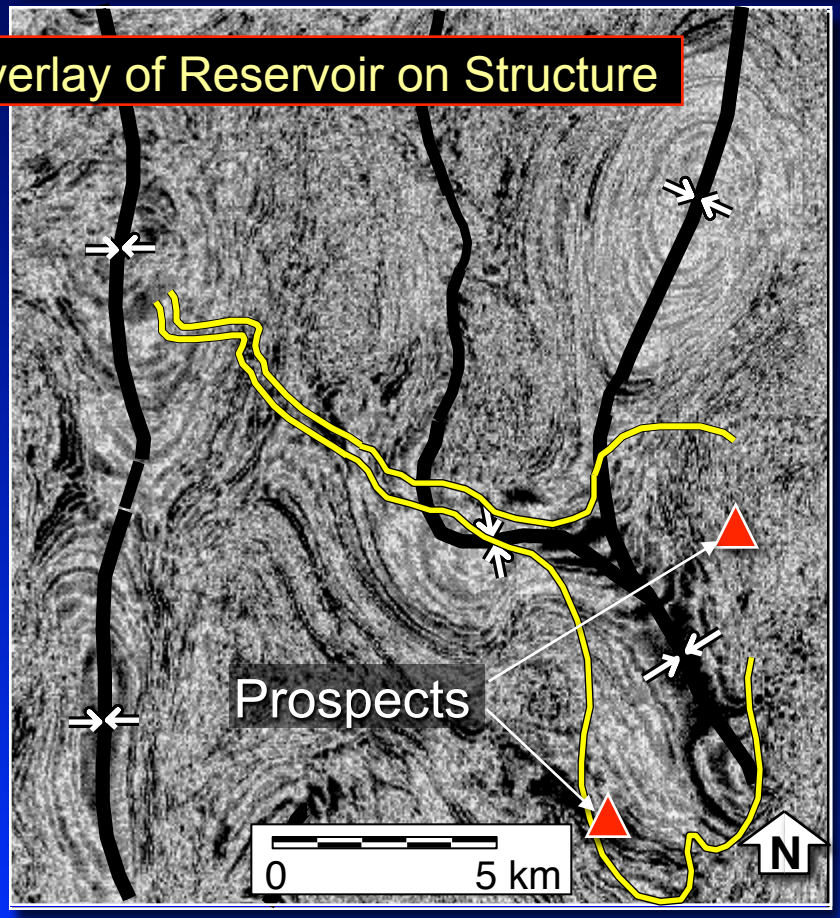
JMA

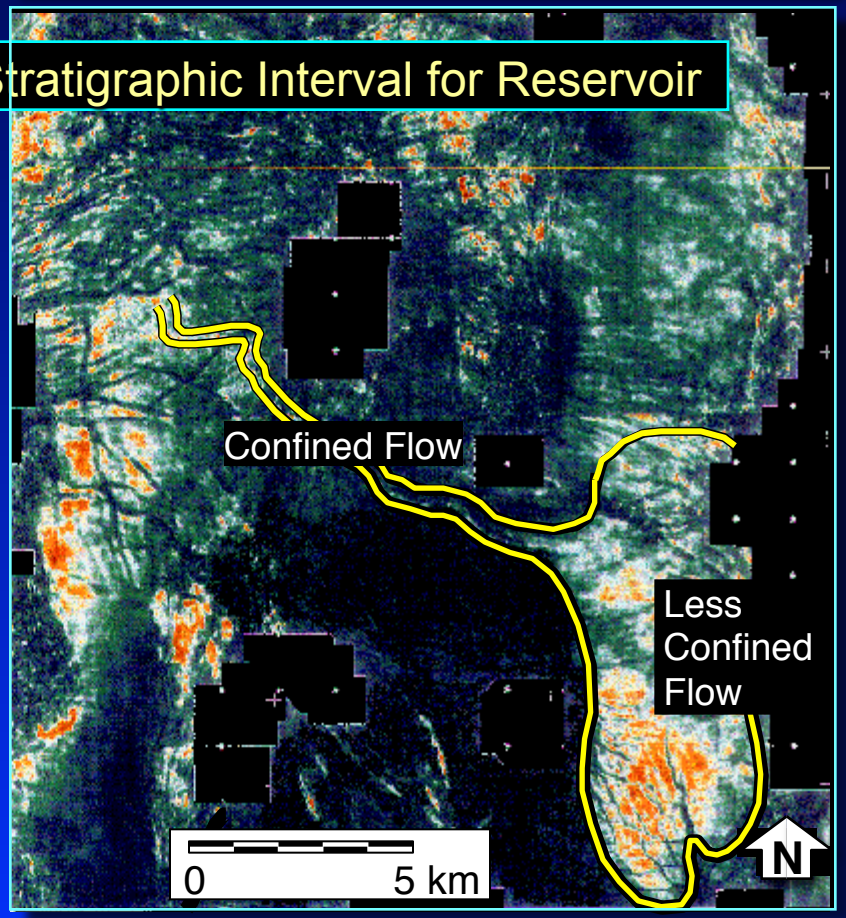
Armentrout *et al.*, 1996

Prospect Mapping using 3D Seismic





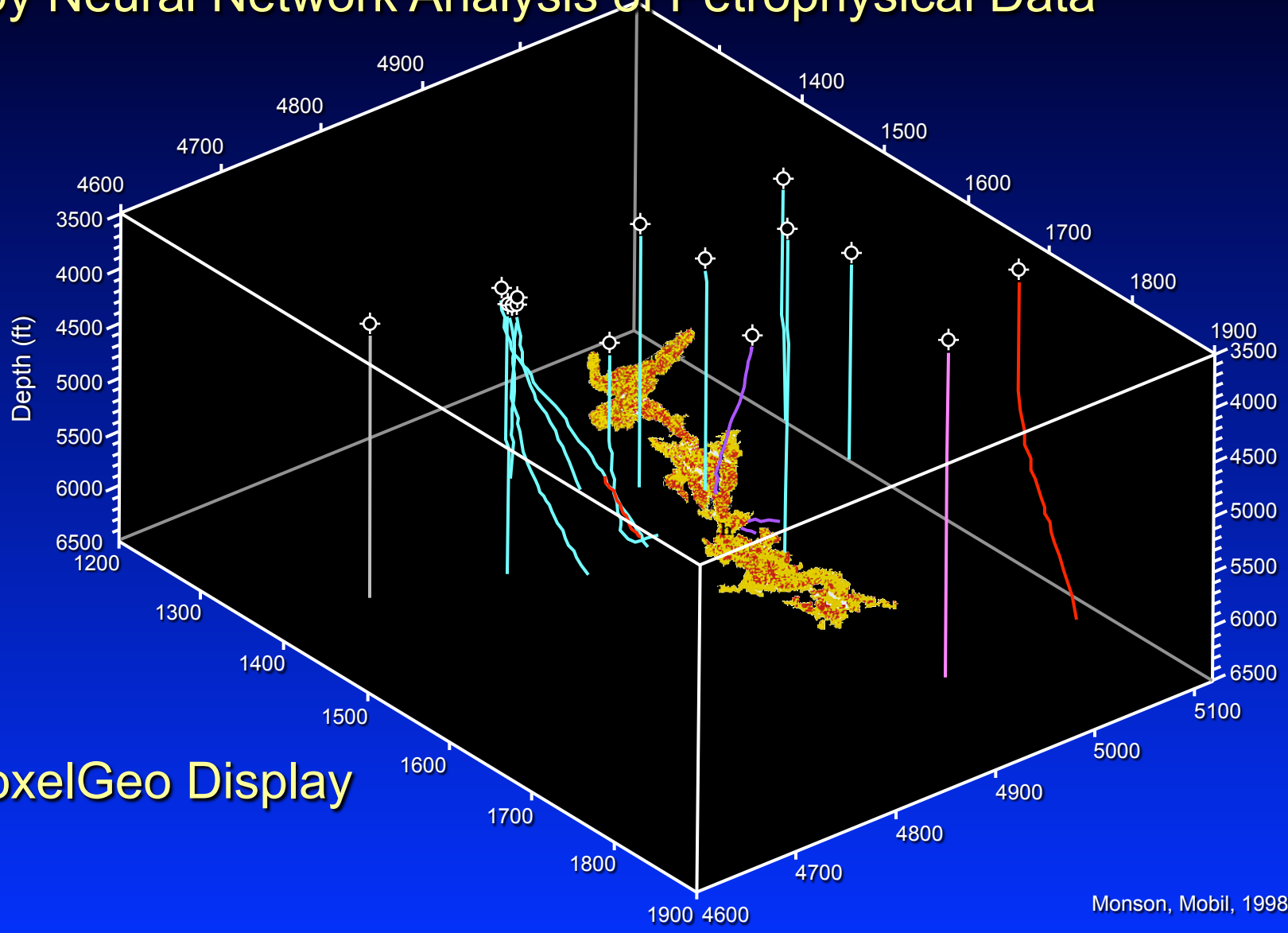




JMA

3D Seismic Image of Channel Sand

Calibrated by Neural Network Analysis of Petrophysical Data

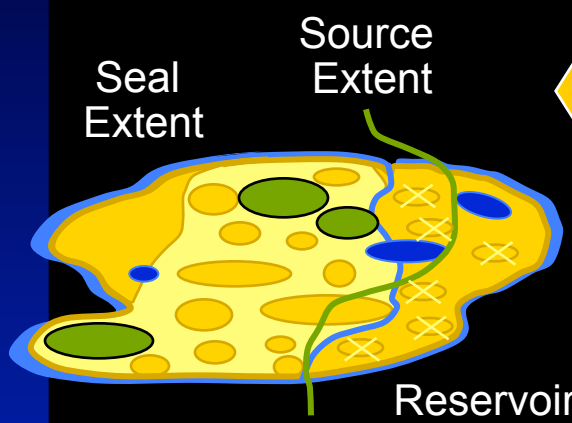


VoxelGeo Display

Monson, Mobil, 1998

Petroleum System, Play Definition, and Risk

Play Maps



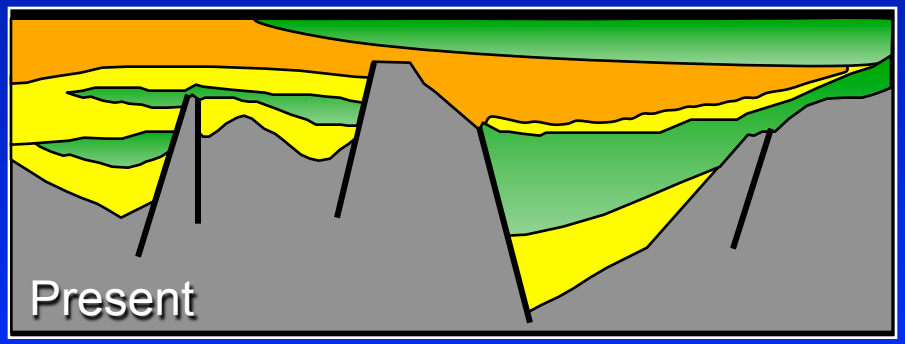
Generation and Migration

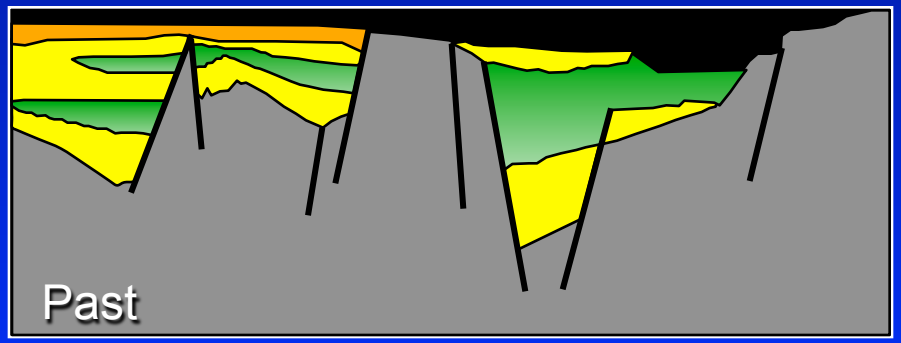
Timing Sheets

Time → Present

- Components
- HC Charge
- Preservation

Critical Reconstruction





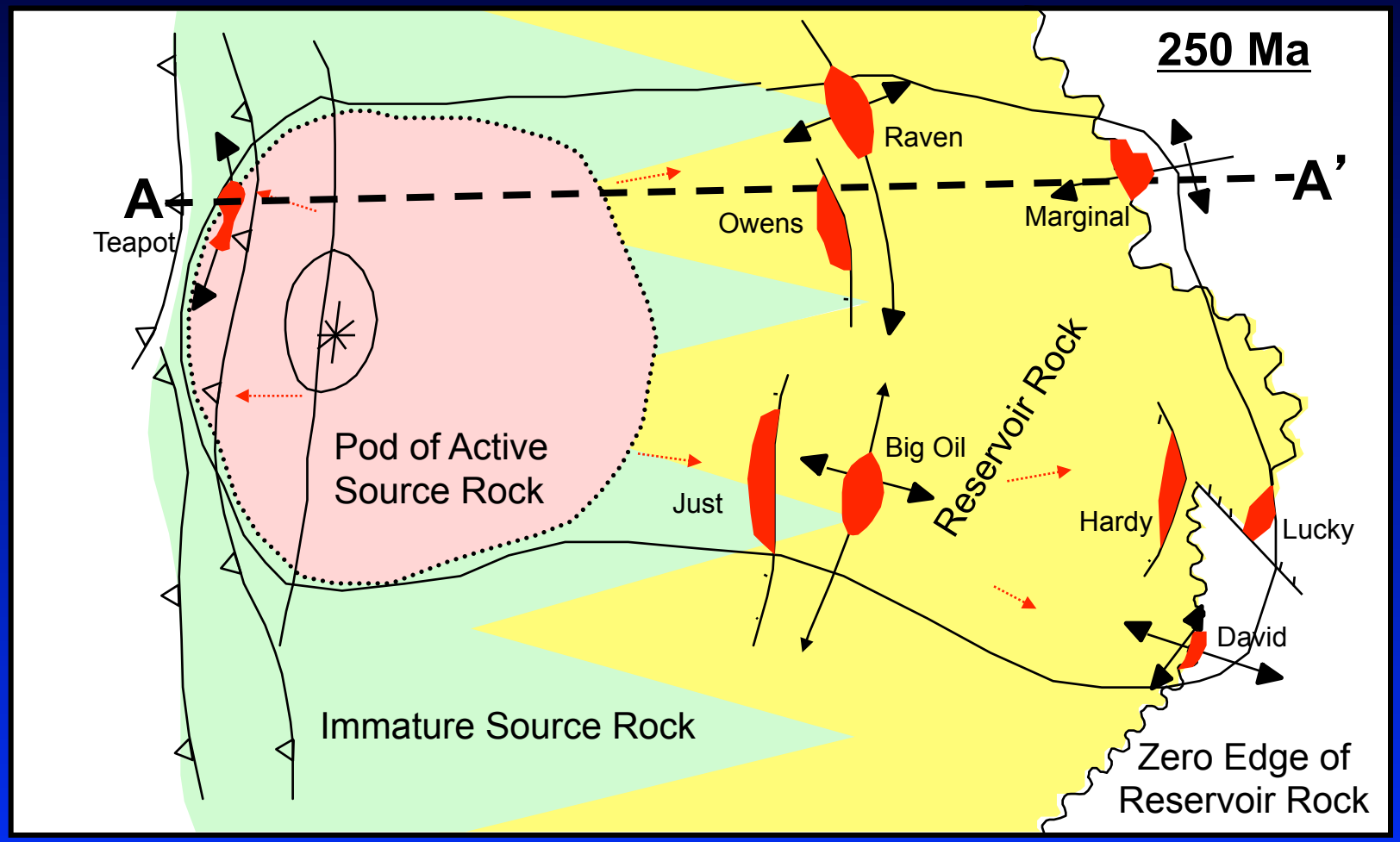
Jeff Brown, Mobil, 1999

Petroleum System Definition

The essential elements and processes and all genetically-related hydrocarbons that occur in petroleum shows, and accumulations whose provenance is a single pod of active source rock.

Elements	Processes
Source Rock	Generation
Migration Route	Migration
Reservoir Rock	Accumulation
Seal Rock	Preservation
Trap	

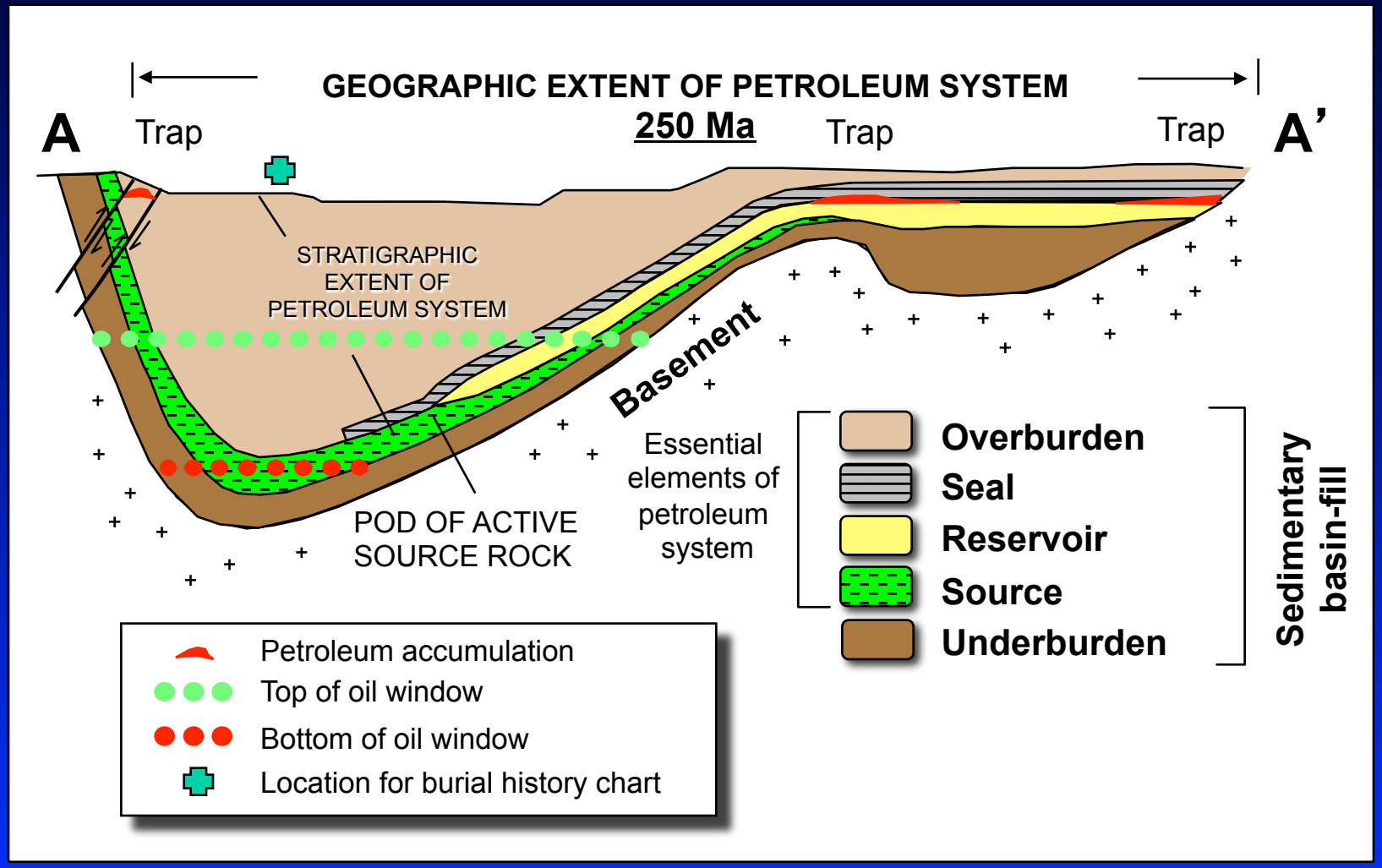
Deer-Boar Petroleum System at Critical Moment



Magoon and Dow, 1994

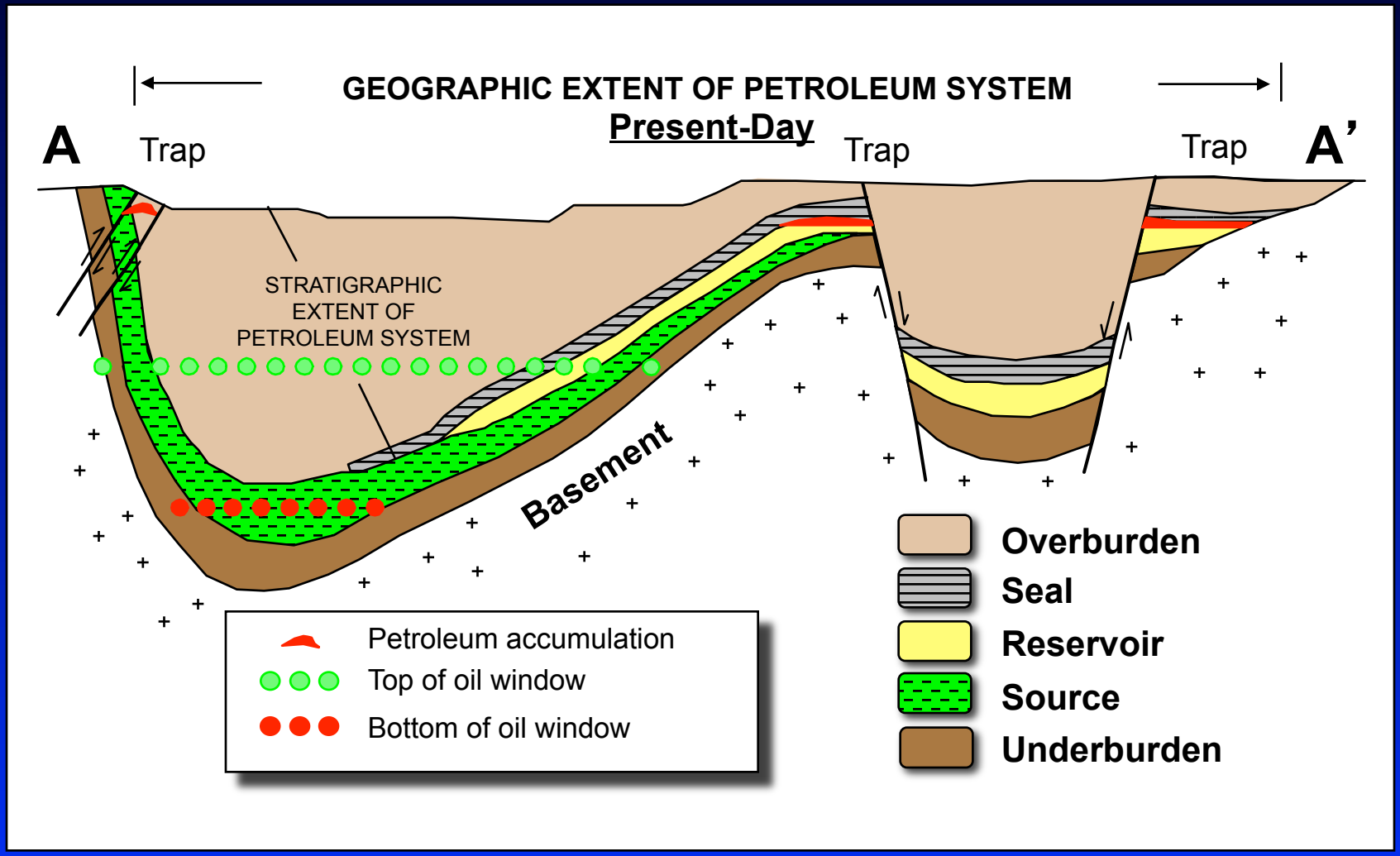
Petroleum System at Critical Moment

Critical Moment = Time of Expulsion/Migration



Magoon and Dow, 1994

Present-Day Petroleum System



Magoon and Dow, 1994

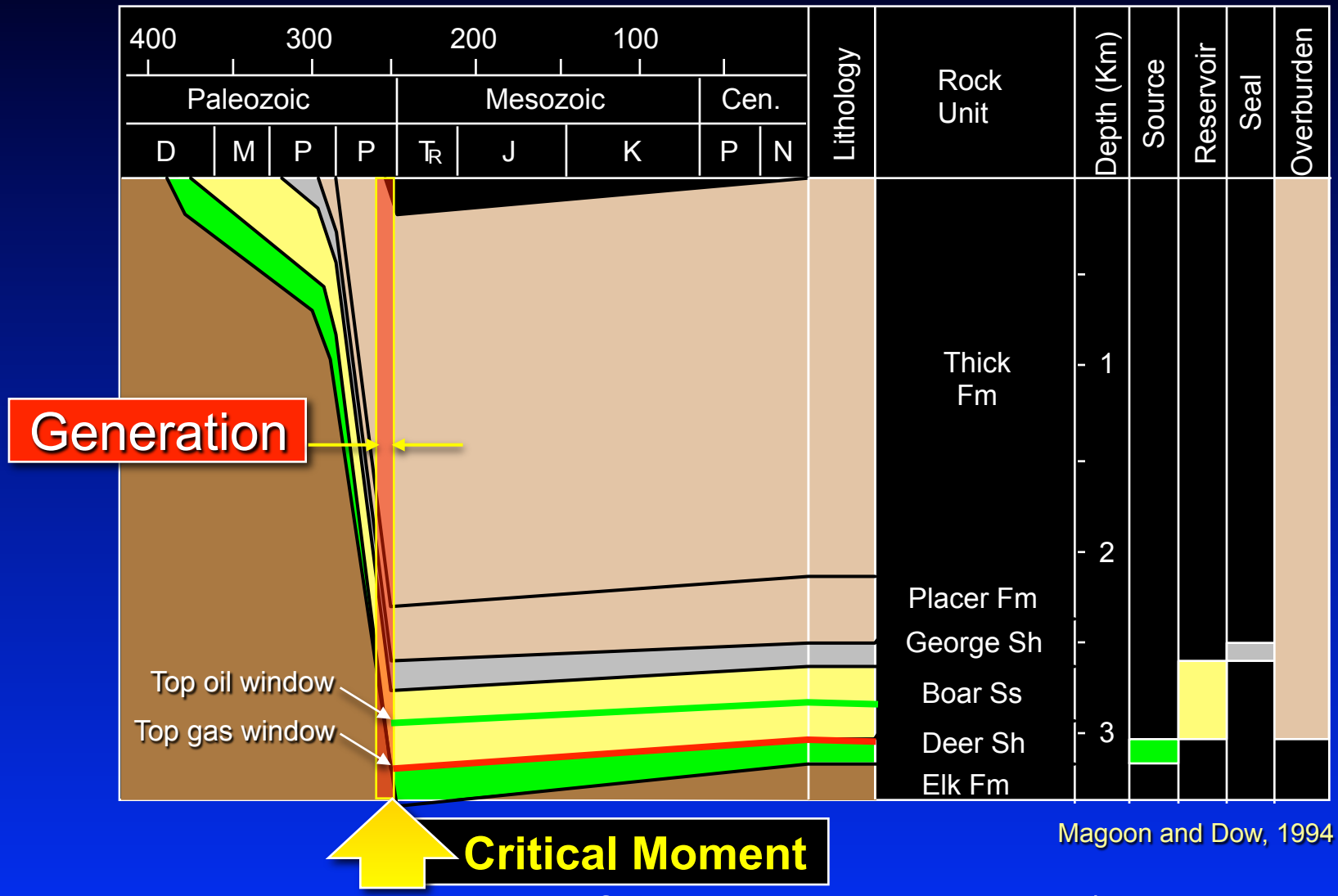
Oil and Gas Fields of Deer-Boar Petroleum System

Inventory of Accumulations

Field Name	Date discovered	Reservoir rock	API Gravity (ºAPI)	Cumulative oil production ($x10^6$ bbl)	Remaining reserves ($x10^6$ bbl)
Big oil	1954	Boar Ss	32	310	90
Raven	1956	Boar Ss	31	120	12
Owens	1959	Boar Ss	33	110	19
Just	1966	Boar Ss	34	160	36
Hardy	1989	Boar Ss	29	85	89
Lucky	1990	Boar Ss	15	5	70
Marginal	1990	Boar Ss	18	12	65
Teapot	1992	Boar Ss	21	9	34

Magoon and Dow, 1994

Burial History Chart

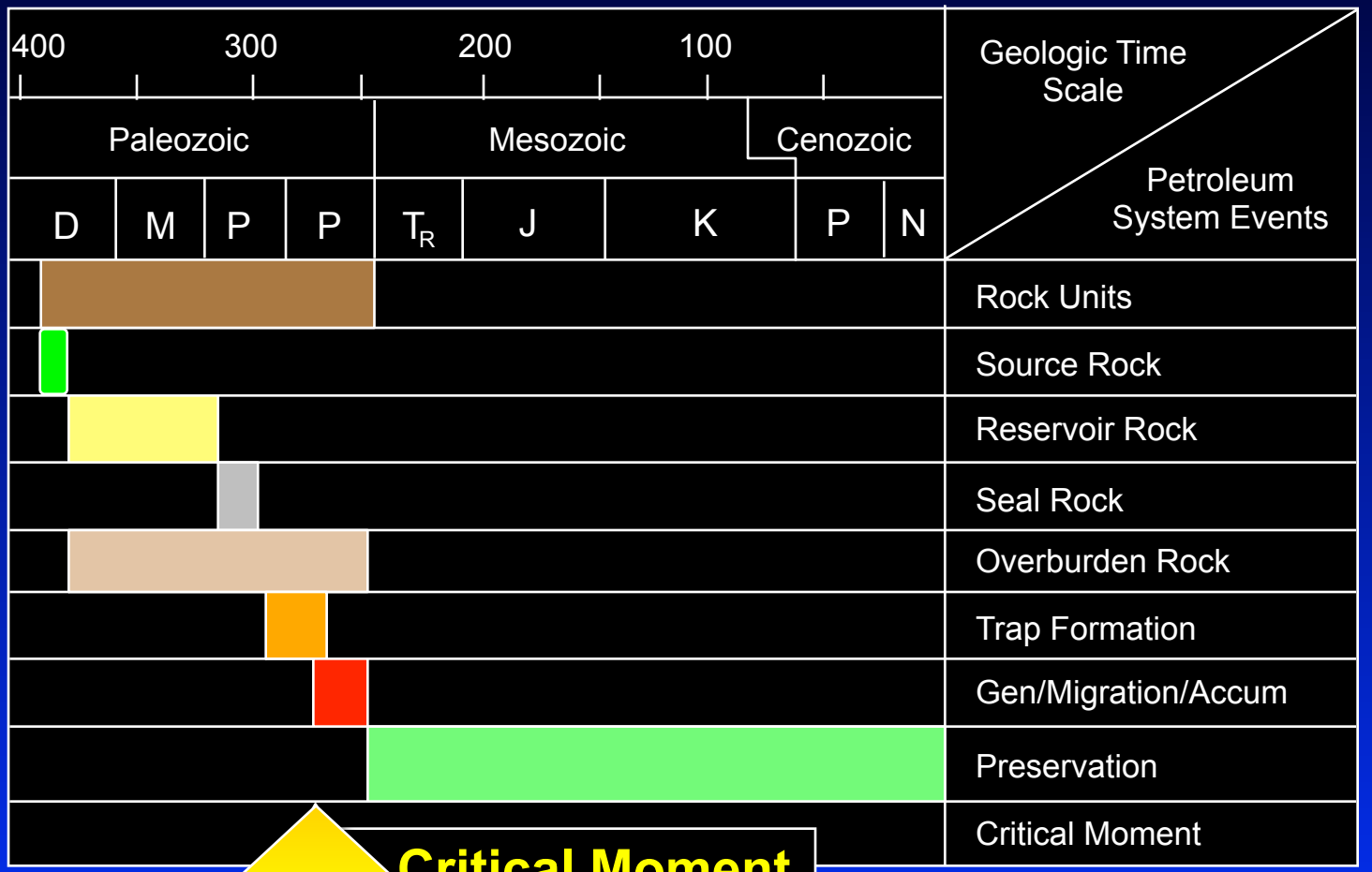


Magoon and Dow, 1994

Time of Expulsion and Migration. (Trap must already exist)

Petroleum System Events Chart

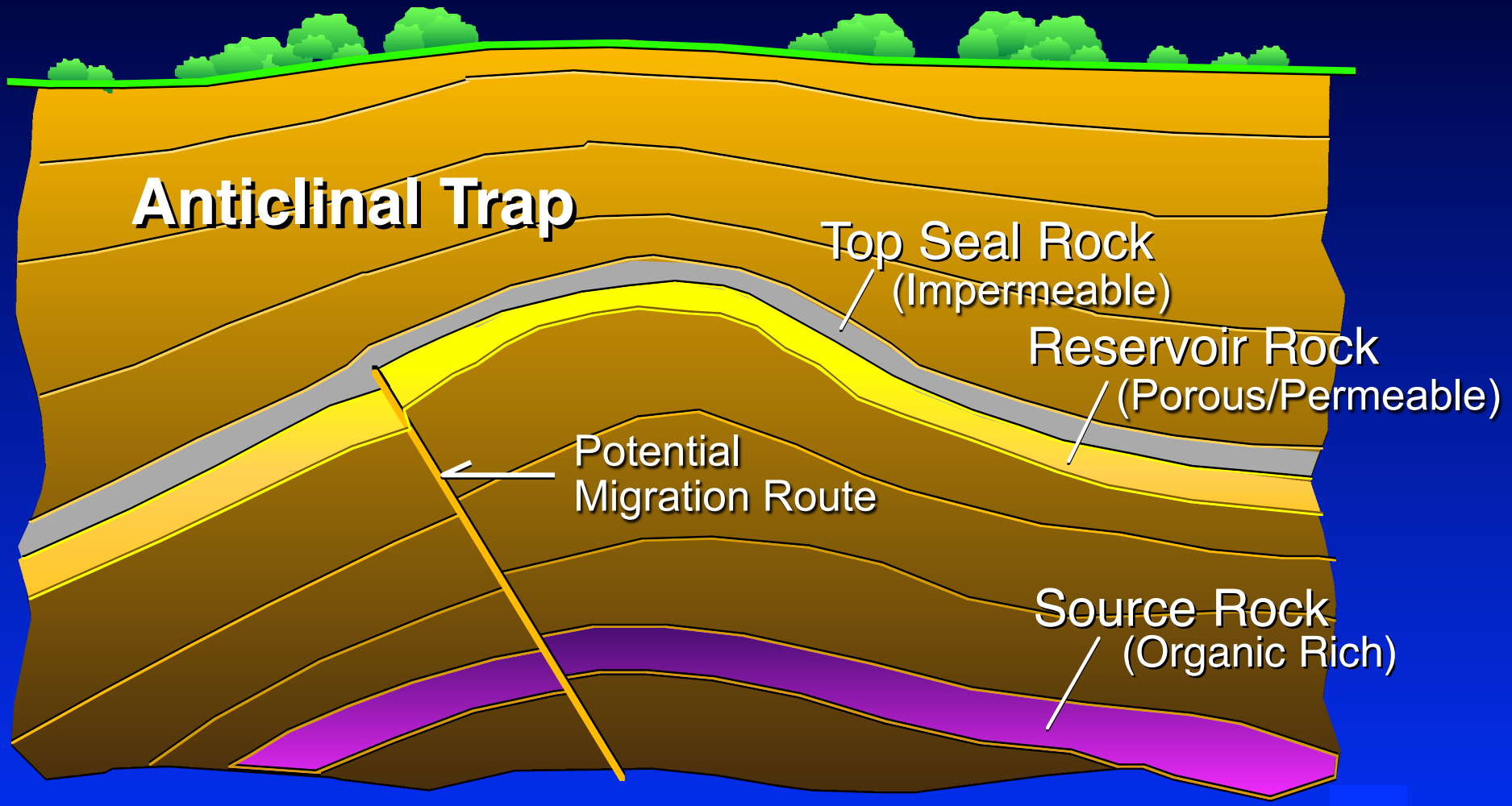
Timing of Elements and Processes



Magoon and Dow, 1994

Time of Expulsion and Migration. (Trap must already exist)

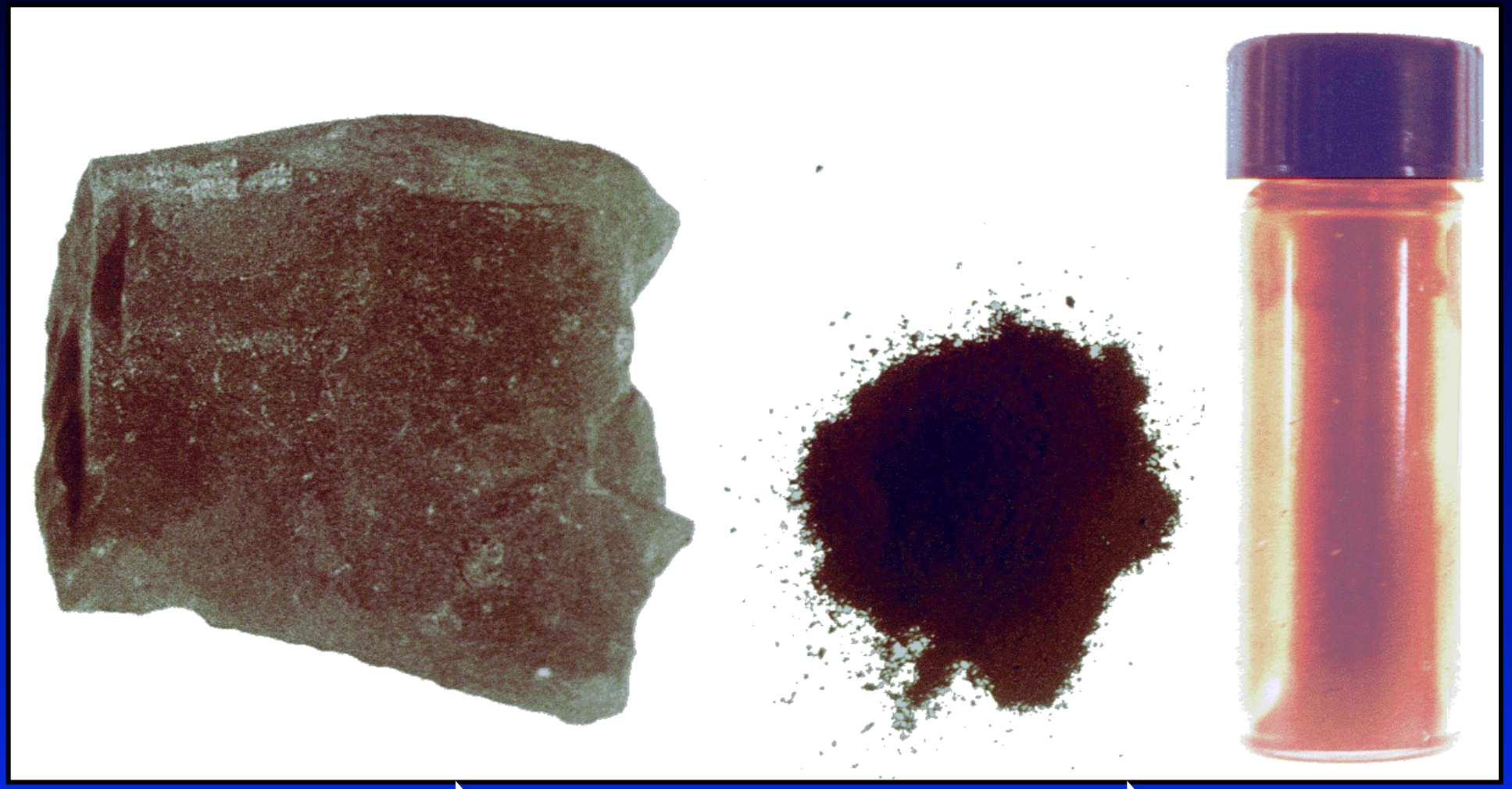
Petroleum System Elements



Petroleum System Elements

- Source Rock - A rock with abundant hydrocarbon-prone organic matter
- Reservoir Rock - A rock in which oil and gas accumulates:
  - Porosity - space between rock grains in which oil accumulates
  - Permeability - passage-ways between pores through which oil and gas moves
- Seal Rock - A rock through which oil and gas cannot move effectively (such as mudstone and claystone)
- Migration Route - Avenues in rock through which oil and gas moves from source rock to trap
- Trap - The structural and stratigraphic configuration that focuses oil and gas into an accumulation

The Origin of Petroleum



Organic-rich Source Rock → Thermally Matured Organic Matter → Oil

JMA

Source Rock for Petroleum

Organic-Rich

Thin Laminae

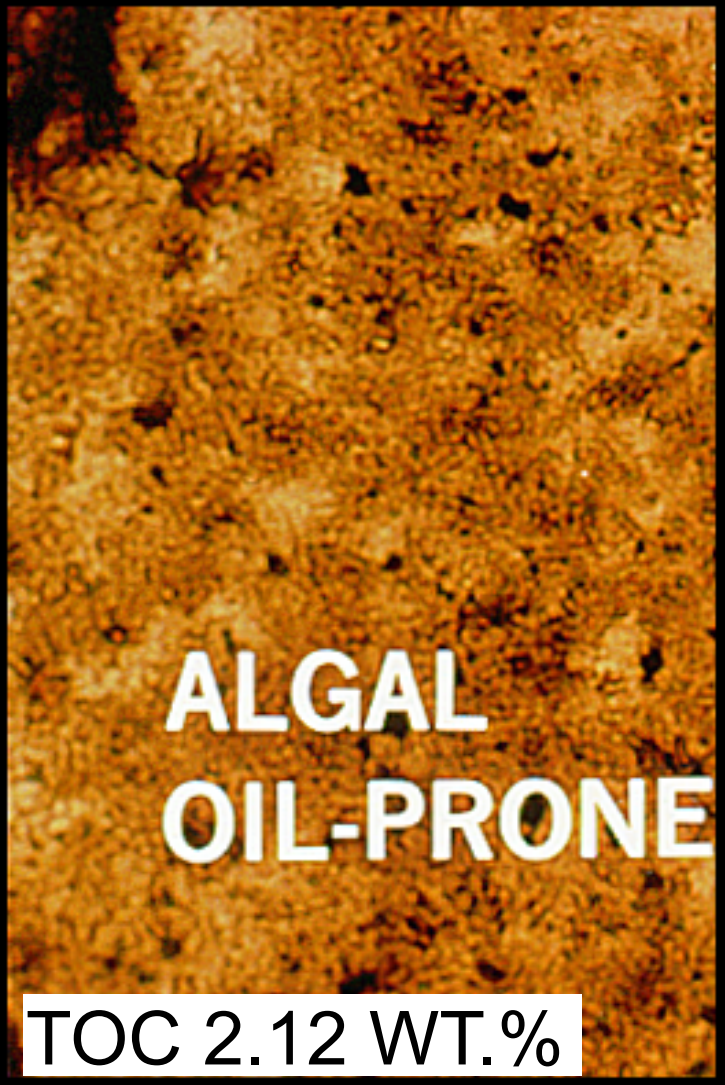
LOMPOC Quarry Sample
Monterey Formation, CA

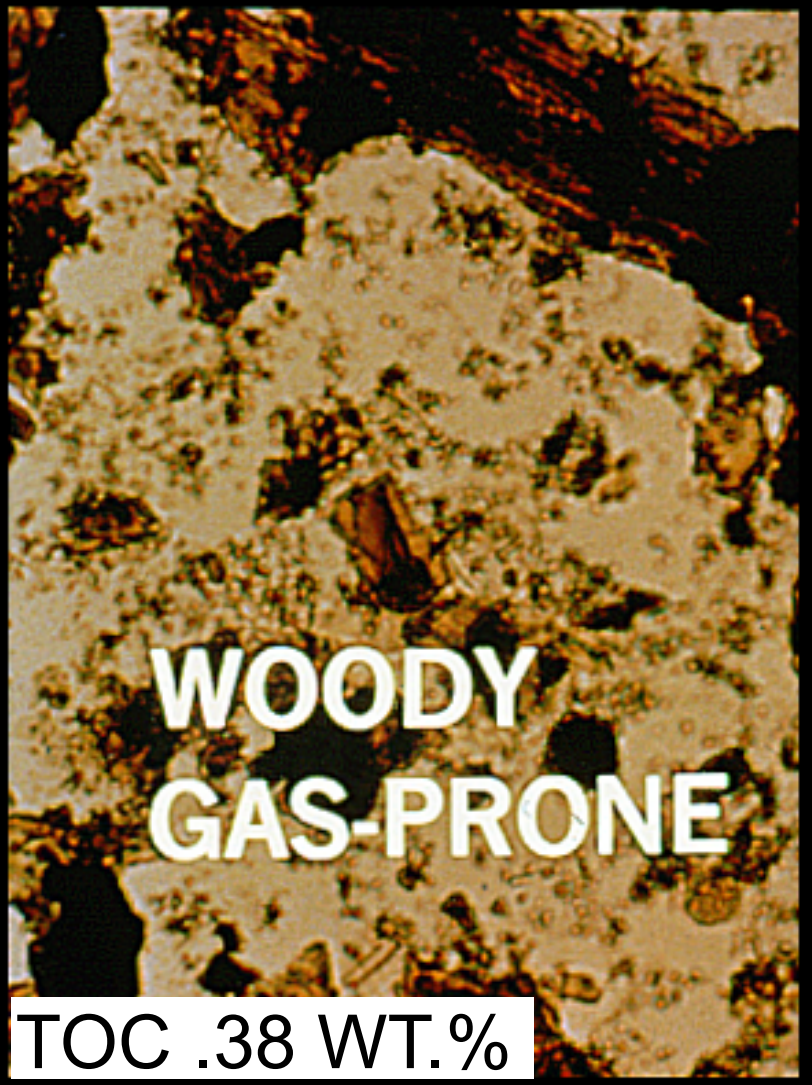
Measured Values

Total Organic Carbon	Hydrogen Index
3.39	378

In-Place Petroleum S_1	Pyrolytically Generated Petroleum S_2
2.24	12.80

Kerogen Types





Types of Petroleum

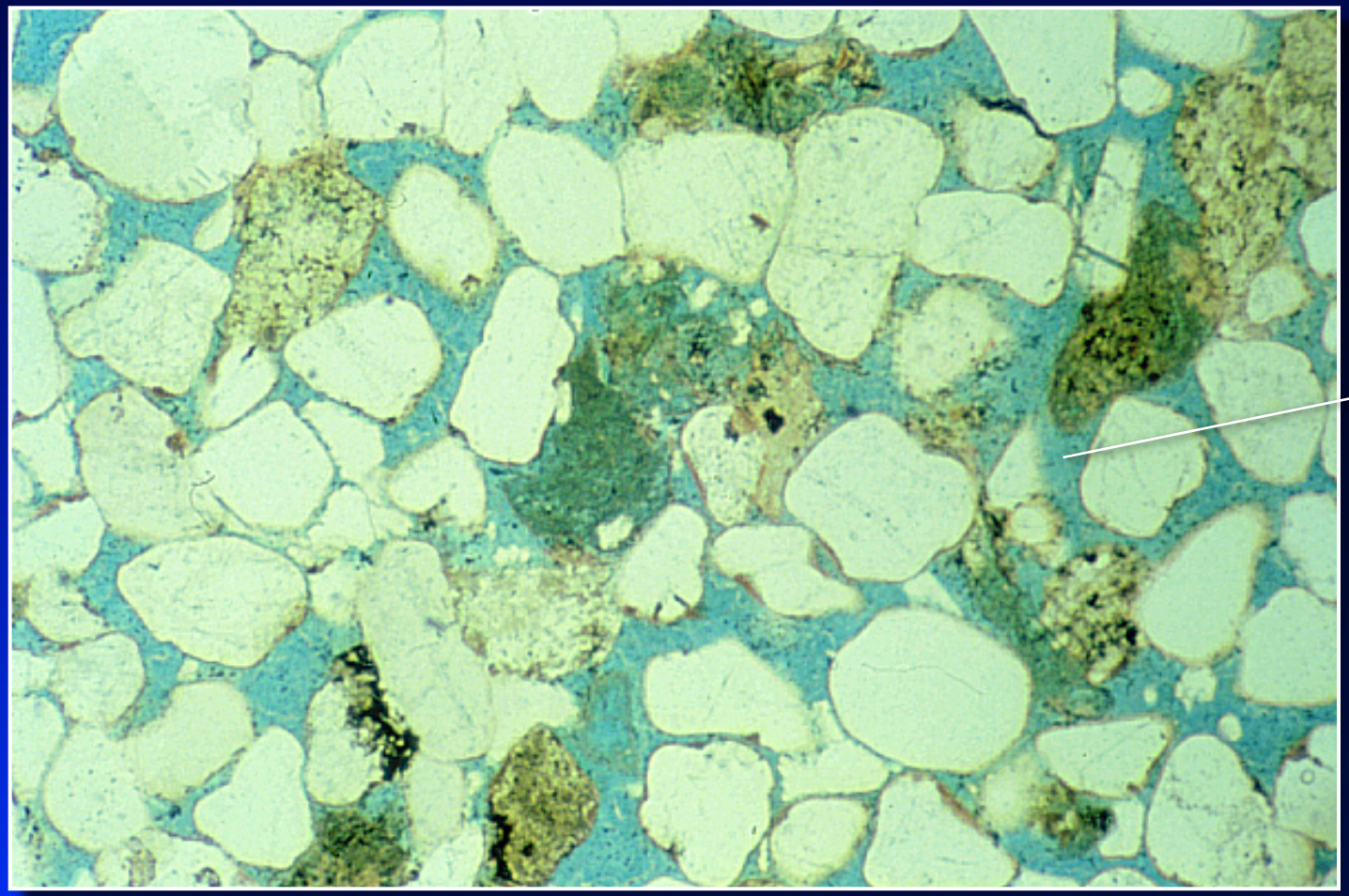
Oil and gas are formed by the thermal cracking of organic compounds buried in fine-grained rocks.

Algae = Hydrogen rich = Oil-prone

Wood = Hydrogen poor = Gas-prone

Reservoir Sandstone

Good Porosity = Lots of Space for Petroleum



Reservoir Sandstone

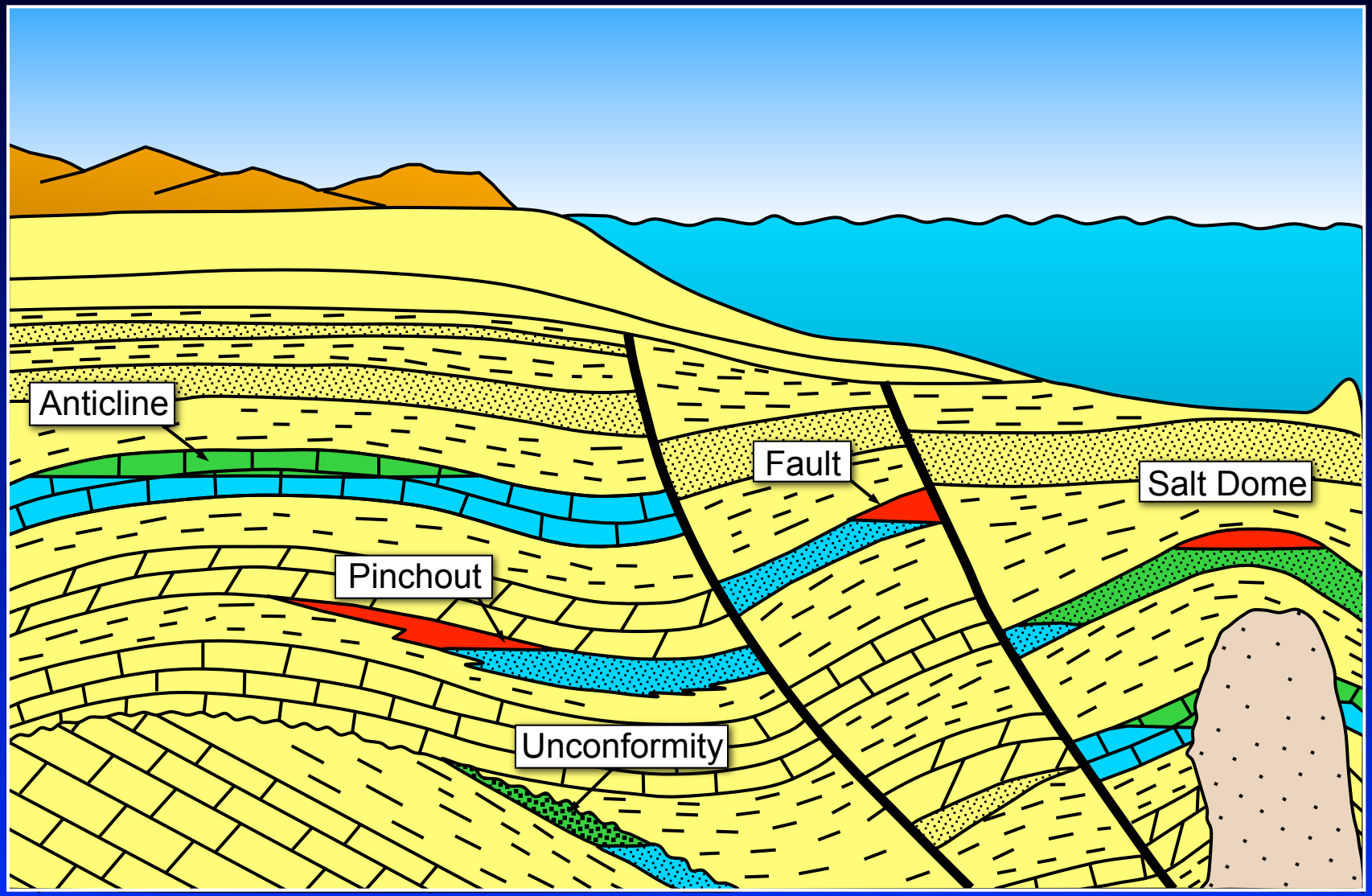
Pore-Filling Cement Reduces Quality

= Less Space for Petroleum

Traps

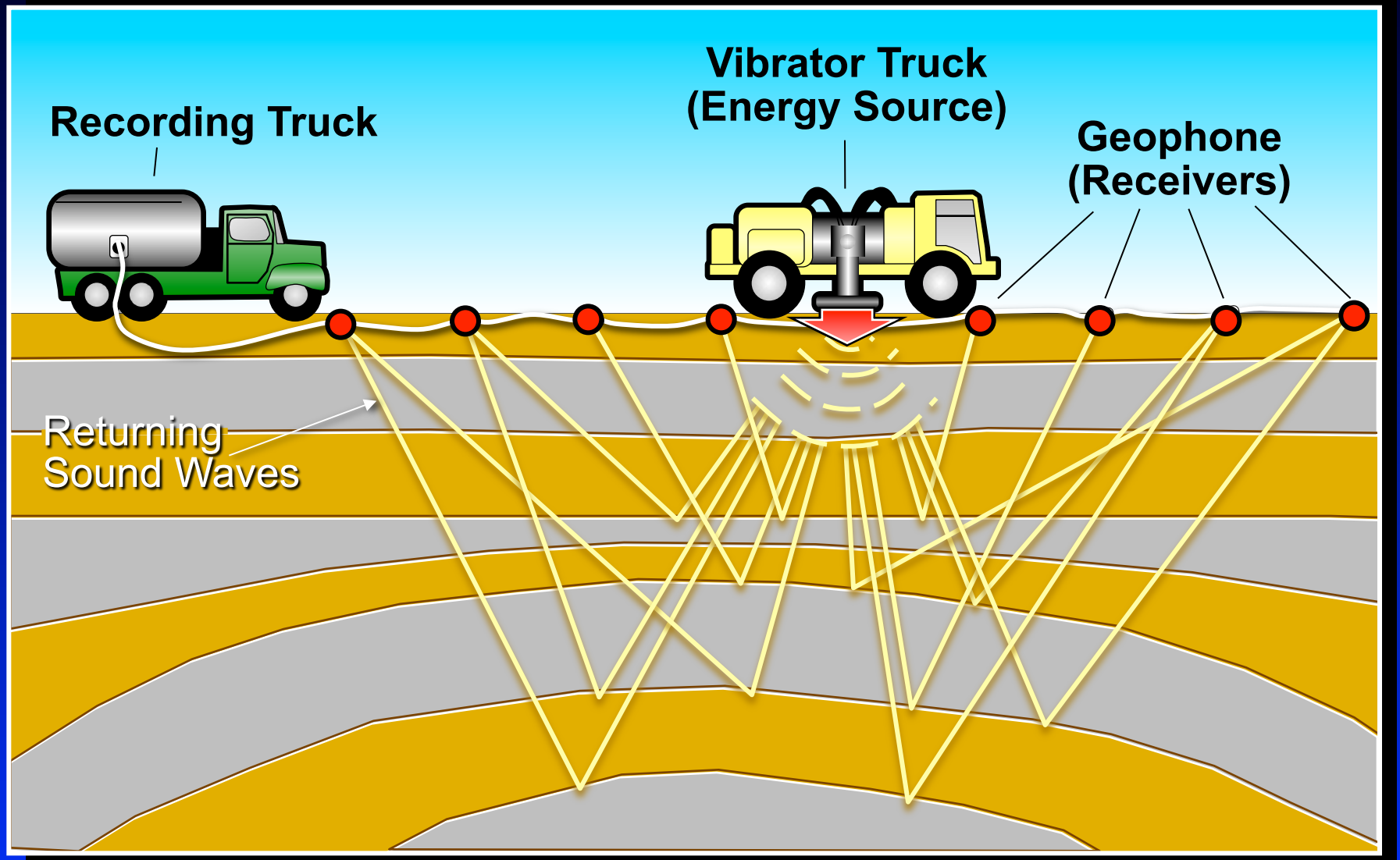
- Anticlinal - Rock layers folded into a dome
- Stratigraphic - Rock layers changing from a good reservoir to non-reservoir due to change in rock type (pinch-out), reservoir quality (diagenesis), or removal (erosional unconformity)
- Fault - Offset of rocks such that oil and gas accumulates in reservoir rock

Hydrocarbon Trap Types



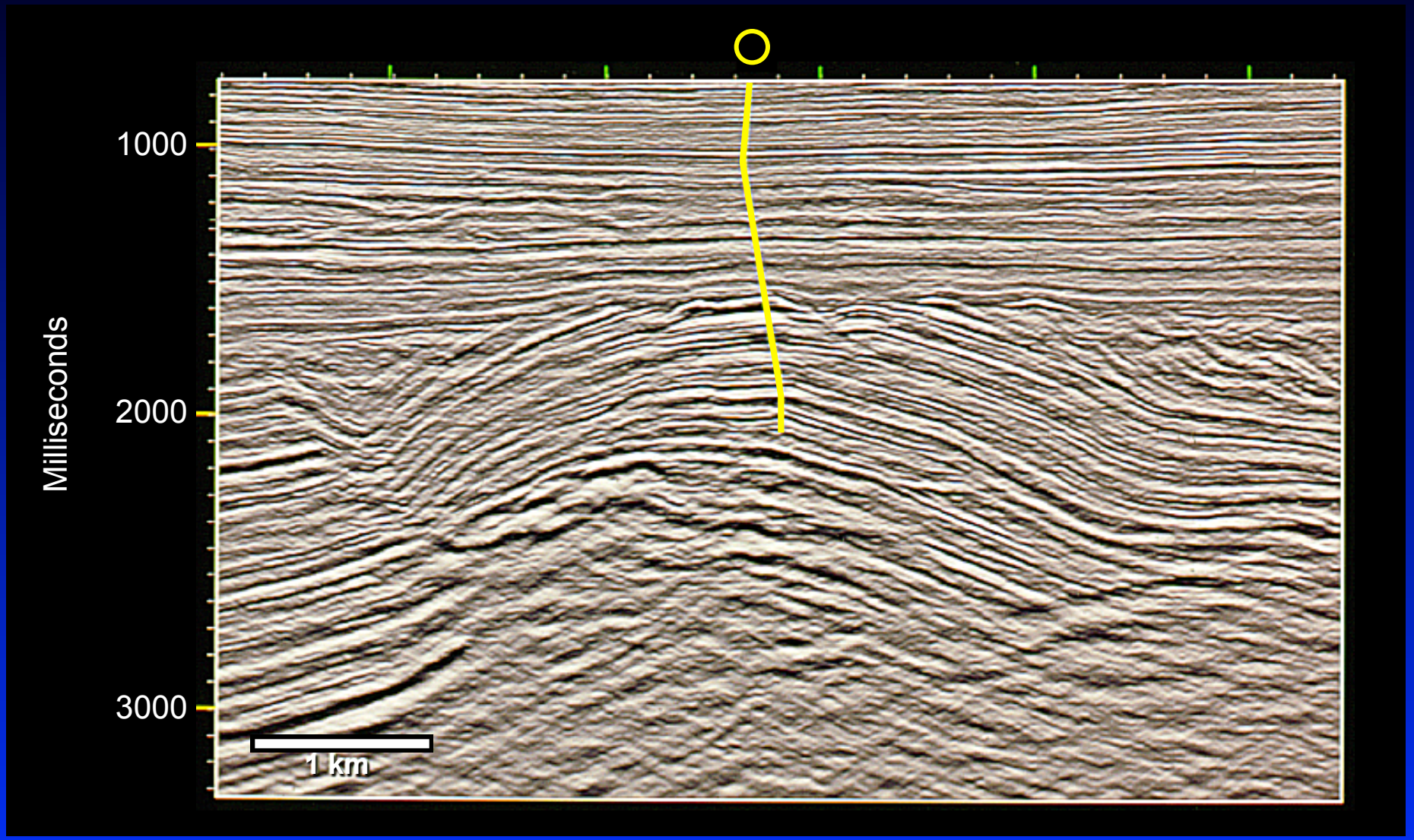
American Petroleum Institute, 1986

Seismic Imaging of Anticline



American Petroleum Institute, 1986

Seismic Image of Anticline



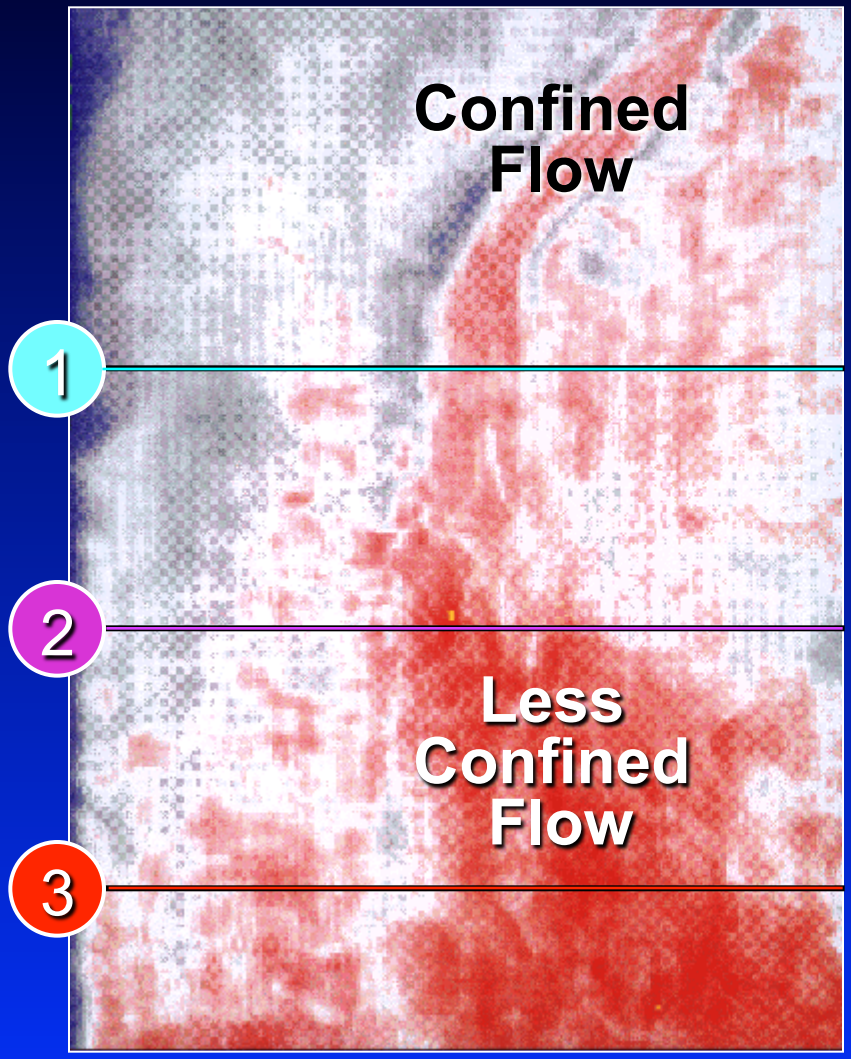
Seismic Imaging

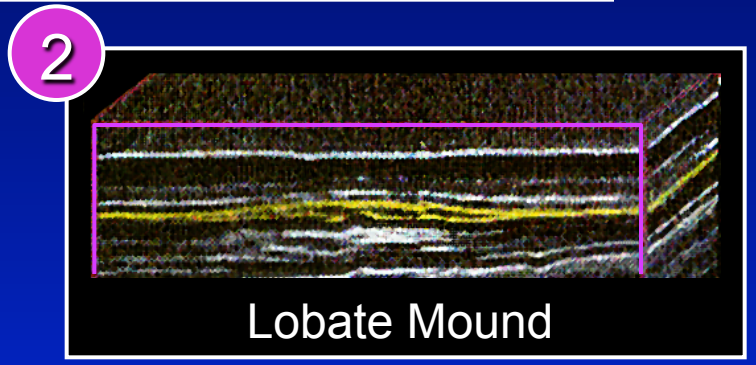
3D Marine Data Acquisition

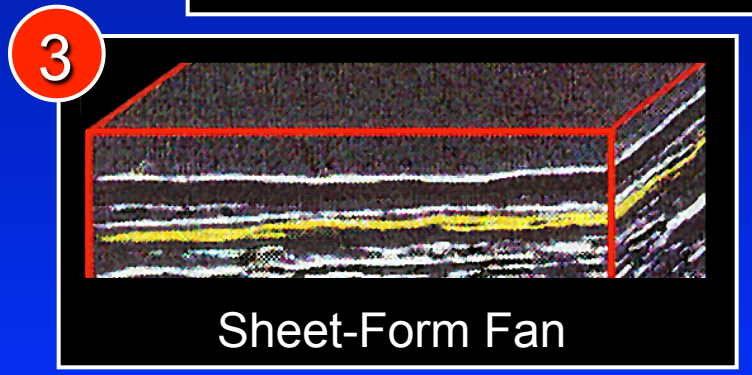
Silicon Graphics

3D Seismic Image - Submarine Fan

New Tools → Better Data → Improved Understanding







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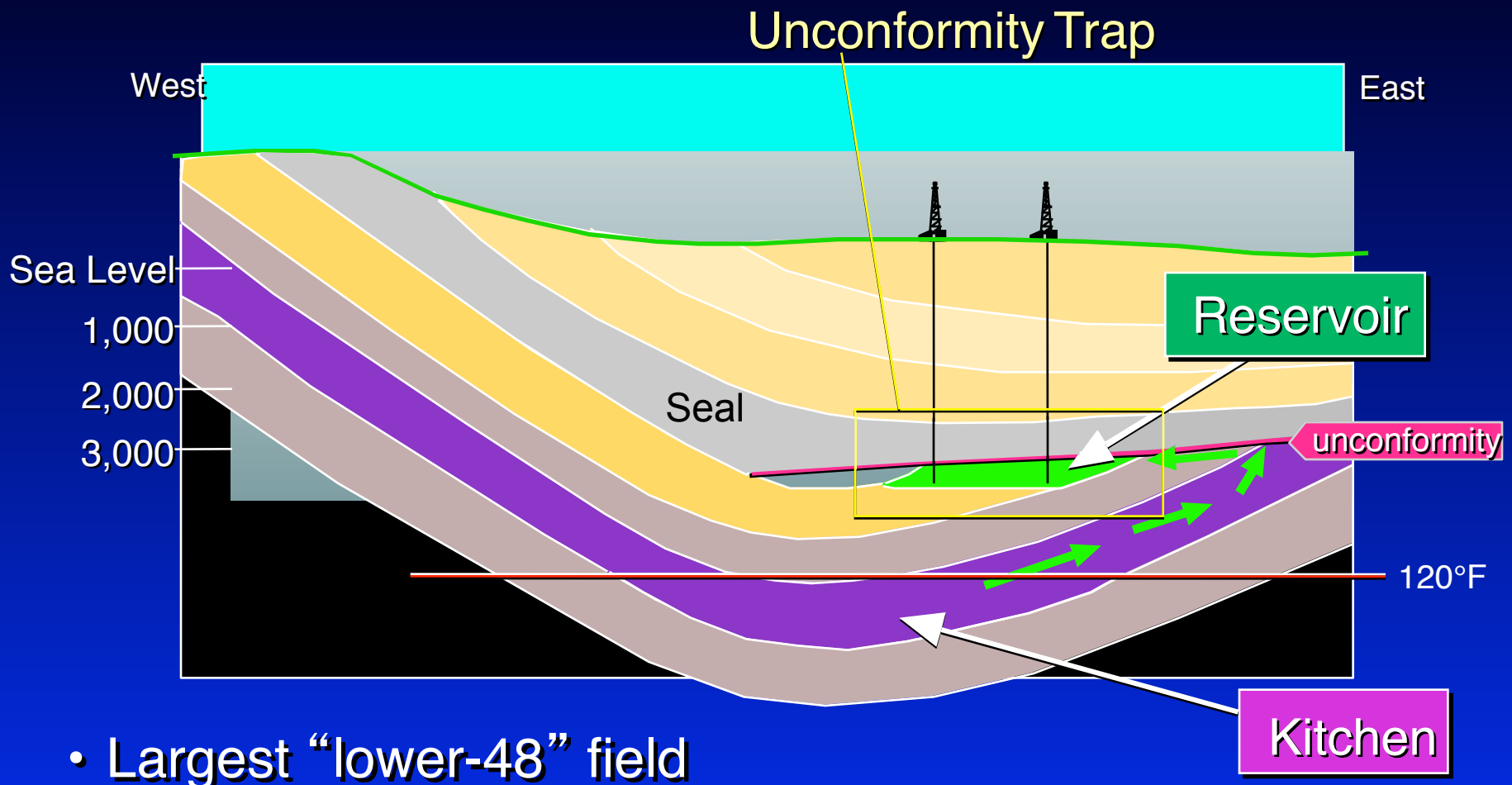
Armentrout *et al.*, 1996

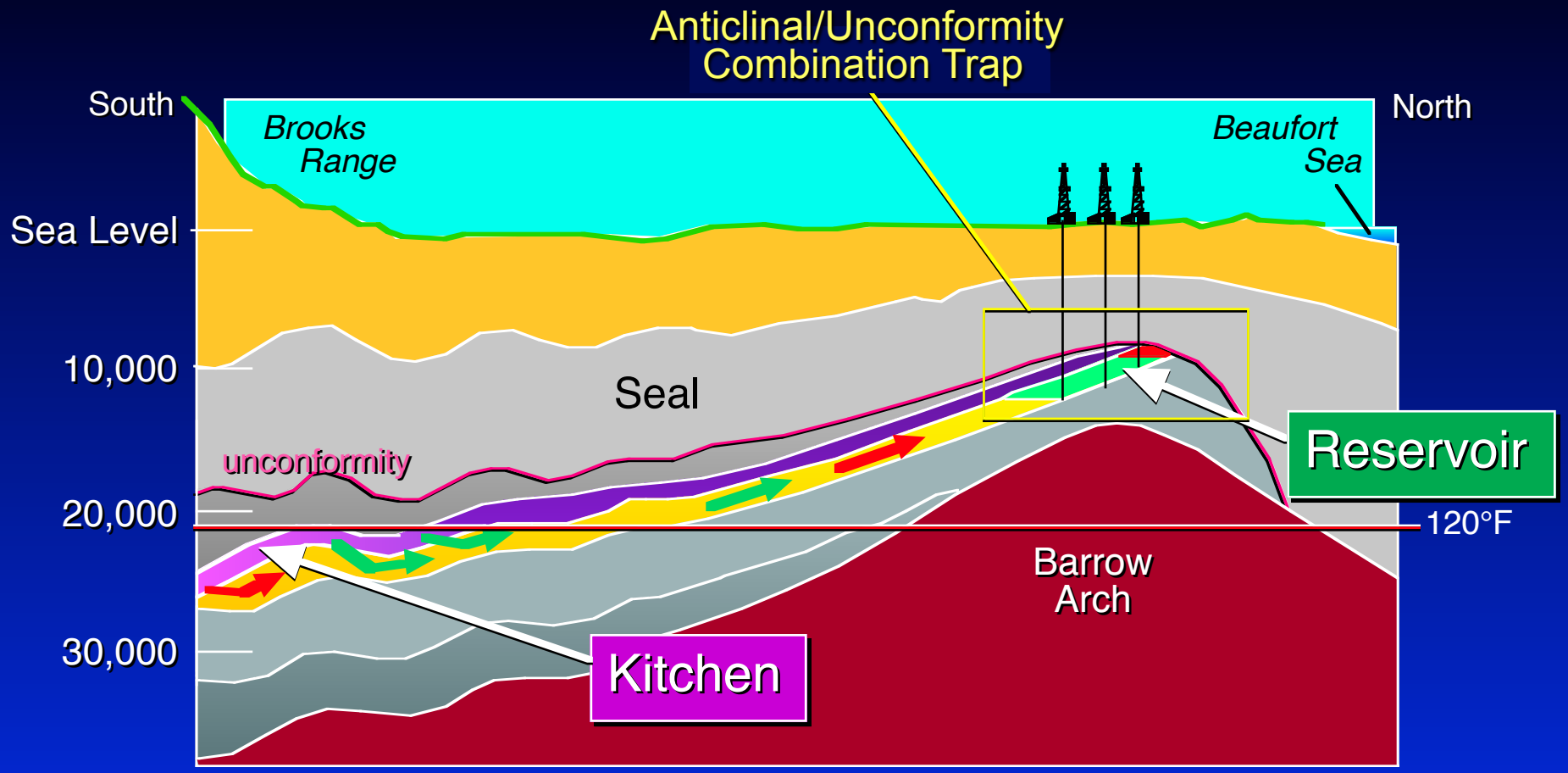
East Texas Oil Field (1930)



- Largest "lower-48" field
- More than 5 billion barrels recoverable

American Association of Petroleum Geologists, 1990

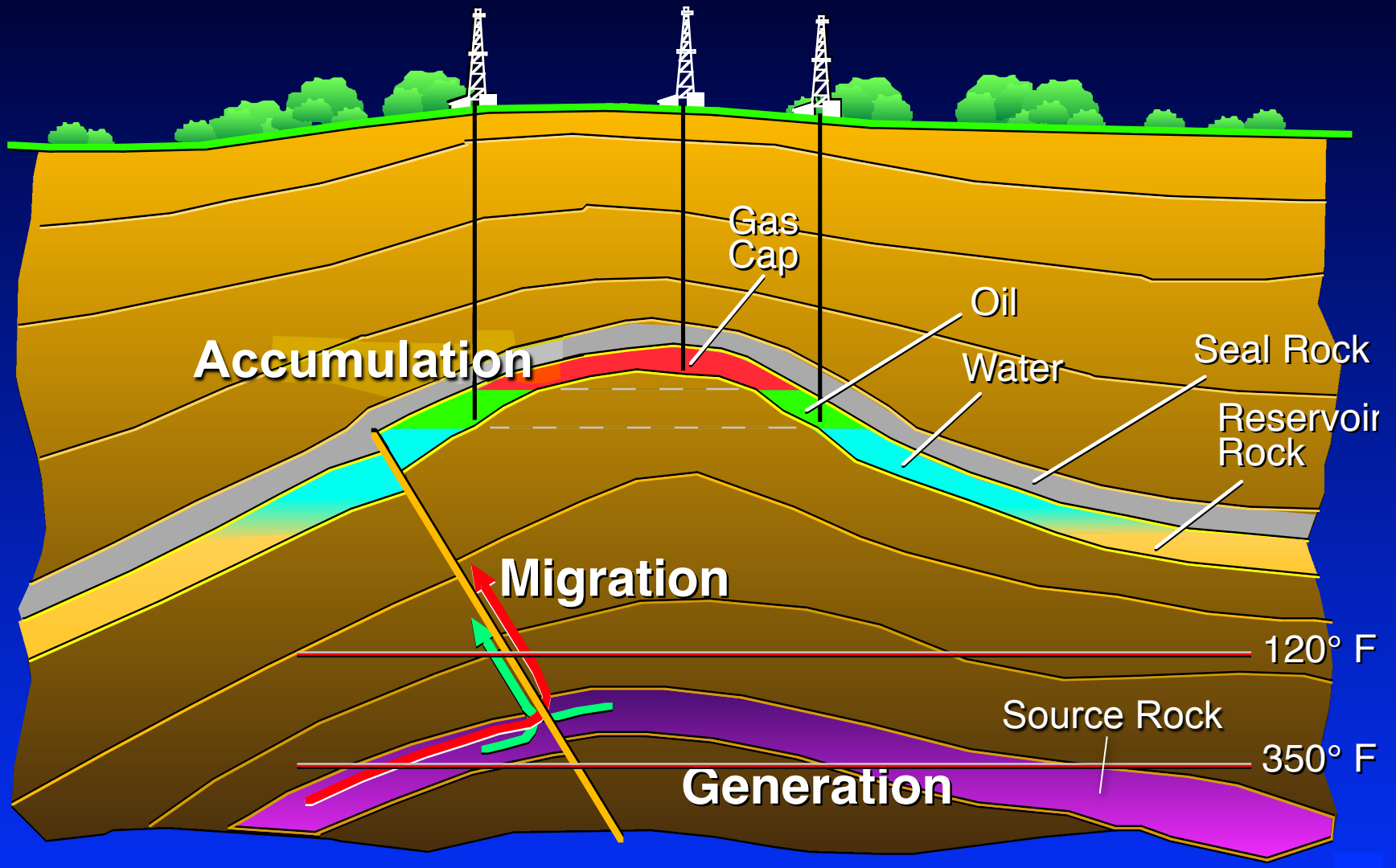
Prudhoe Bay Oil Field (1968)



- Largest North American field
- More than 8 billion barrels recoverable

American Association of Petroleum Geologists, 1990

Petroleum System Processes

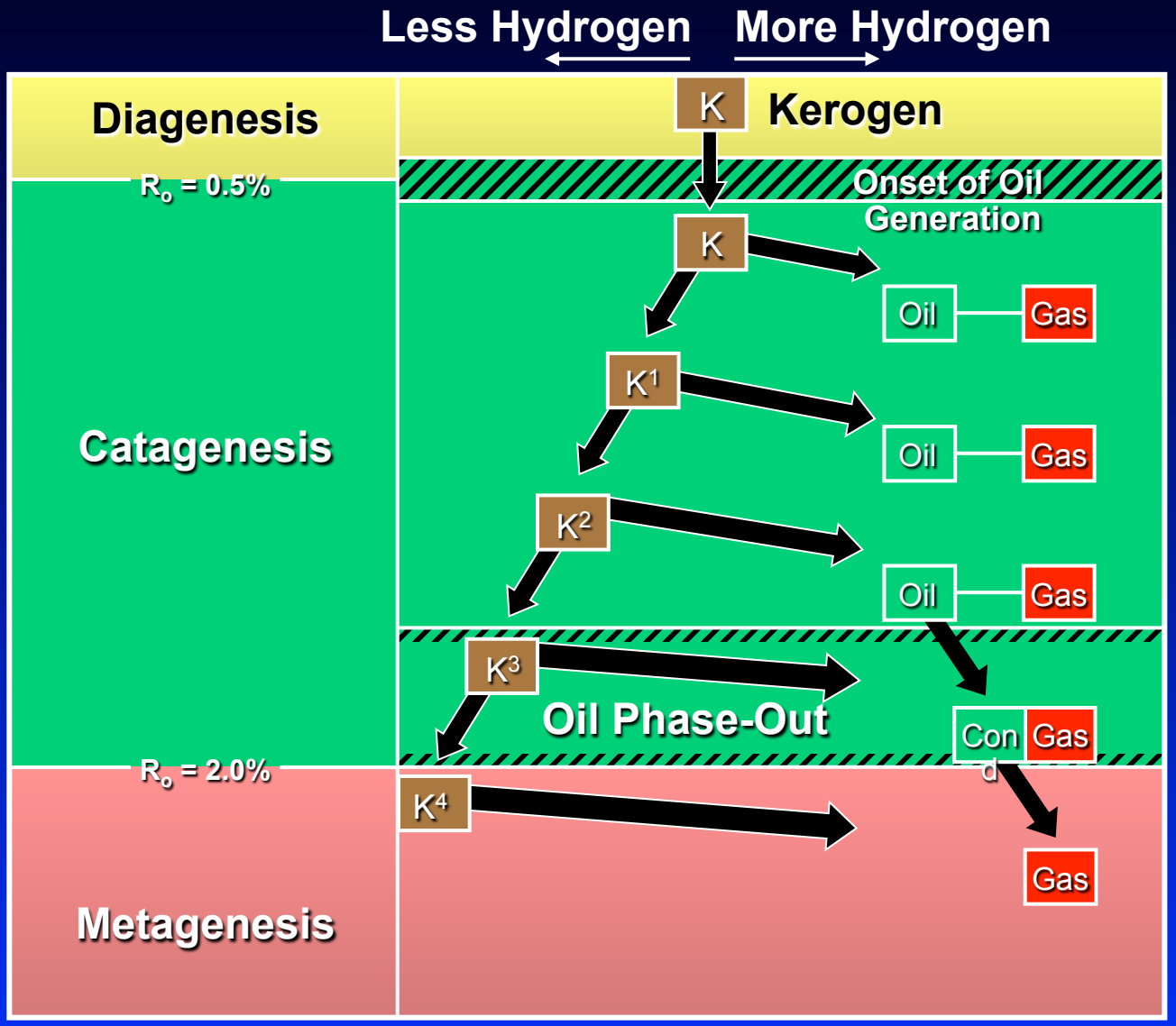


Petroleum System Processes

- Generation - Burial of source rock to temperature and pressure regime sufficient to convert organic matter into hydrocarbon
- Migration - Movement of hydrocarbon out of the source rock toward and into a trap
- Accumulation - A volume of hydrocarbon migrating into a trap faster than the trap leaks resulting in an accumulation
- Preservation - Hydrocarbon remains in reservoir and is not altered by biodegradation or “water-washing”
- Timing - Trap forms before and during hydrocarbon migrating

Thermal Maturation History

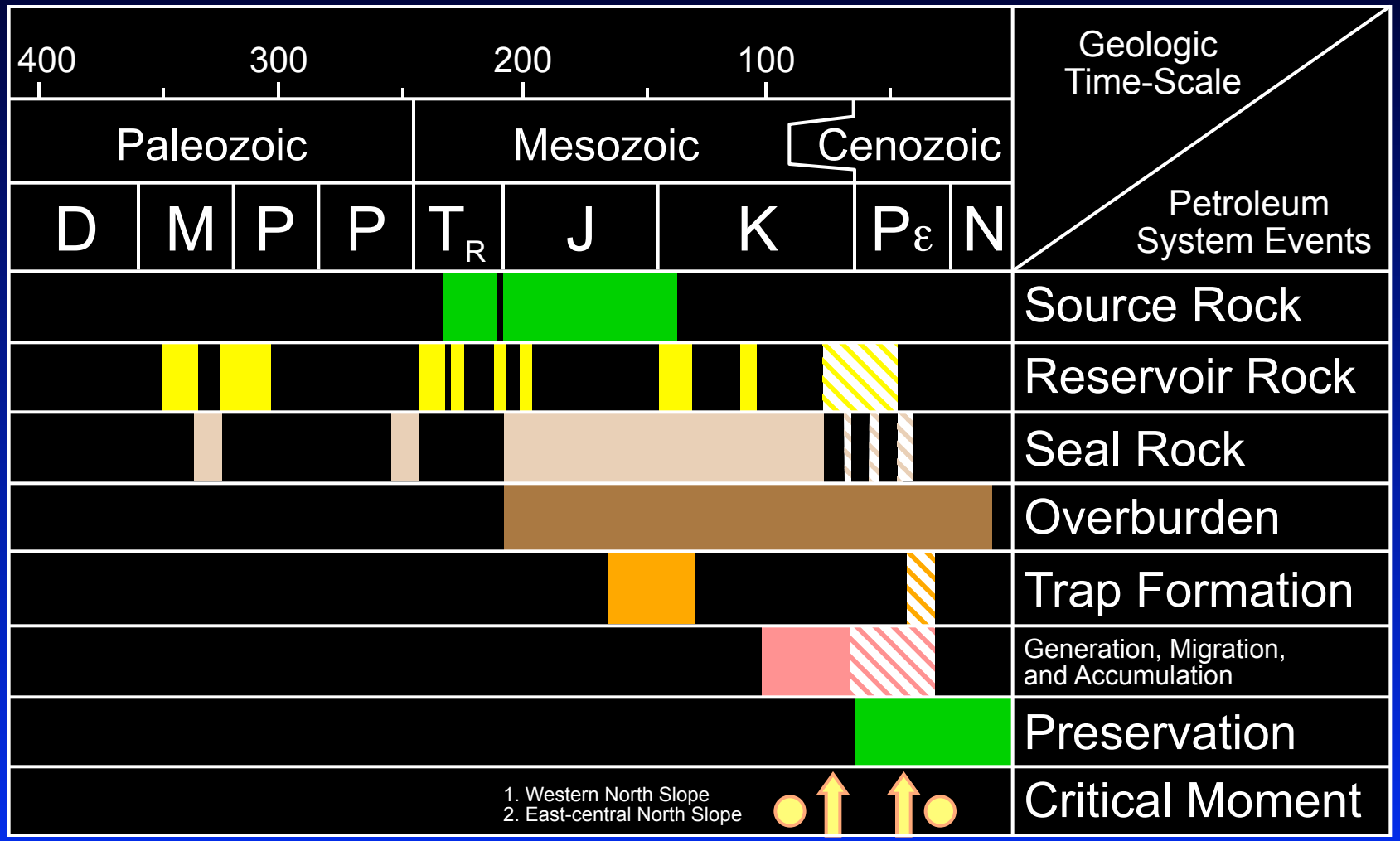
Burial to Greater and Hotter Depths



Horsfield and Rullkotter, 1994

Petroleum System Events Chart

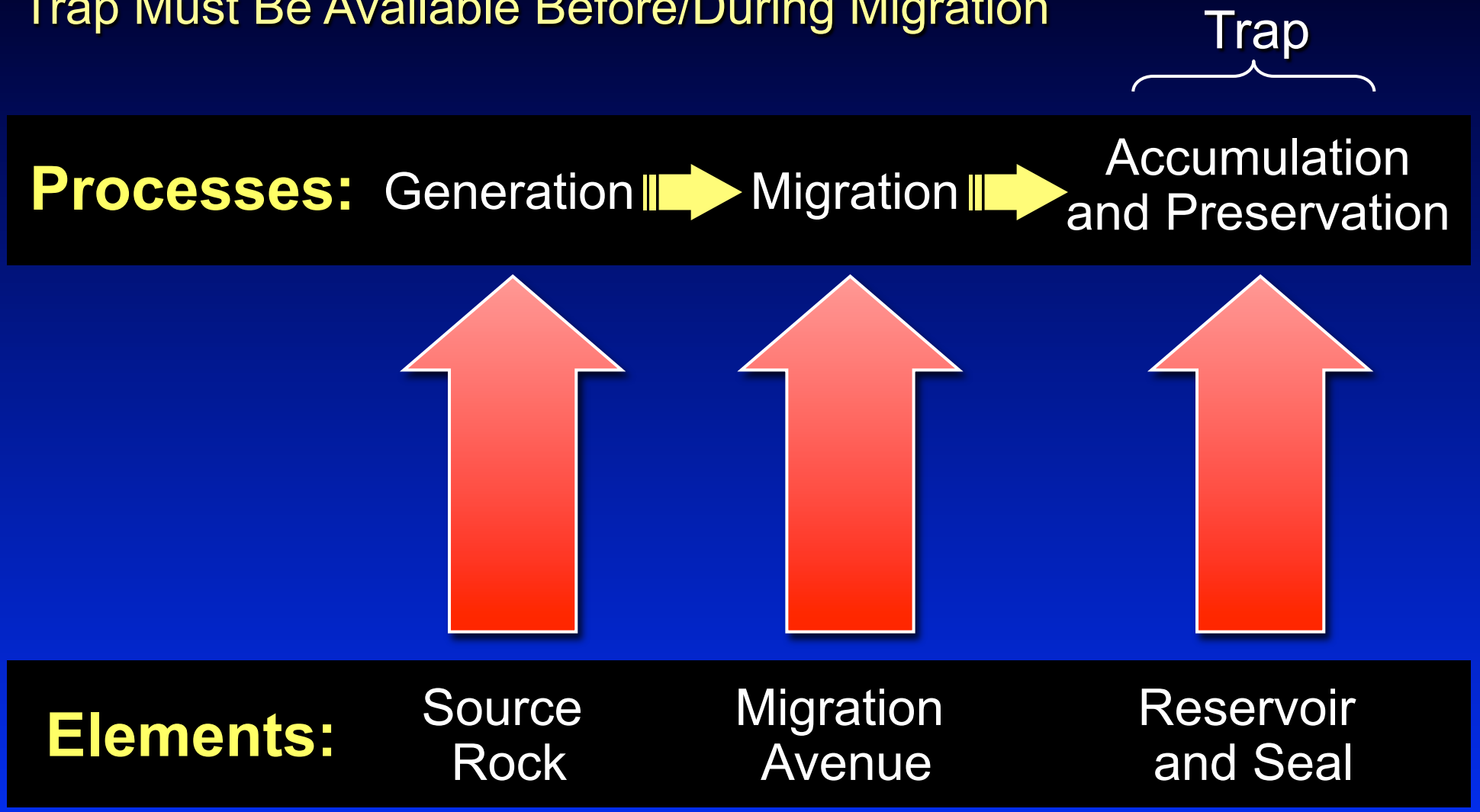
North Slope, Alaska



Bird, 1994

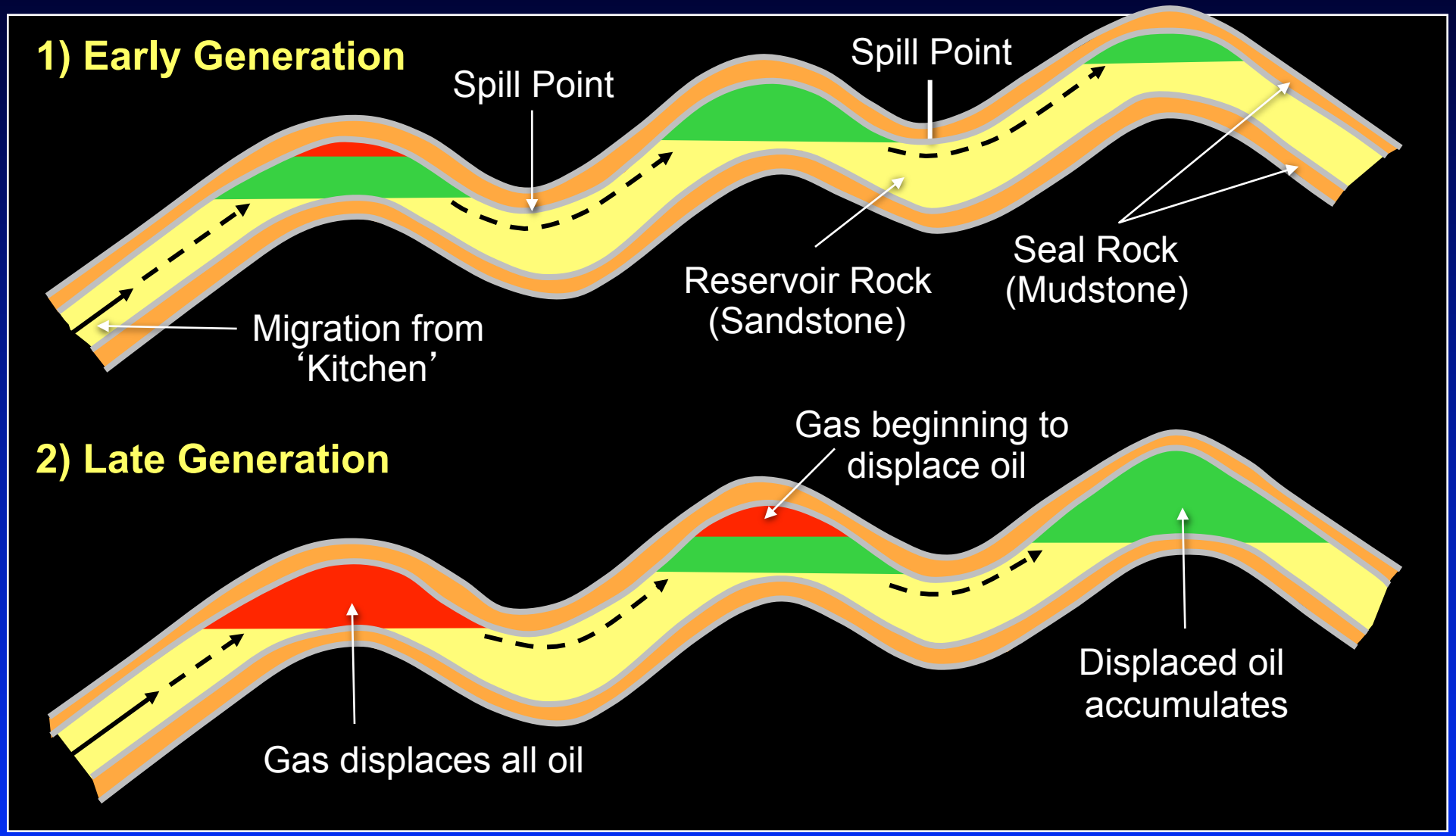
Petroleum System: Timing is Critical

Trap Must Be Available Before/During Migration



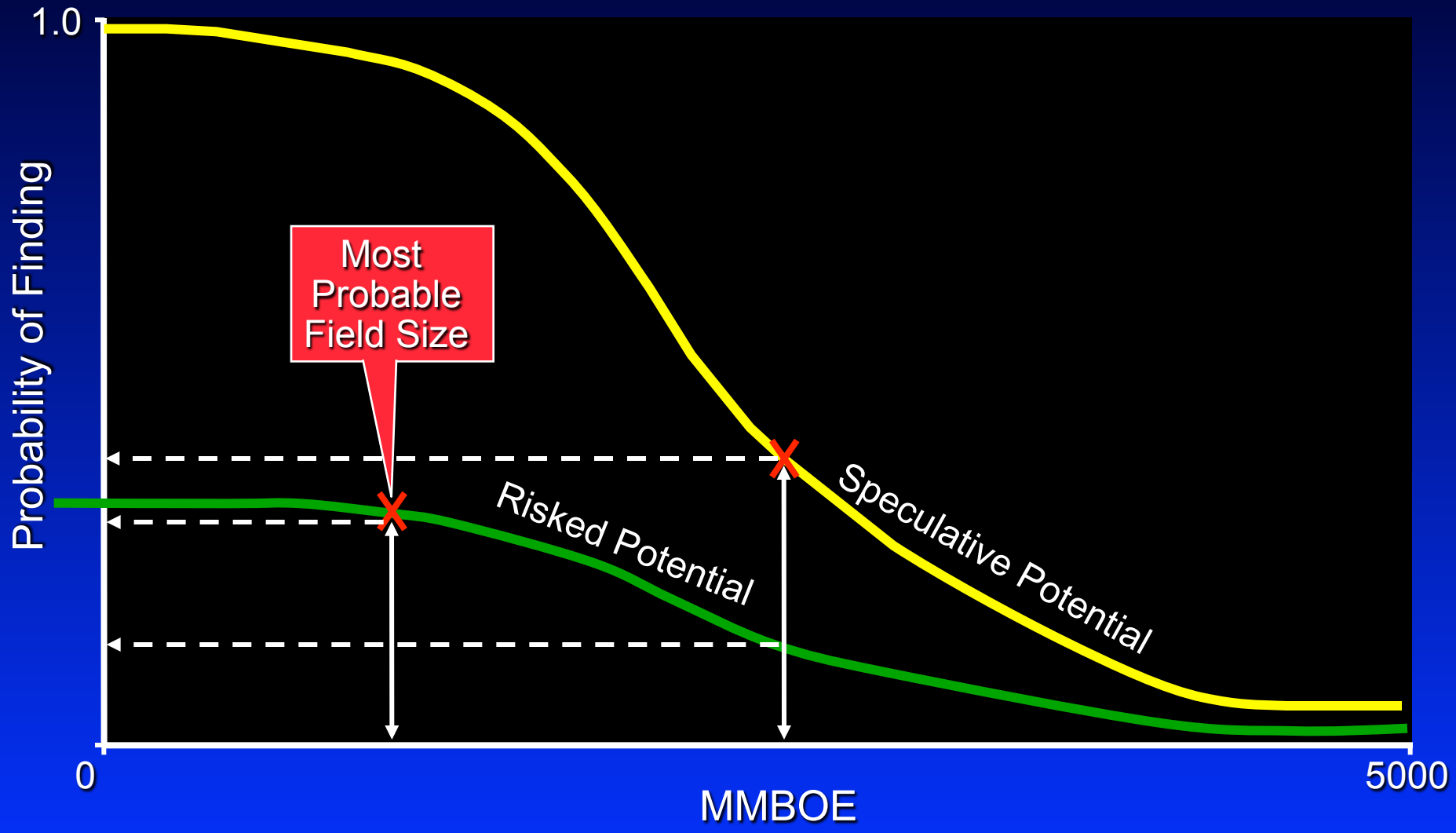
Petroleum System

A Dynamic Entity



Quantitative Play Analysis

Statistical Estimate of Chance for Success



Exploration Costs: 1999

Seismic Surveys

	Alaska North Slope	Gulf of Mexico
2D	$50,000/mile	$70 - $150/mile
3D		$25,000 - $80,000/9mi^2
3D Proprietary		$250,000 - $400,000/9mi^2

Wildcat Wells

Alaska North Slope		Texas	Gulf of Mexico		
Offshore	Onshore	Onshore	Shelf	Slope	Deep-Water
$30 Million	$16 Million	$7 Million	$12 Million	$25 Million	$40 Million

January 1999 Estimates

Cost of Drilling Rigs

Offshore

Daily Rig Cost

1998	$90,000
1999	$40,000

(Single year contract)

Ultra Deep Daily Rig Cost

1998	$180,000
1999	$180,000

(Five year contract)

Onshore

Daily Rig Cost

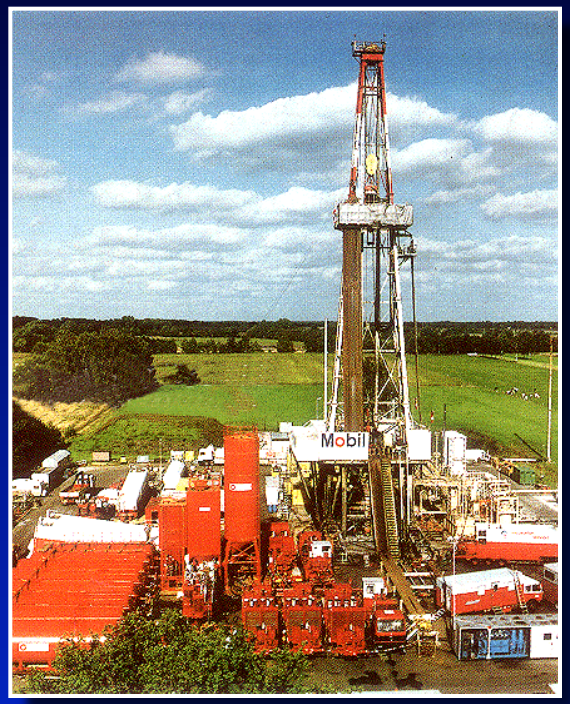
1998	$60,000
1999	$30,000

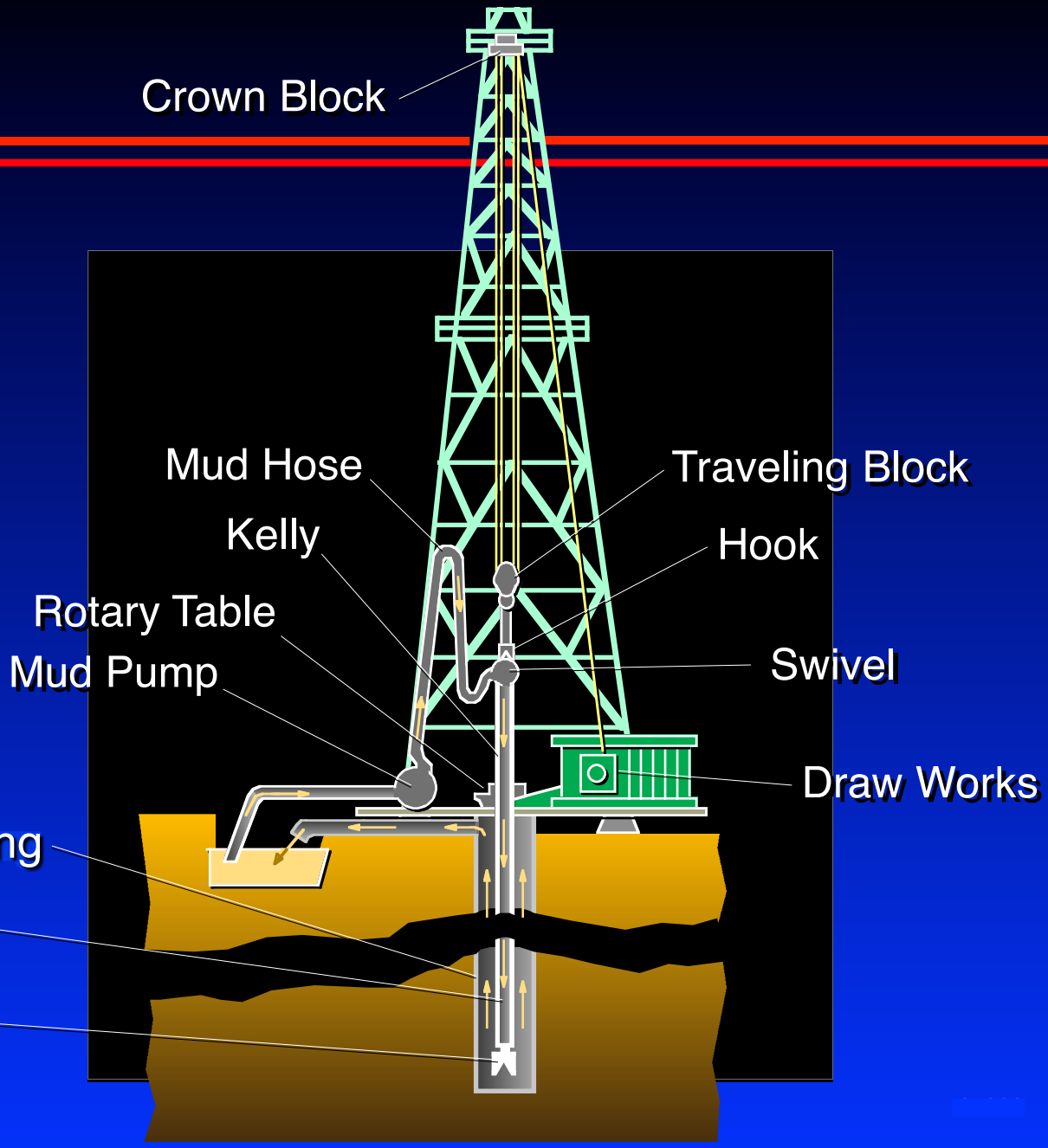
(Single year contract)

Different Ways Industry Pays for Drilling Rights

- Rental - Annual fee for land use while exploring
- Bonus - One-time lump sum paid upfront for right to explore
- Royalty - Percentage payments of oil and gas value produced
- Tax - Governmental ‘fee’ on product value produced

Drilling Rig





Drilling

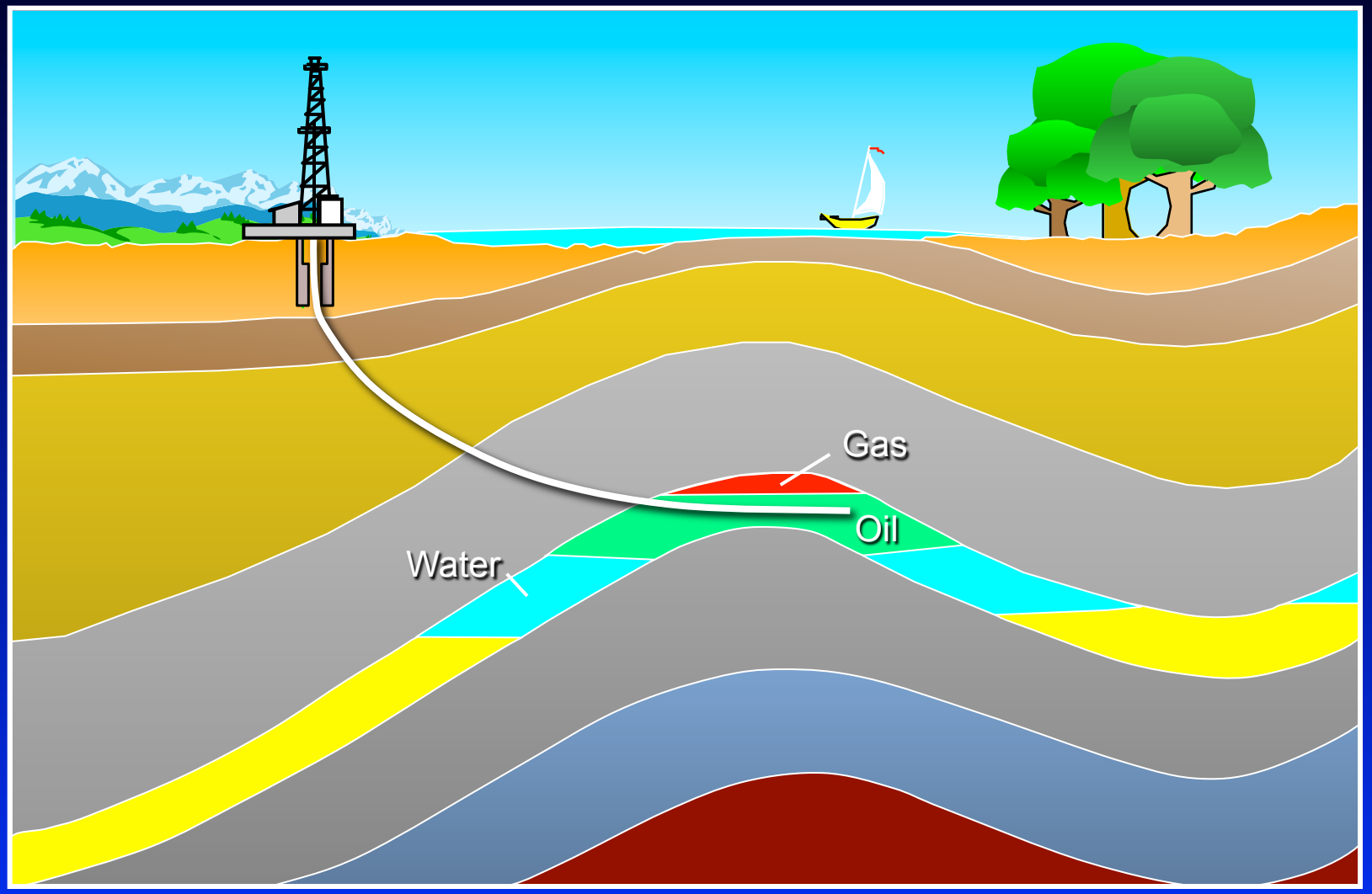
Rock Bit

Cuttings

Core (Diamond) Bit

Core

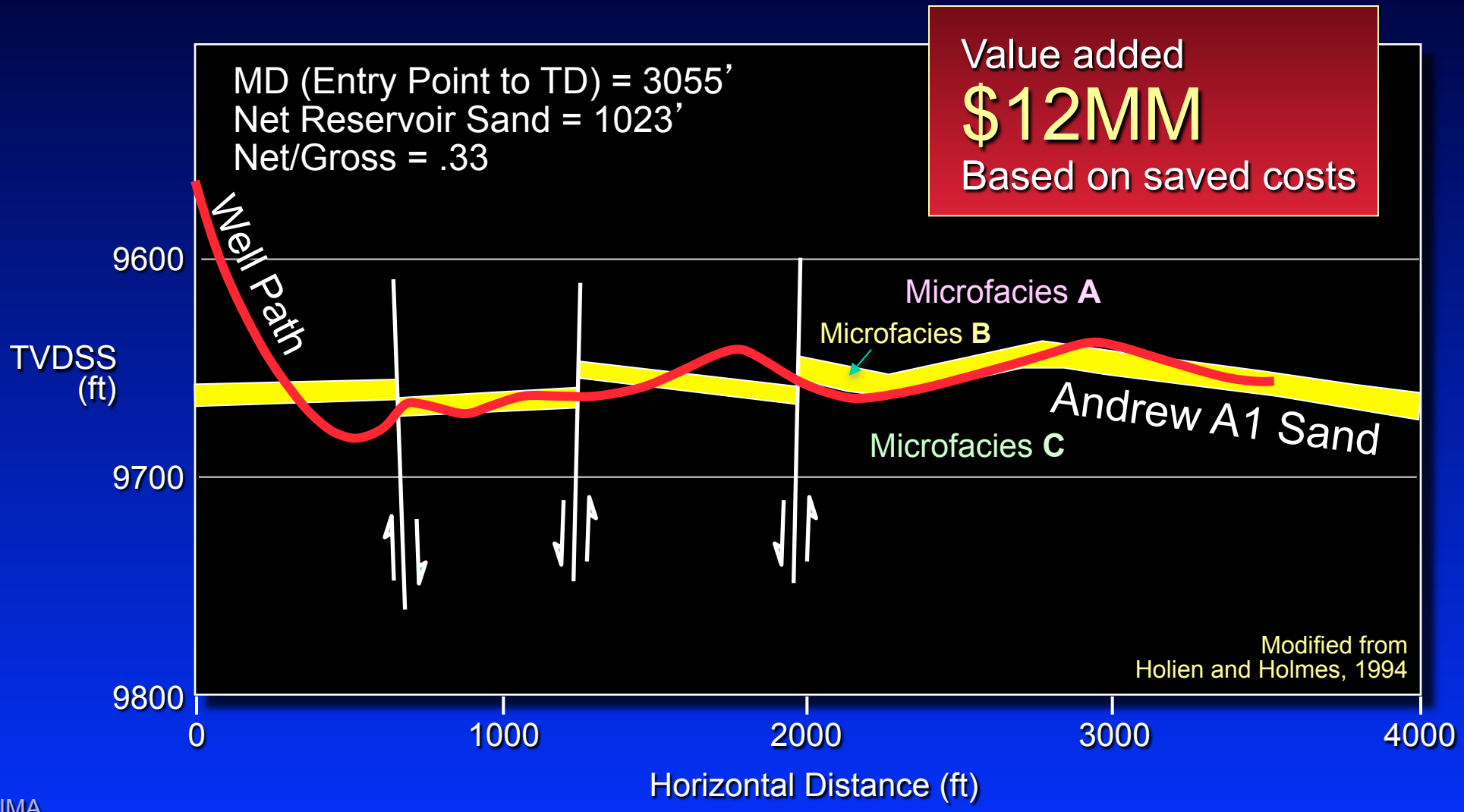
Directional Drilling Avoids Surface Hazards



American Petroleum Institute, 1986

Biosteering

North Sea - Joanne Field - Andrew Reservoir



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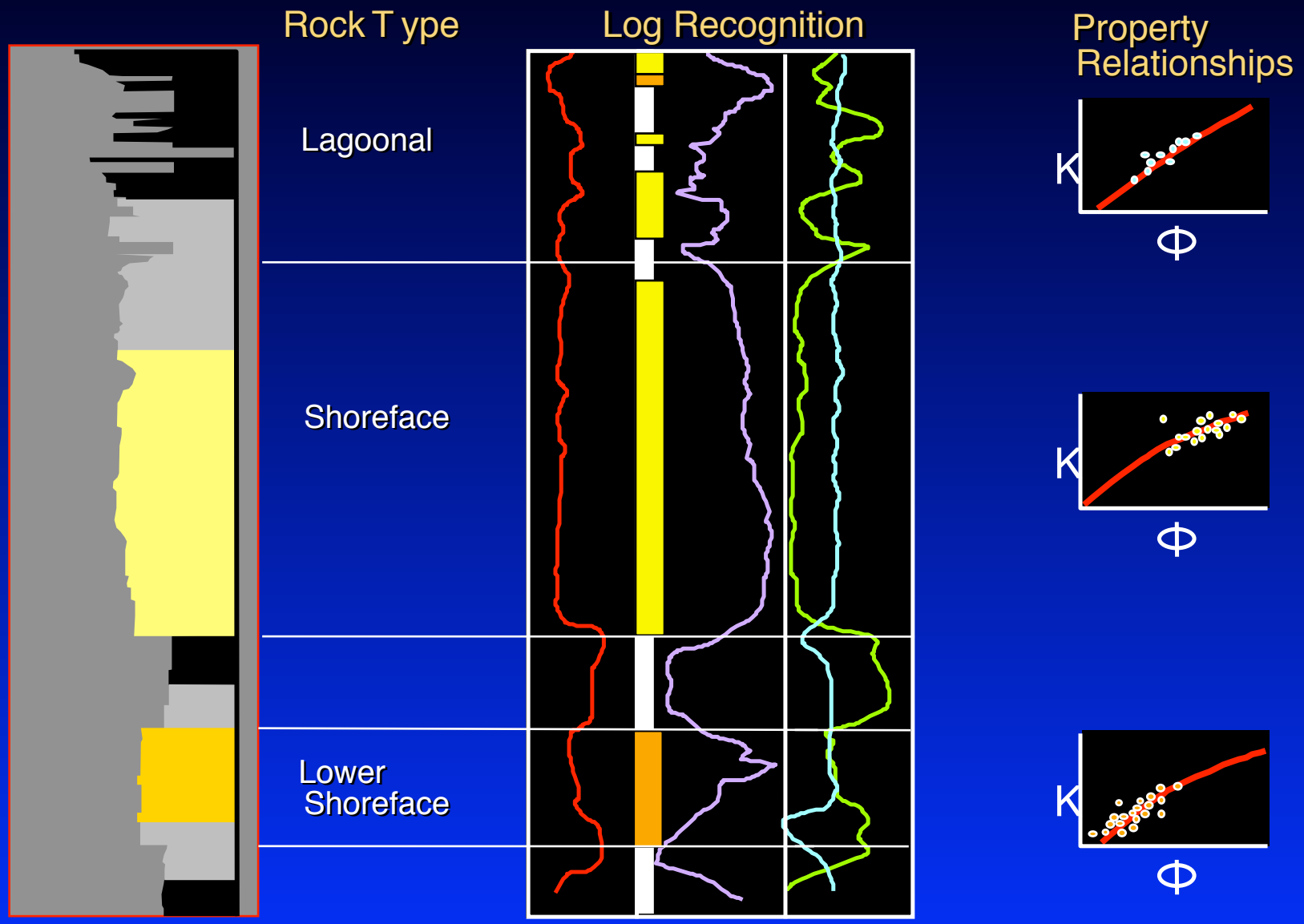
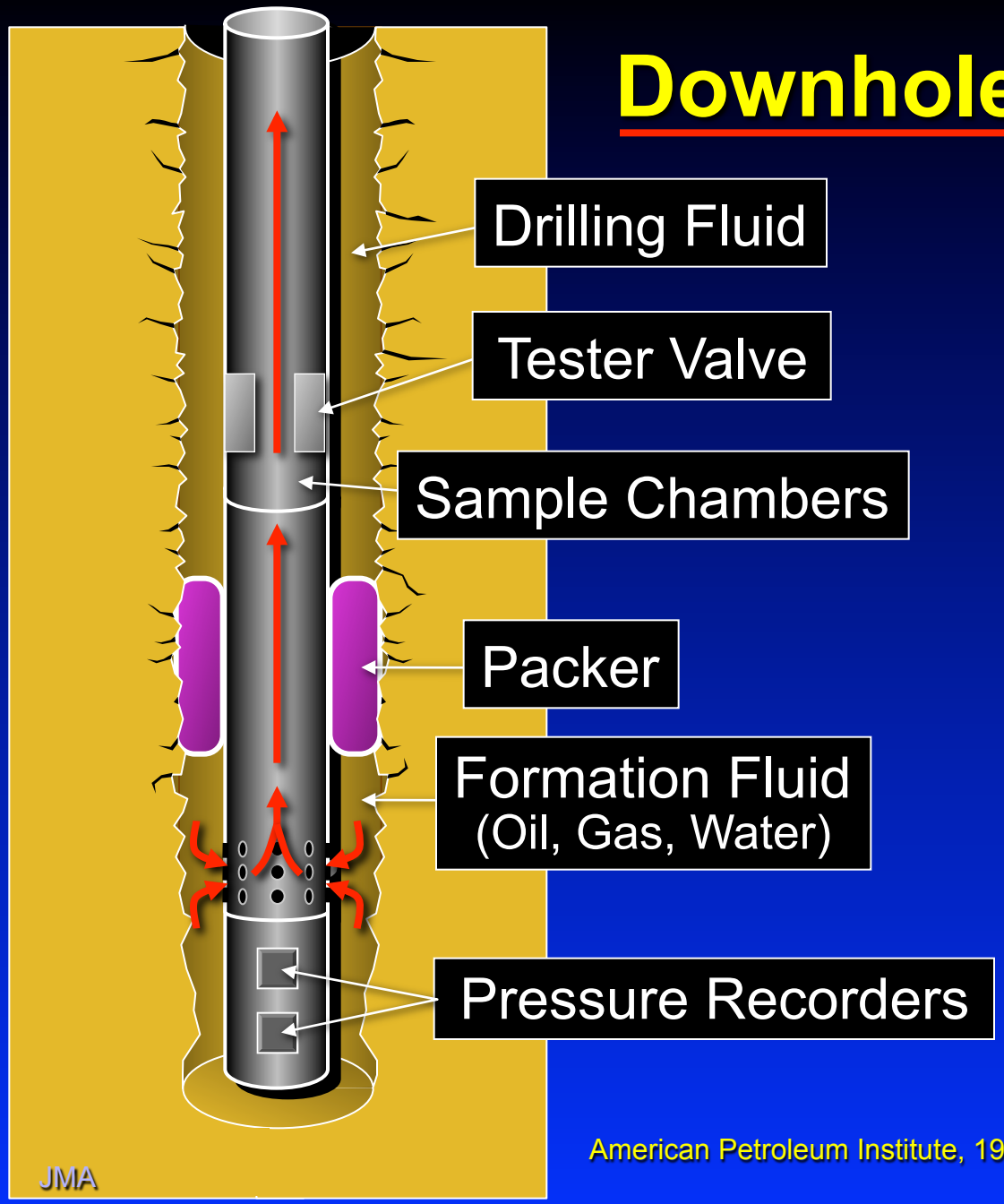
Log Analysis for Flow Unit Determination



Downhole Drill Stem



Tool for testing formation fluid

American Petroleum Institute, 1986

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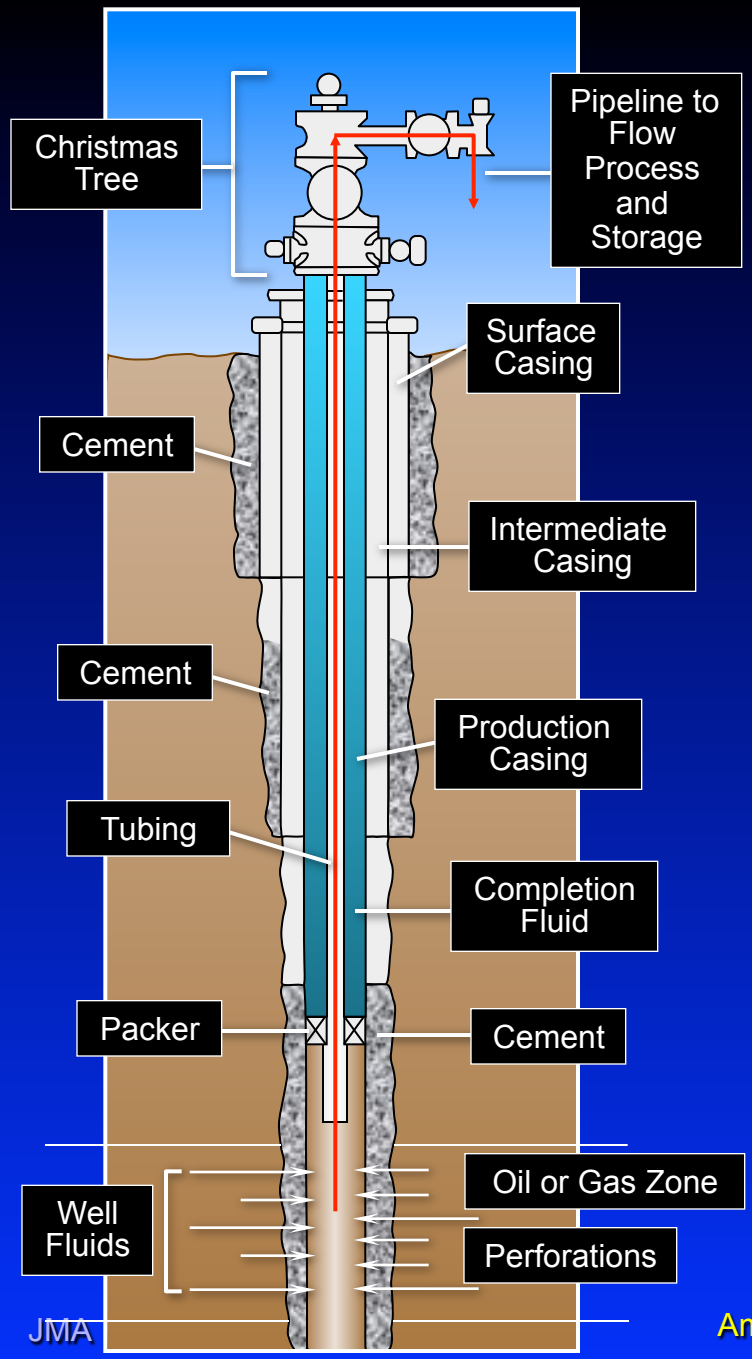


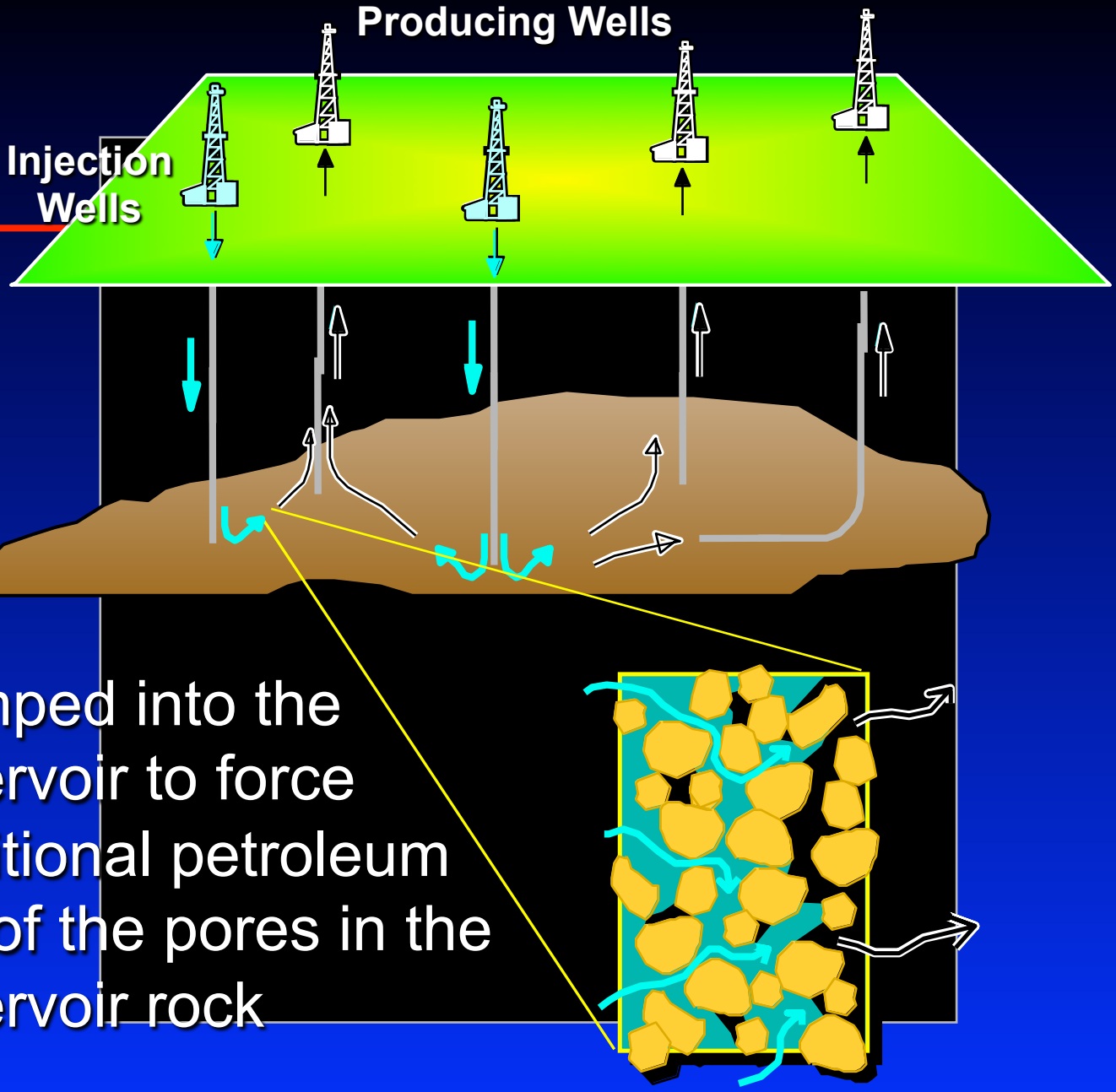
Completed Oil Well

- Water Drive - Hydrostatic pressure pushes oil and gas to surface
- Gas-Cap Drive - Expansion of gas under pressure pushes oil to surface
- Dissolved-Gas Drive - Gas disseminated in oil; usually requires pumping

American Petroleum Institute, 1986

Secondary Recovery

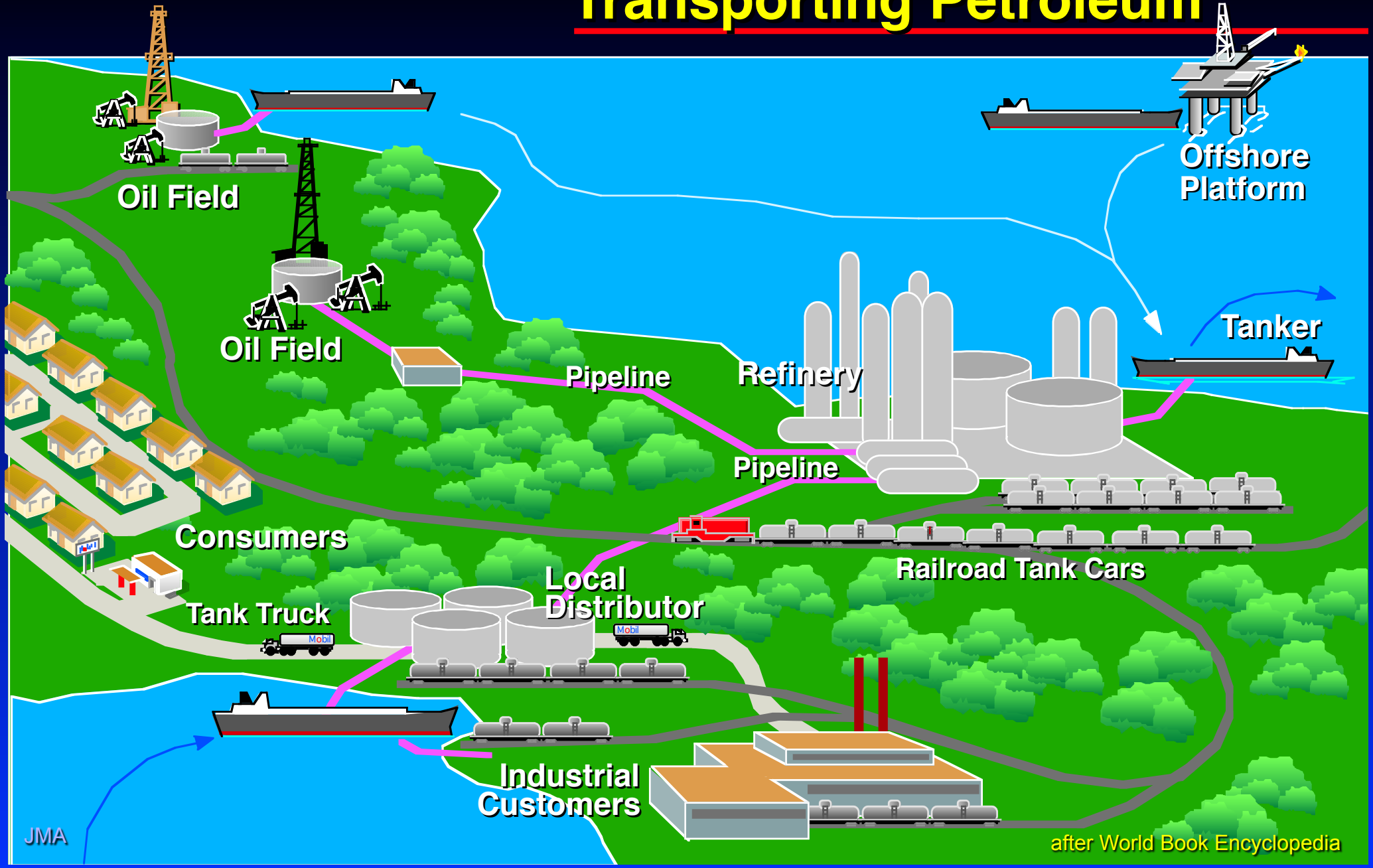
Of 60% Remaining in Reservoir



- Water
- Gas
- Steam
- Chemical
- Fire

Pumped into the reservoir to force additional petroleum out of the pores in the reservoir rock

Transporting Petroleum



Refining Petroleum

Fuel Gas

Gasoline

Kerosene –
Jet Fuel

Heating
Oil

Lubricating
Oil

Residual Products–
Asphalt,
Heavy Fuel Oil

Crude Oil
Vapor

Liquid Crude Oil

after World Book Encyclopedia
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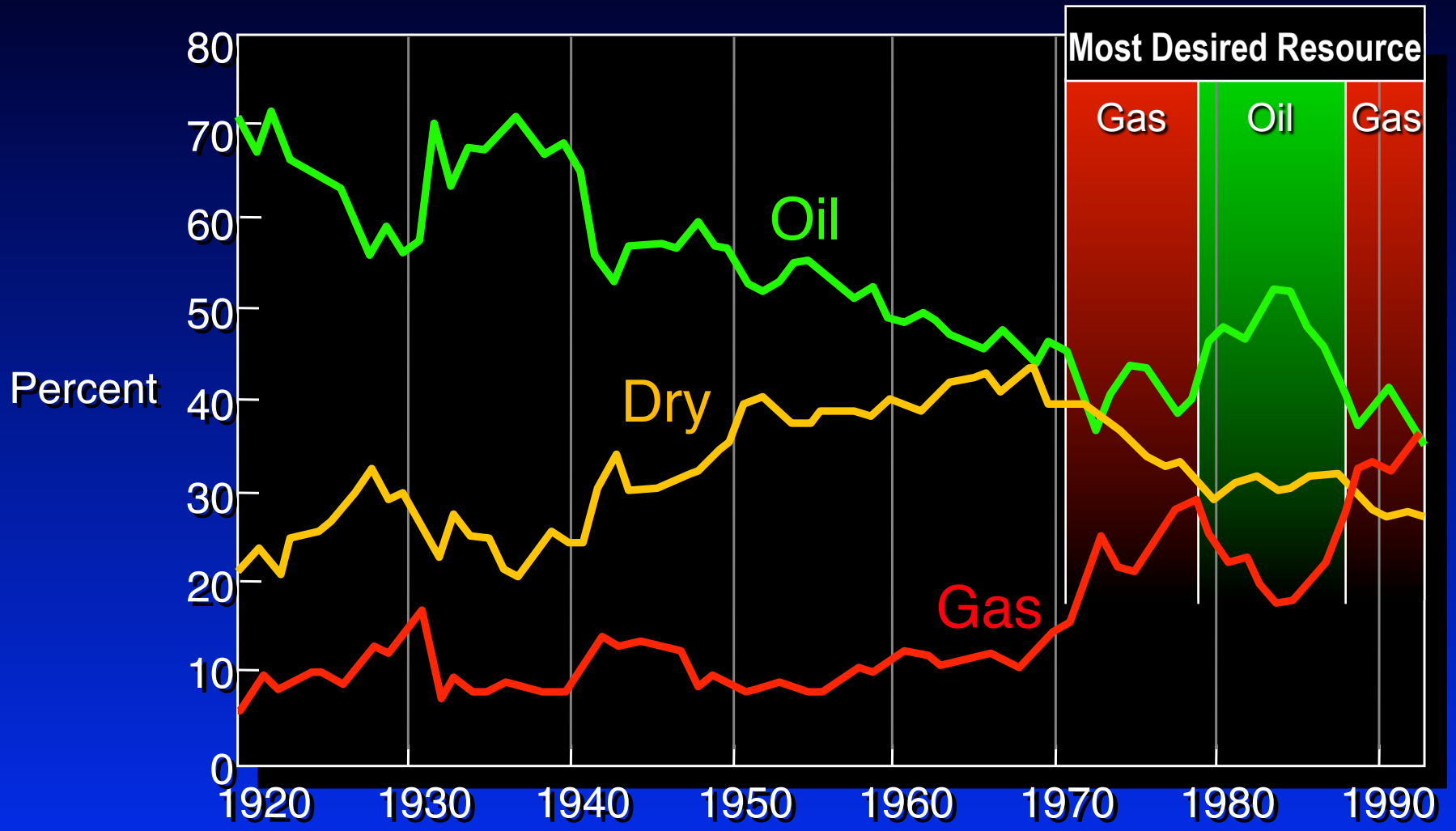
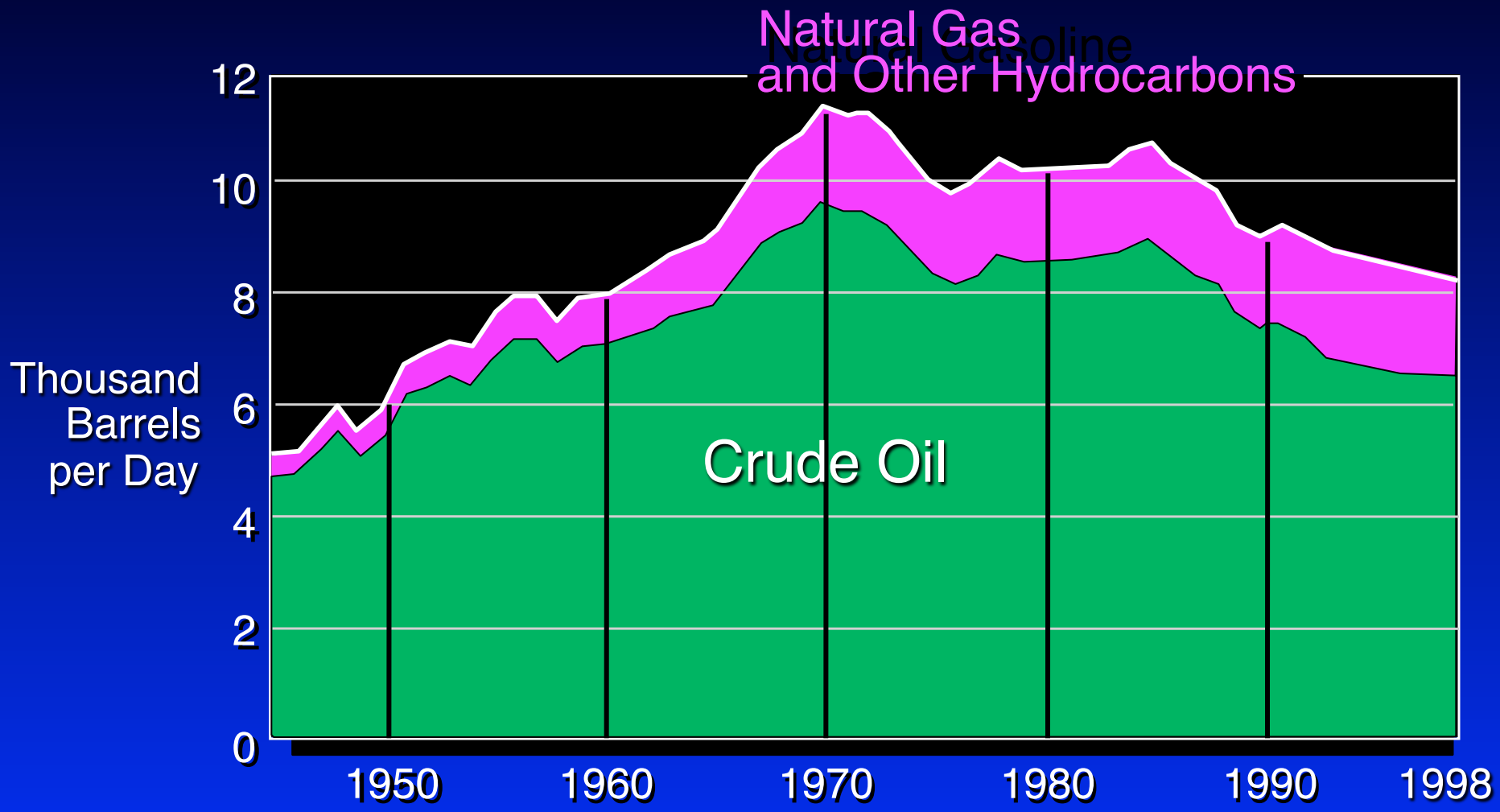
Wells Drilled in the USA



American Petroleum Institute, 1994

US Domestic Production



American Petroleum Institute, 1999

United States Petroleum Imports

1950s	15%
1960s	20%
1970s	36%
1980s	42%
1990s	50%
2000s	?

American Petroleum Institute, 1999

Major Suppliers of Oil to the U.S.

Millions of Barrels Per Day

1.68	1.61	1.48	1.36
Venezuela	Canada	Saudi Arabia	Mexico




U.S. Dept. of Energy
Embassy of Venezuela
12/98 U.S. News & World Report

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Costs/Barrel of Oil - At Well Head

1999 USA

	$24/BOE	$12/BOE
Exploration	$2.60 (11%)	$1.70 (14%)
Development	$6.00 (25%)	$5.10 (43%)
Operations	$3.00 (12%)	$2.00 (17%)
Tax	$2.40 (10%)	$1.20 (10%)
Basic Costs	$14.00/B (58%)	$10.00/B (84%)
Margin	$10.00/B (42%)	$2.00/B (16%)

50% Market decline → 500% Margin decline

January 1999 Estimates

USA Average Wellhead Oil Price

Oil Price (1996 Dollars/Barrel)

U.S. Department of Energy, 1996

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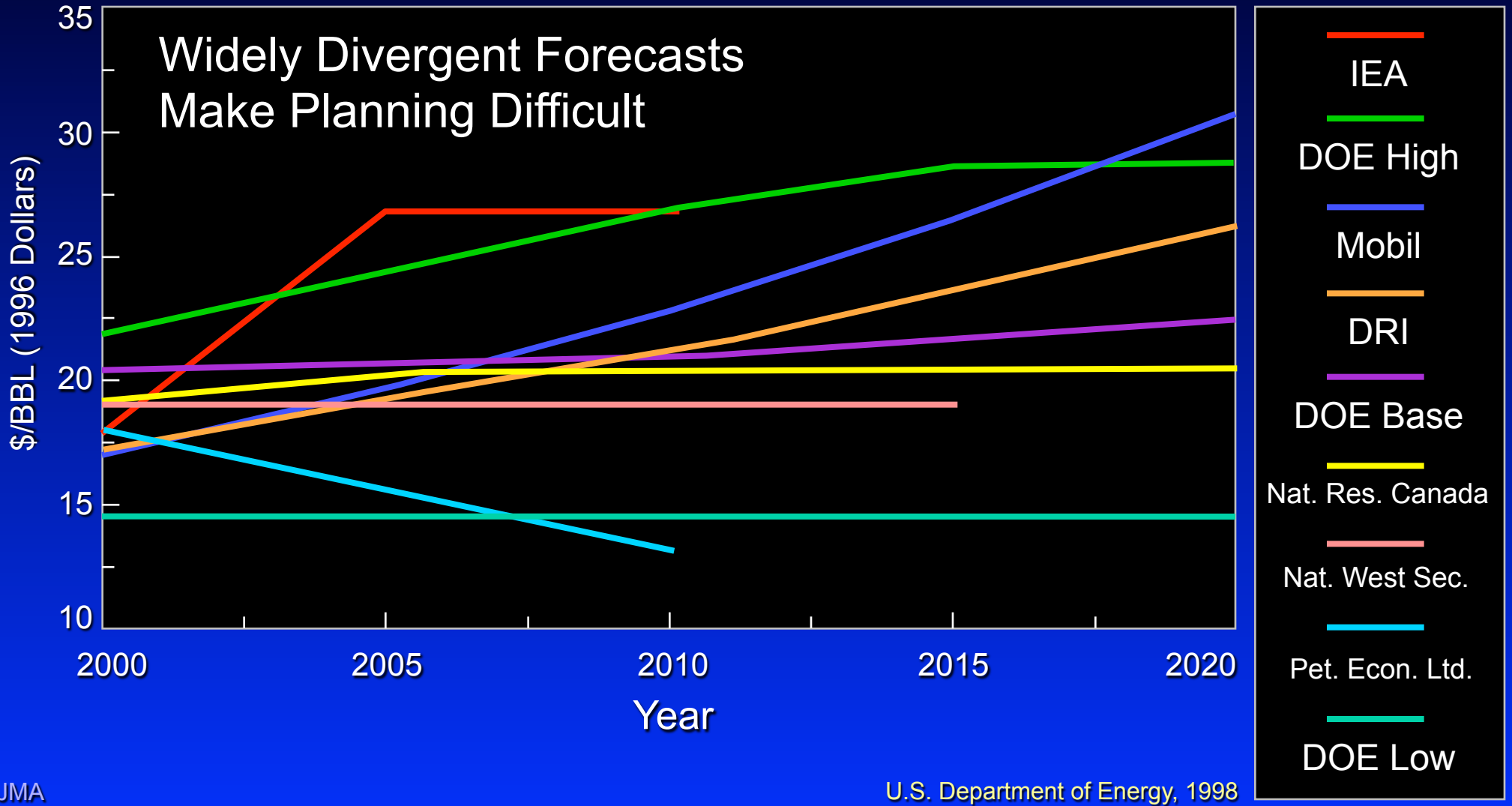
1998 Oil Price Forecasts

Nine Organizations



U.S. Department of Energy, 1998

Gasoline Price: Cost vs. Tax

Per Gallon Unleaded Self-Service in 1998 Dollars

City	Pump Price		Tax	Product
	July '98	Jan. '99		
San Francisco, CA	1.45	1.25	.46	.78
San Diego, CA	1.49	1.18	.46	.71
Portland, OR	1.35	1.15	.42	.73
Boston, MA	1.18	1.13	.40	.73
Seattle, WA	1.31	1.10	.41	.68
Washington, DC	1.24	1.08	.38	.70
Atlanta, GA	.93	.98	.30	.67
Dallas, TX	1.08	.95	.38	.57
Denver, CO	1.18	.94	.40	.53
Kansas City, MO	.96	.86	.35	.51
Tulsa, OK	.97	.81	.35	.45

Oil and Gas Journal, January 18, 1999

Gasoline Price: Cost vs. Tax

Per Gallon in 1998 Dollars (December 1998)

Country	Pump Price	Tax	Product Price
UK[1]	4.45	3.78	0.68
Italy[1]	4.15	3.24	0.91
France[1]	4.14	3.50	0.64
Germany[1]	3.32	2.68	0.64
Japan[1]	3.11	1.90	1.21
Spain[1]	2.98	2.18	0.80
Canada[1]	1.30	0.71	0.59
USA[2]	0.98	0.39	0.59

[1] International Energy Agency [2] Oil and Gas Journal

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Gasoline Price: Cost vs. Tax

Per Gallon in 1998 Dollars (December 1998)

Country	Pump Price[A]	Tax[B]	Product Price[A]
UK[1]	4.45 (454%)	3.78 (85%)	0.68 (115%)
Italy[1]	4.15 (423%)	3.24 (78%)	0.91 (154%)
France[1]	4.14 (422%)	3.50 (85%)	0.64 (108%)
Germany[1]	3.32 (339%)	2.68 (80%)	0.64 (108%)
Japan[1]	3.11 (317%)	1.90 (61%)	1.21 (205%)
Spain[1]	2.98 (304%)	2.18 (73%)	0.80 (136%)
Canada[1]	1.30 (133%)	0.71 (55%)	0.59 (100%)
USA[2]	0.98 (100%)	0.39 (40%)	0.59 (100%)

[1] International Energy Agency
[2] Oil and Gas Journal
[A] Percent of US Price
[B] Percent of Pump Price

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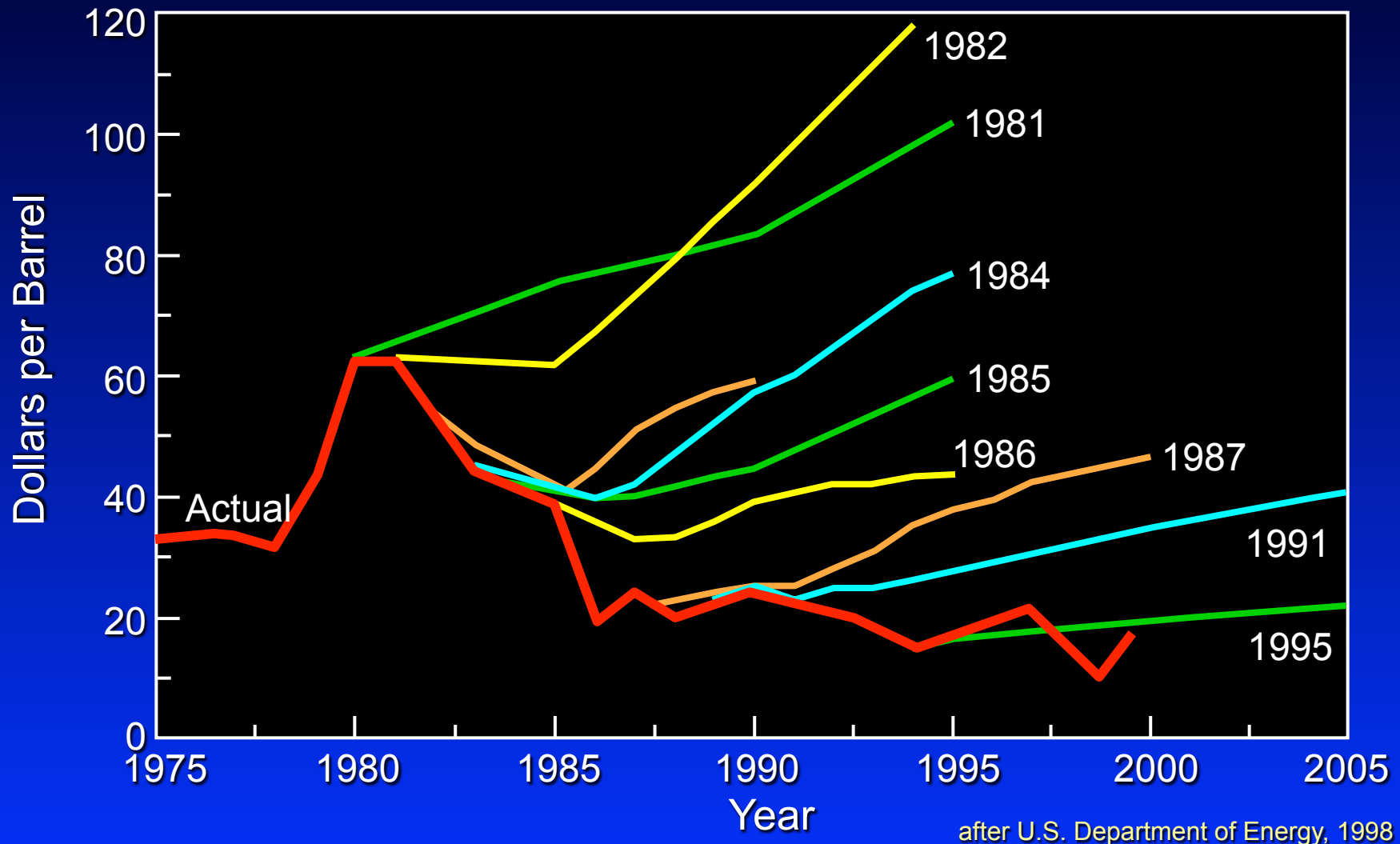
DOE Oil Price Forecasts

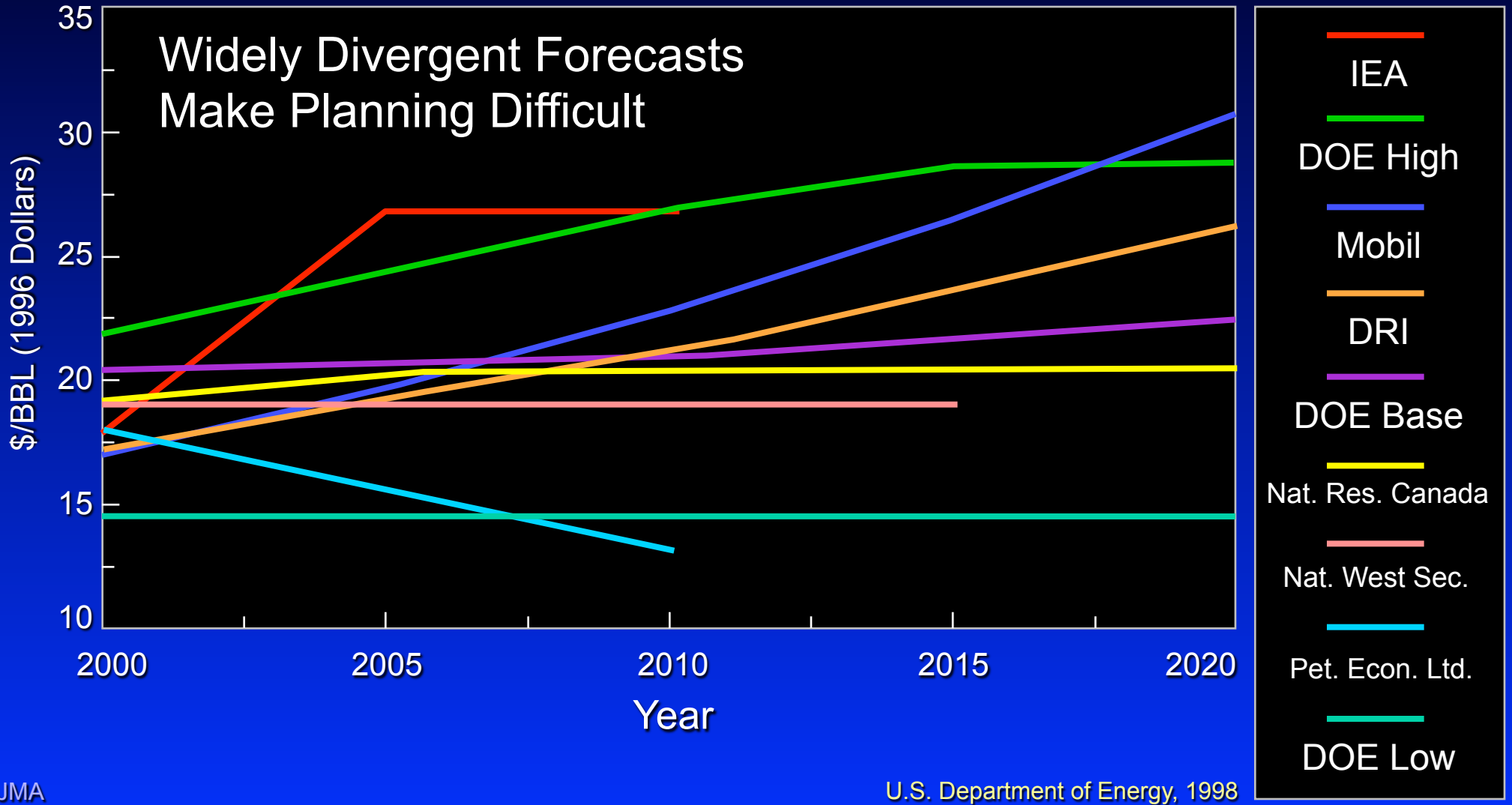
Linear Trends Predicted Beginning From the Actual Price of Year Listed



after U.S. Department of Energy, 1998

1998 Oil Price Forecasts

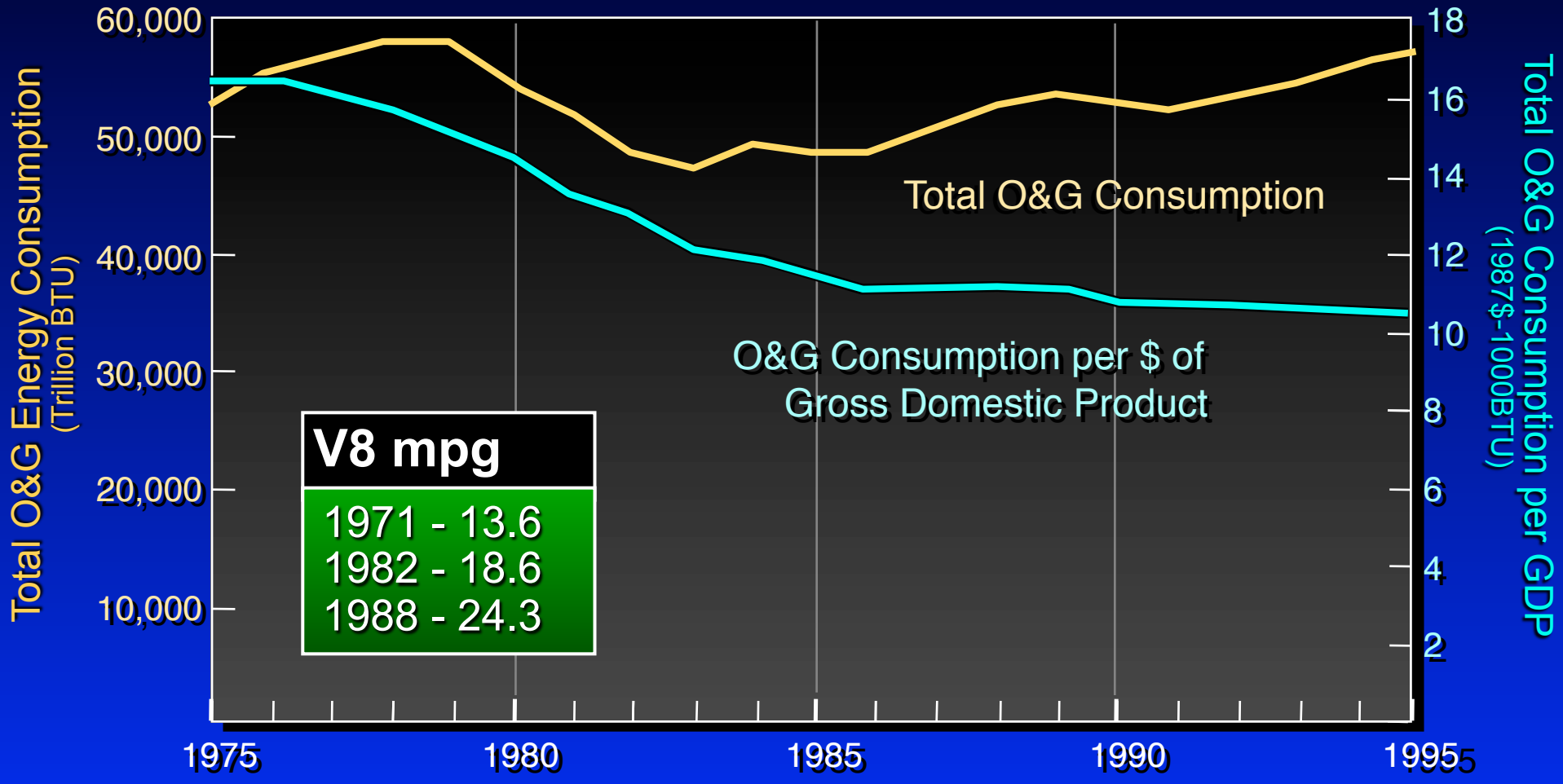
Nine Organizations



U.S. Department of Energy, 1998

US Oil & Gas Consumption/Efficiency

Technology Drives Efficiency: Population Drives Consumption



Robert McGill - AAPG Explorer, 11/95

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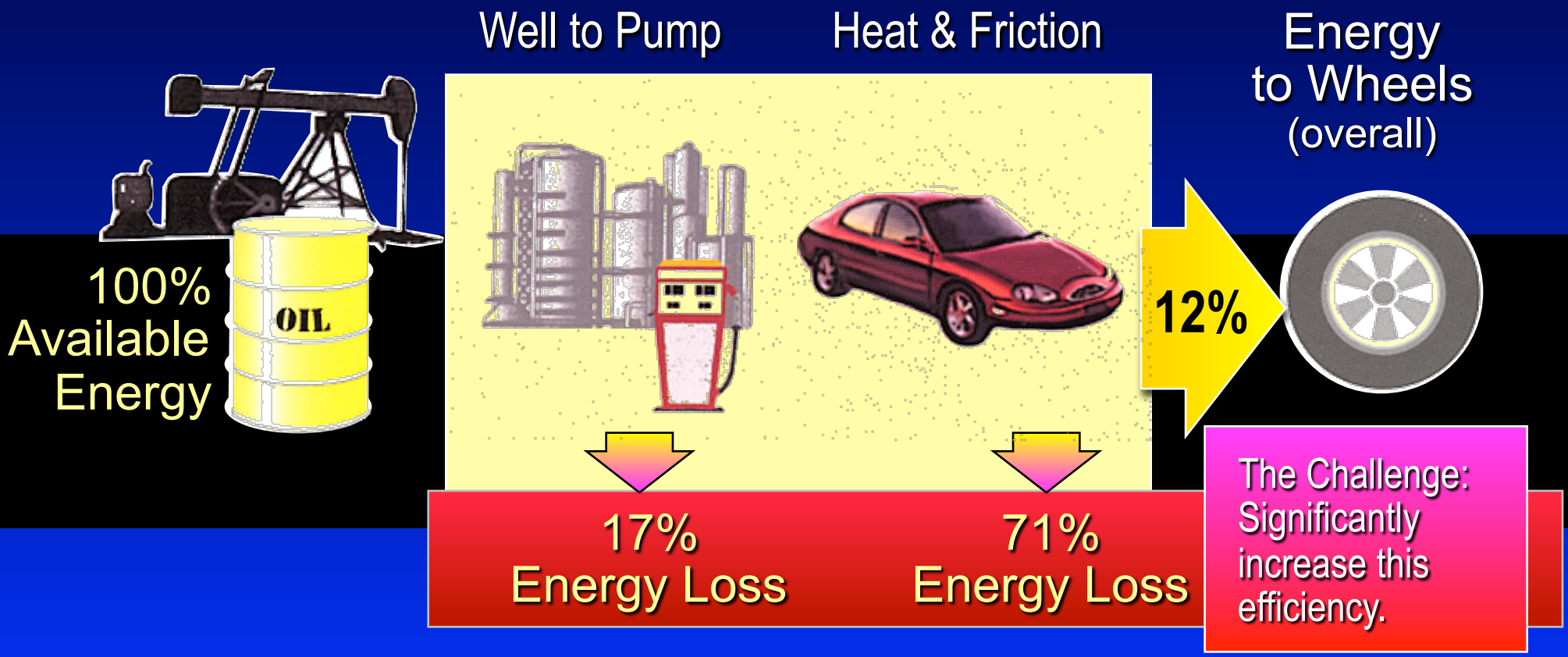
More Efficient Energy Use

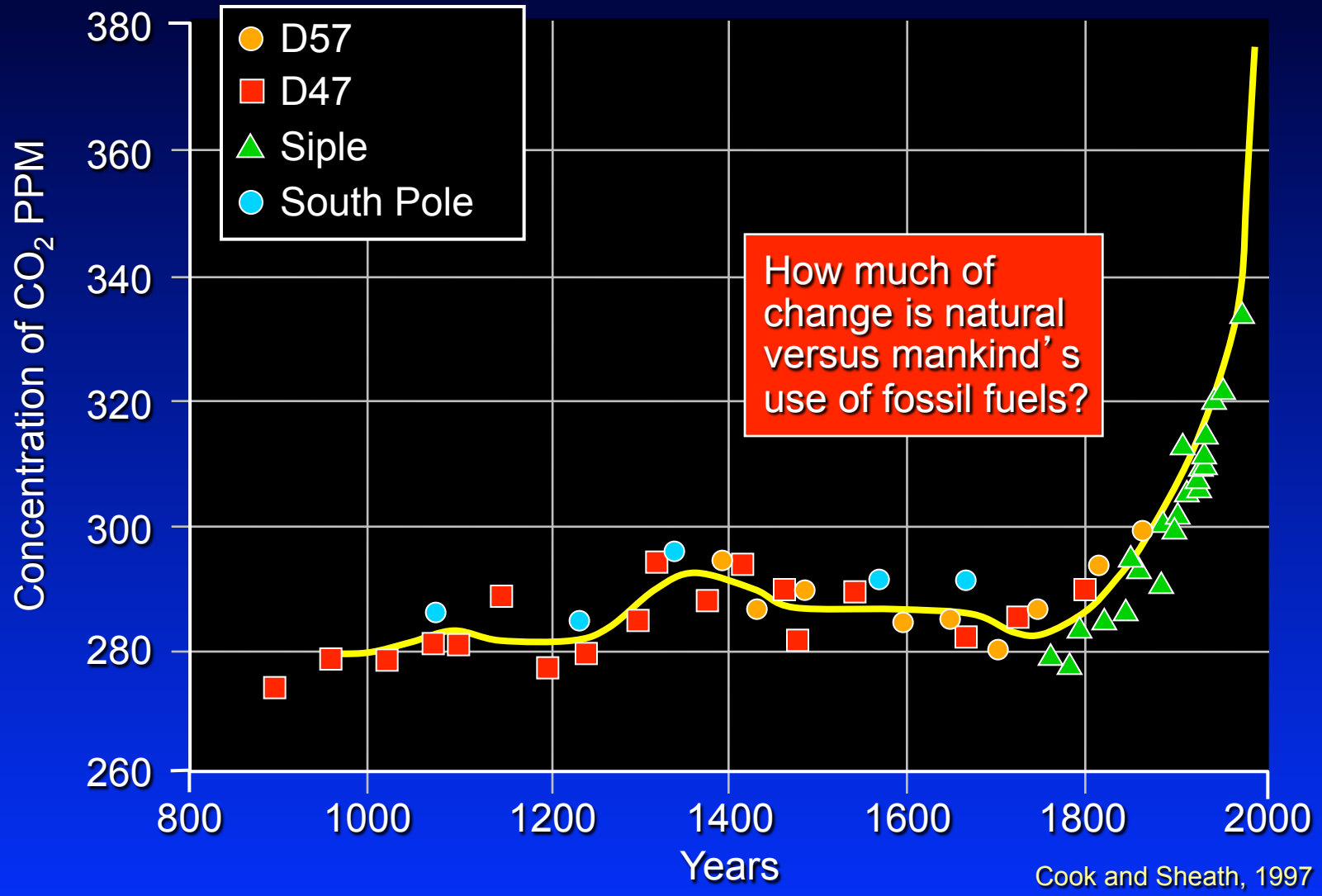
Only 12% of Wellhead Oil Energy Potential is Actually Driving a Car's Wheels



Source: Mobil Technology Company

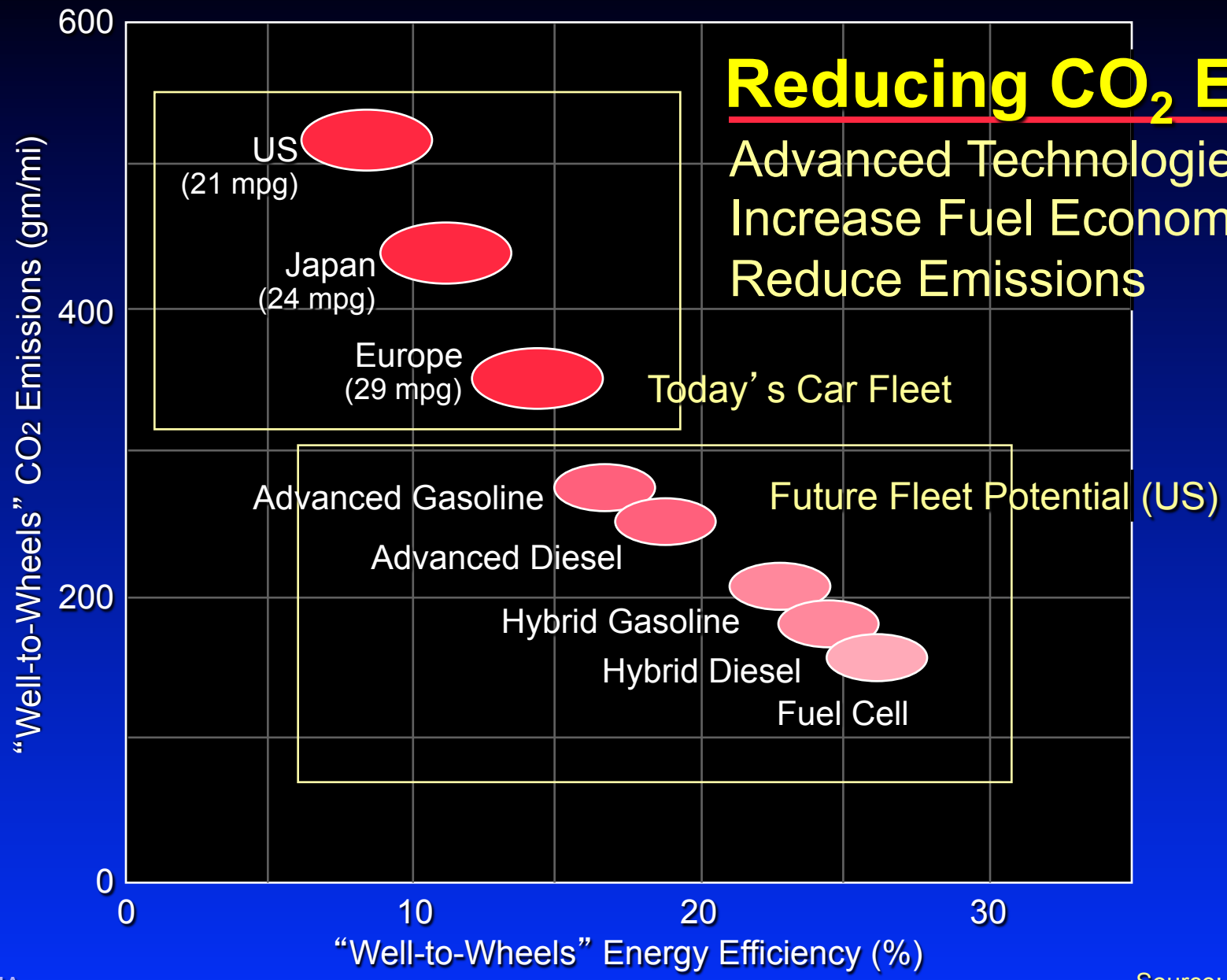
Atmospheric Concentration of CO_2

1000 Year History



Reducing CO_2 Emissions

Advanced Technologies Can Increase Fuel Economy and Reduce Emissions



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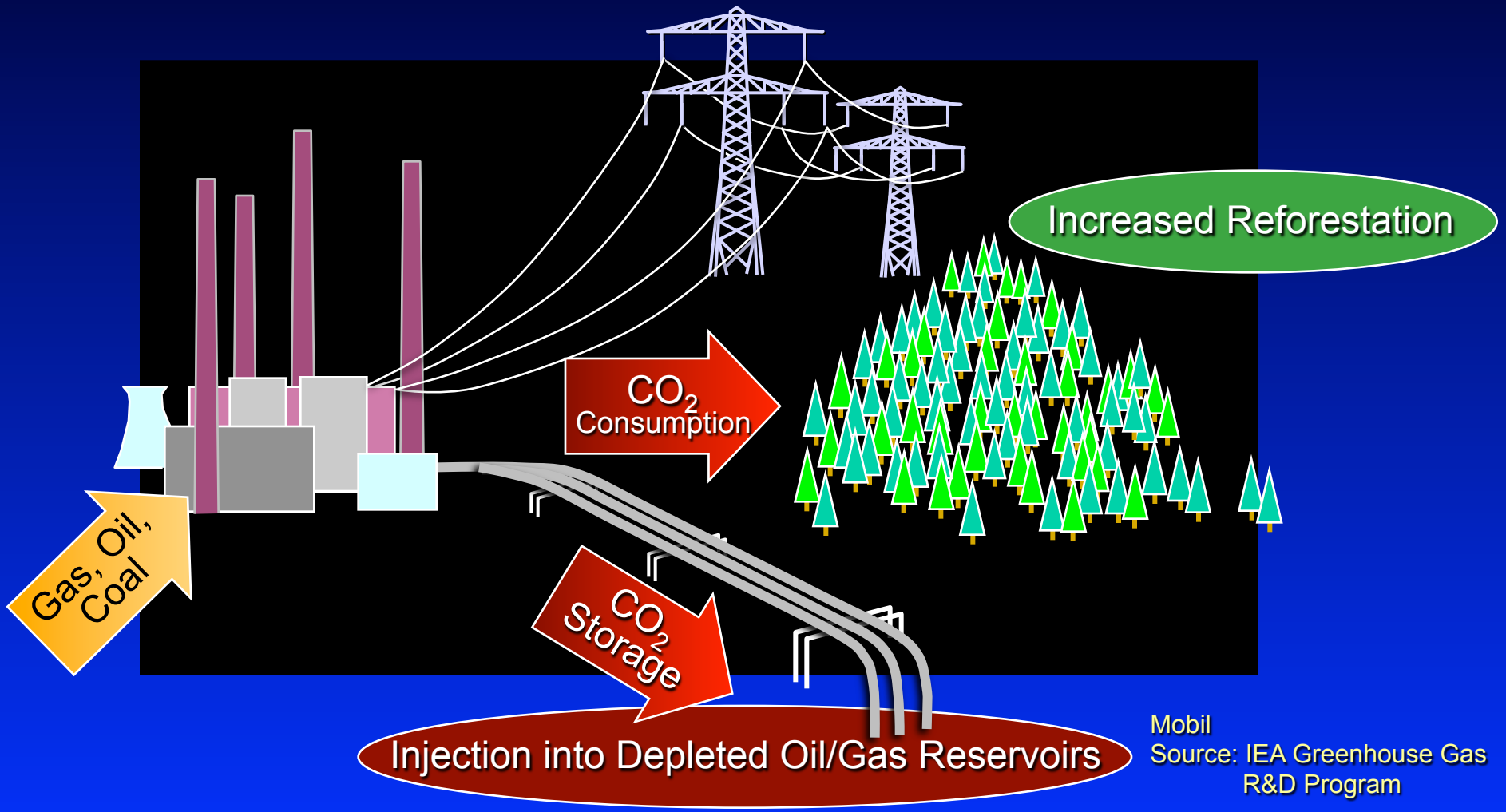
Source: Mobil Technology Company

CO_2 Capture and Storage

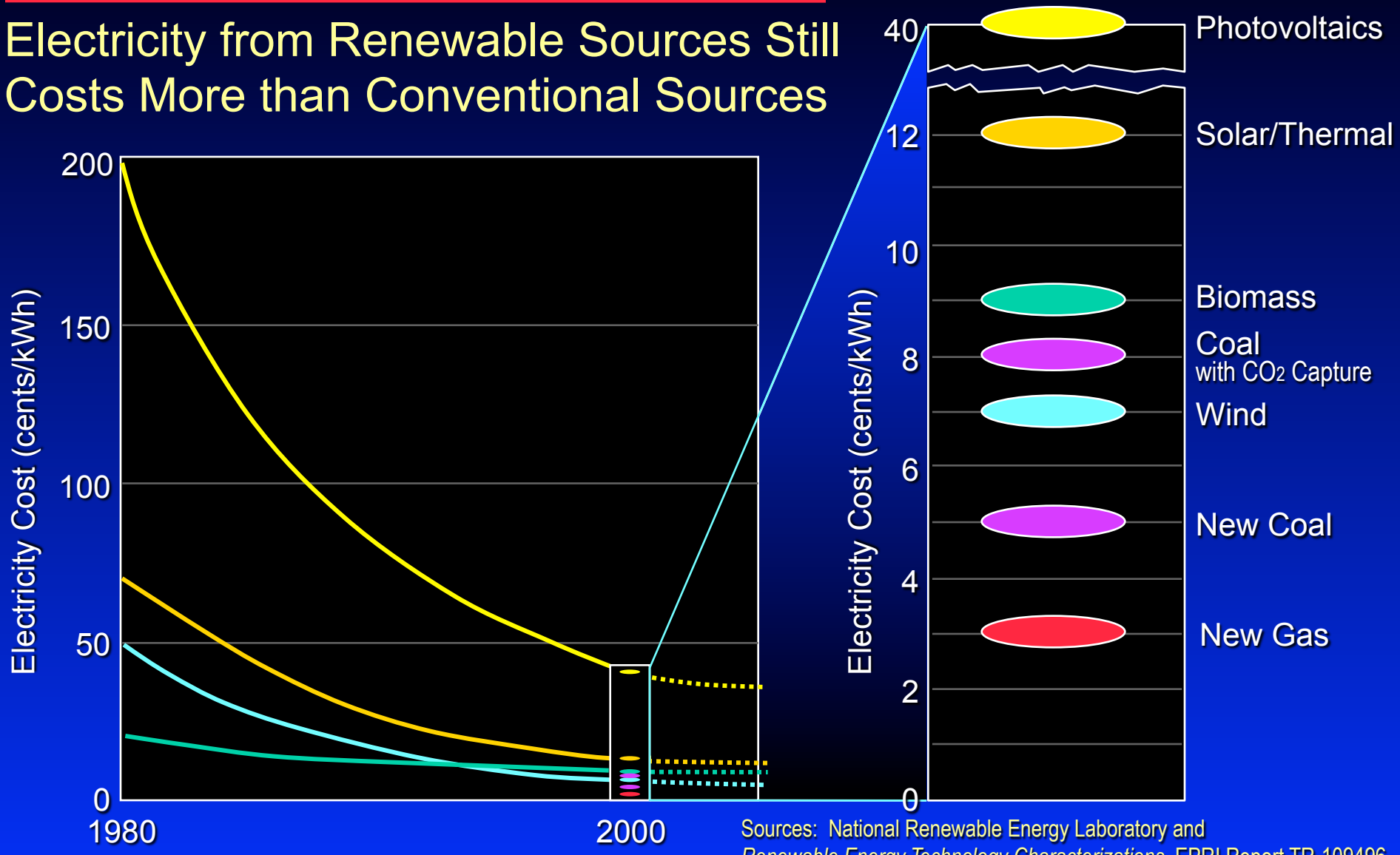
Potential for Reducing CO_2 Emissions from Fossil Fuel Power Generation



Mobil
Source: IEA Greenhouse Gas R&D Program

Electrical Power Generation

Electricity from Renewable Sources Still Costs More than Conventional Sources



Sources: National Renewable Energy Laboratory and *Renewable Energy Technology Characterizations,* EPRI Report TR-109496

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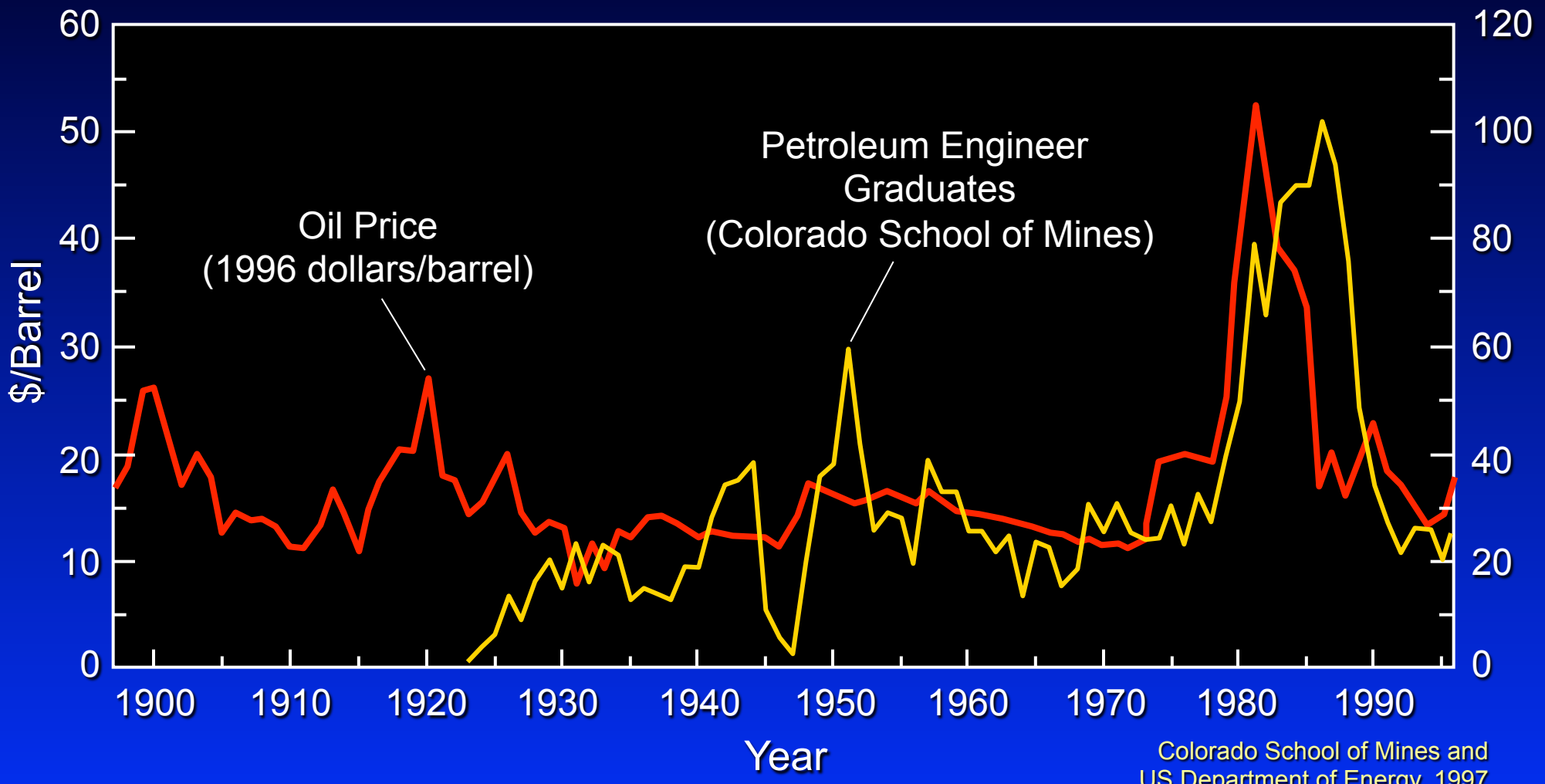
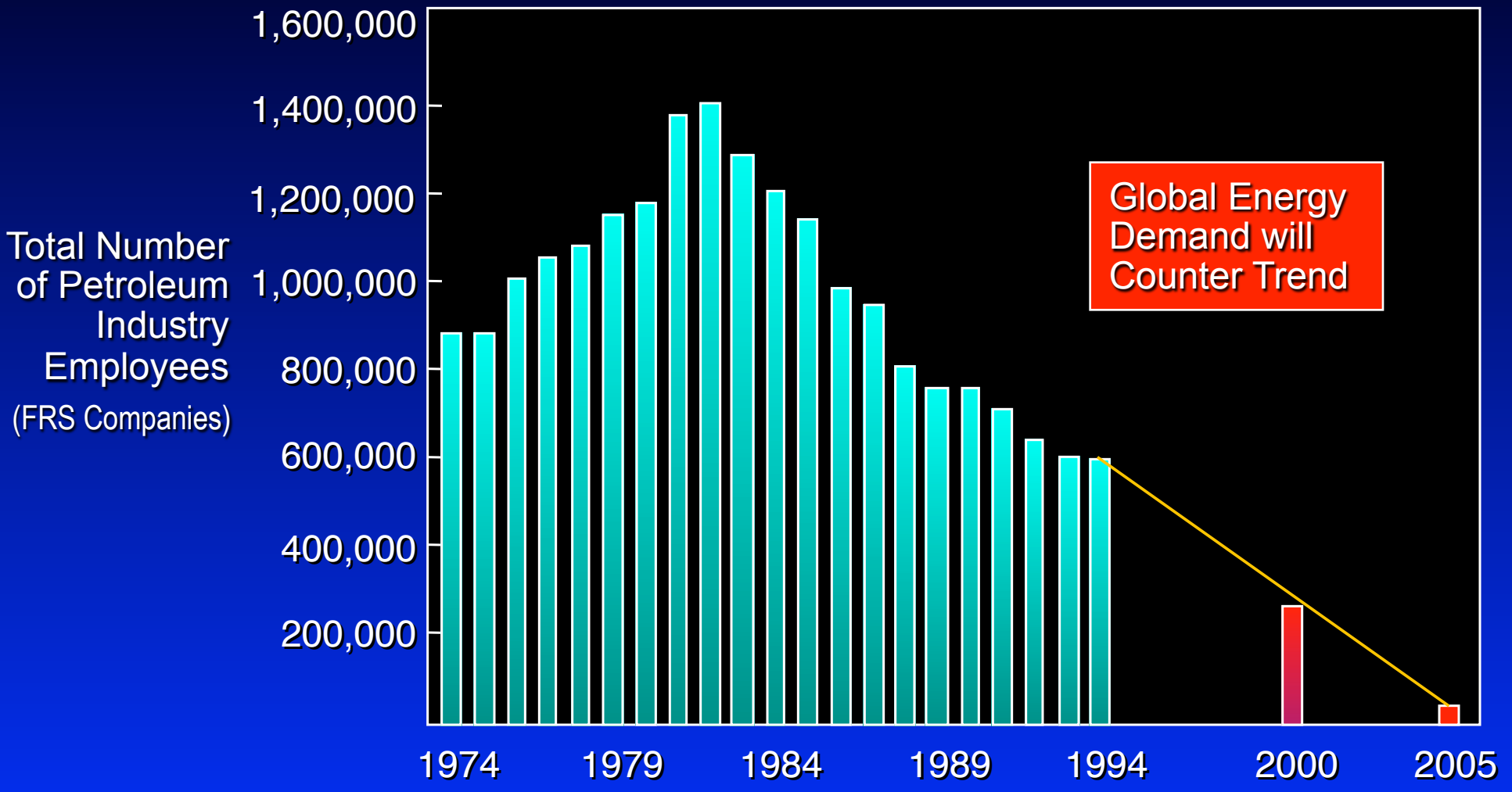
Impact on Students

Linkage of Petroleum Industry and Geoscience Students



Colorado School of Mines and
US Department of Energy, 1997

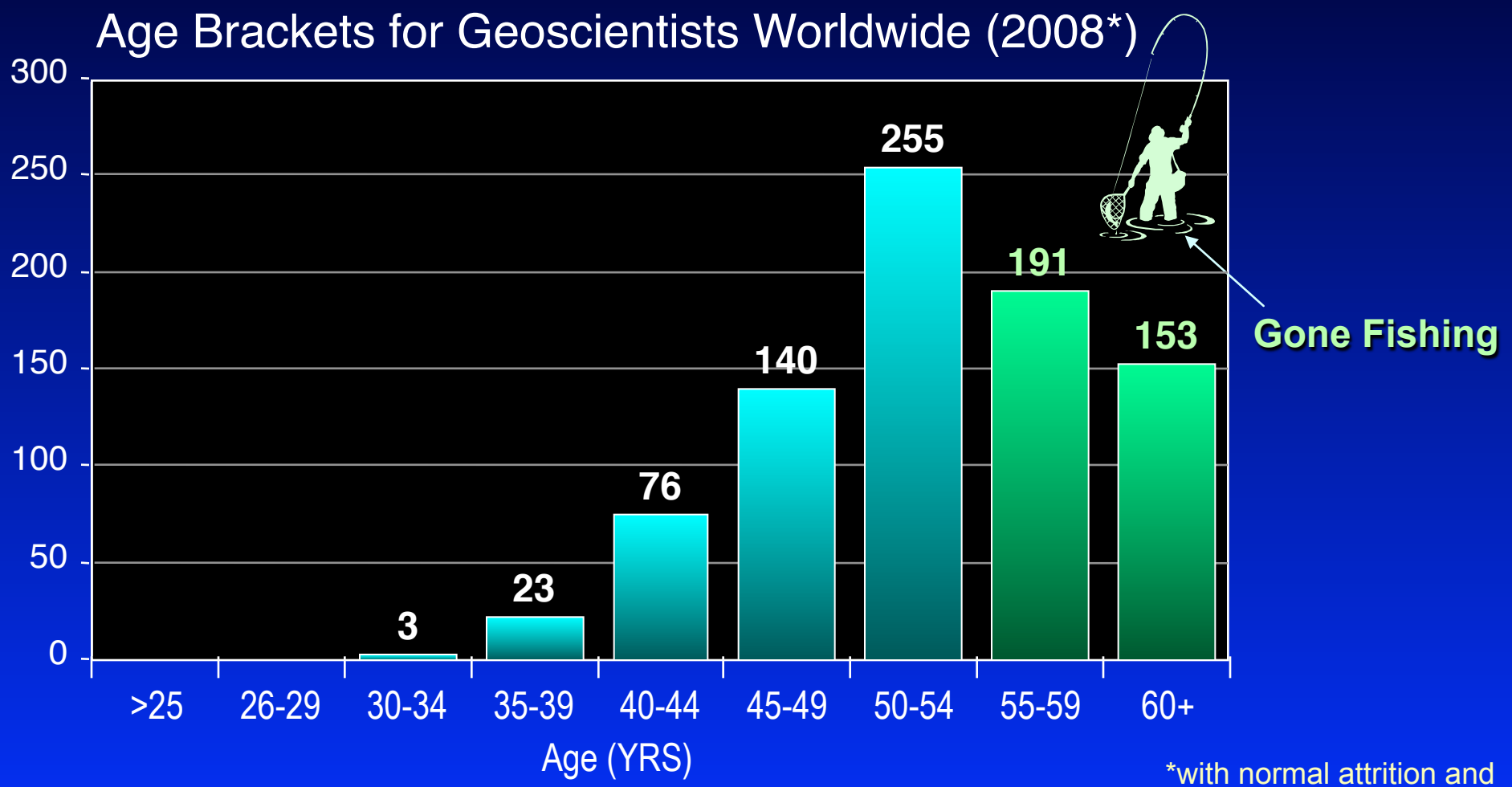
Worst Case Employment Scenario



Arthur L. Smith, CFA - Abilene, Texas, 1996

Geoscience Demographics

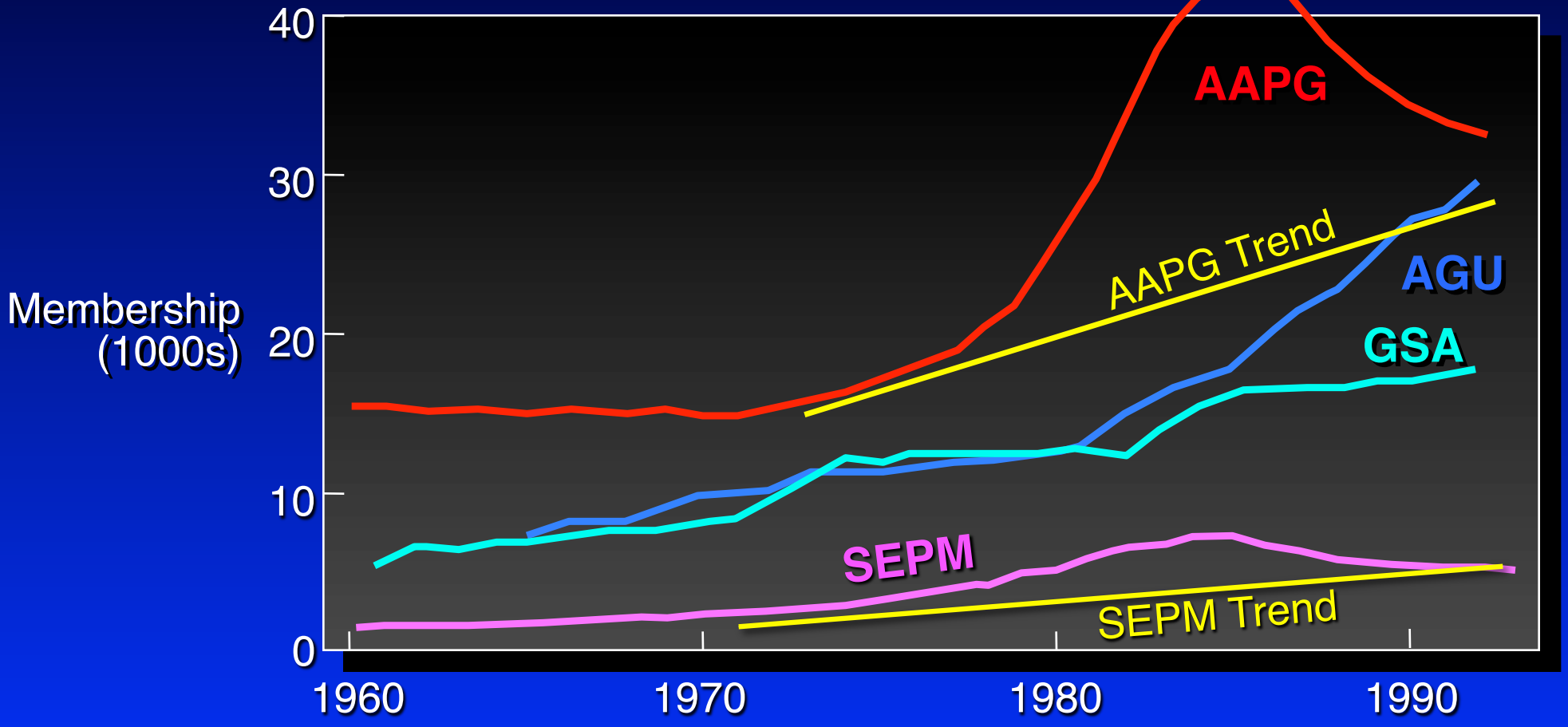
For a Typical Major Oil Company



*with normal attrition and no replenishment

Optimistic Long-range Trends for Geoscience Employment

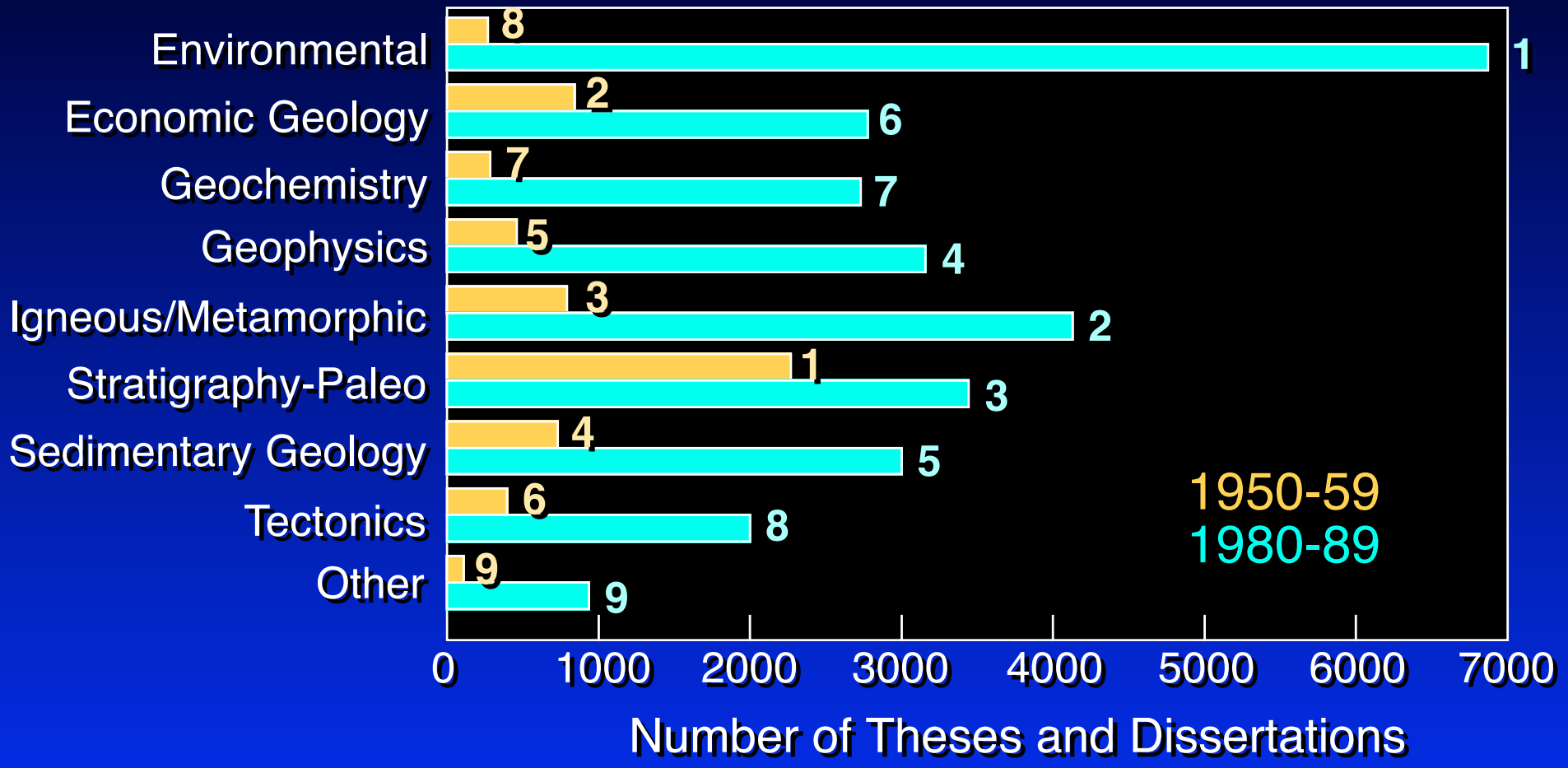
Total Employment Continues to Grow



after Marcus Milling - AGI, 1995

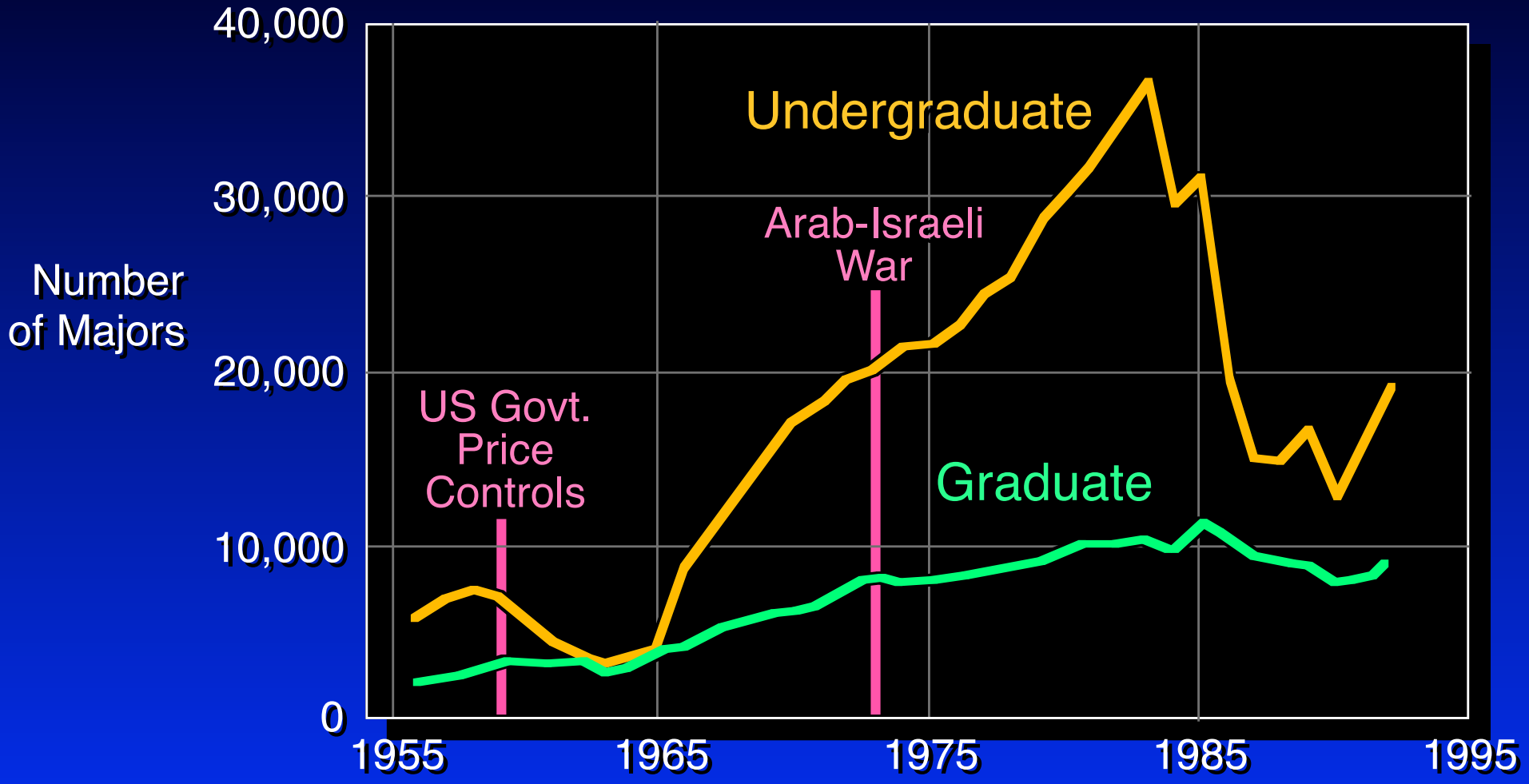
Geoscience Theses and Dissertation Topics

1950s versus 1980s



Marcus Milling
AGI, 1996

US Geoscience Student Enrollment



Marcus Milling
AGI, 1993

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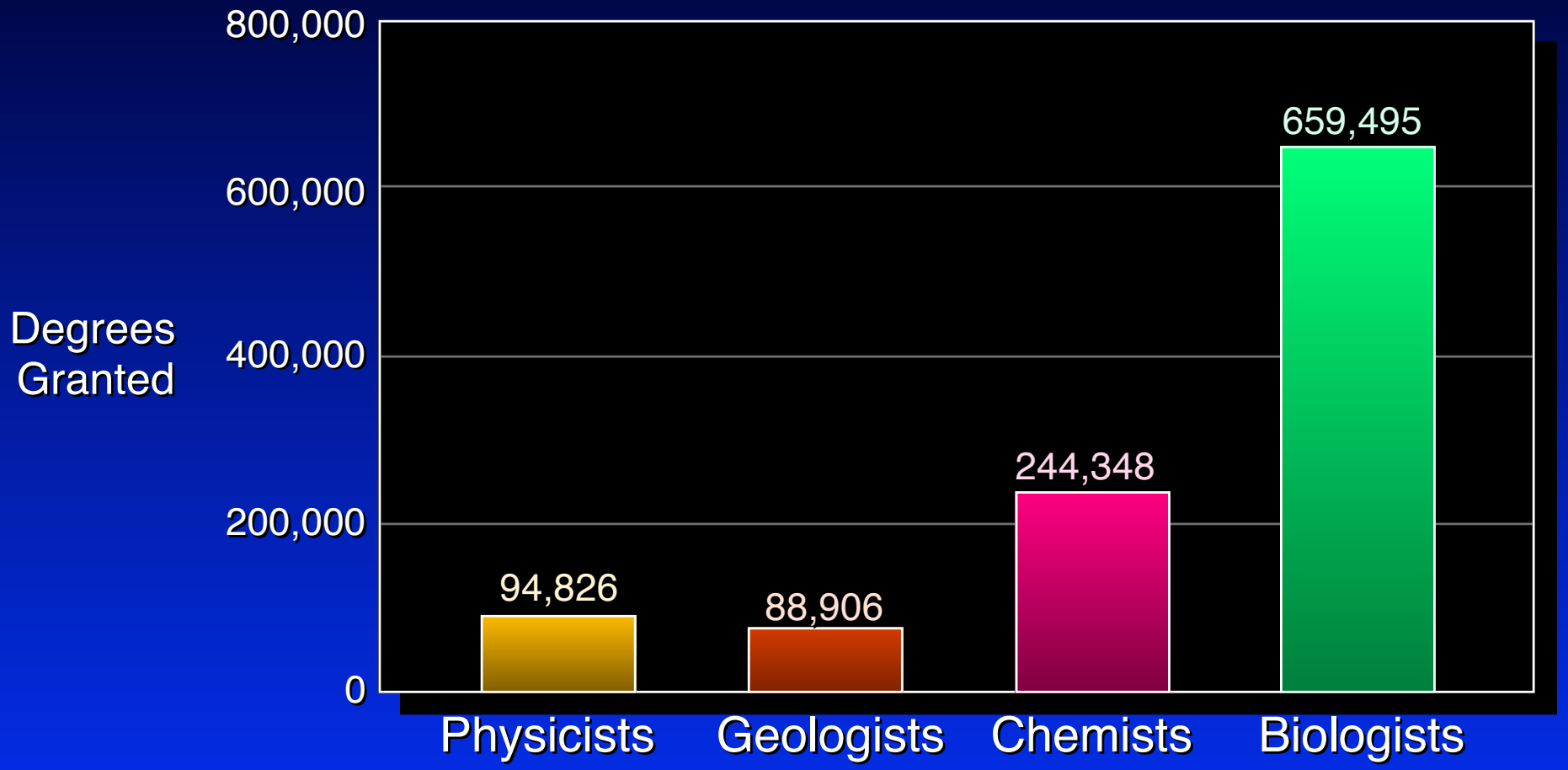
Supply

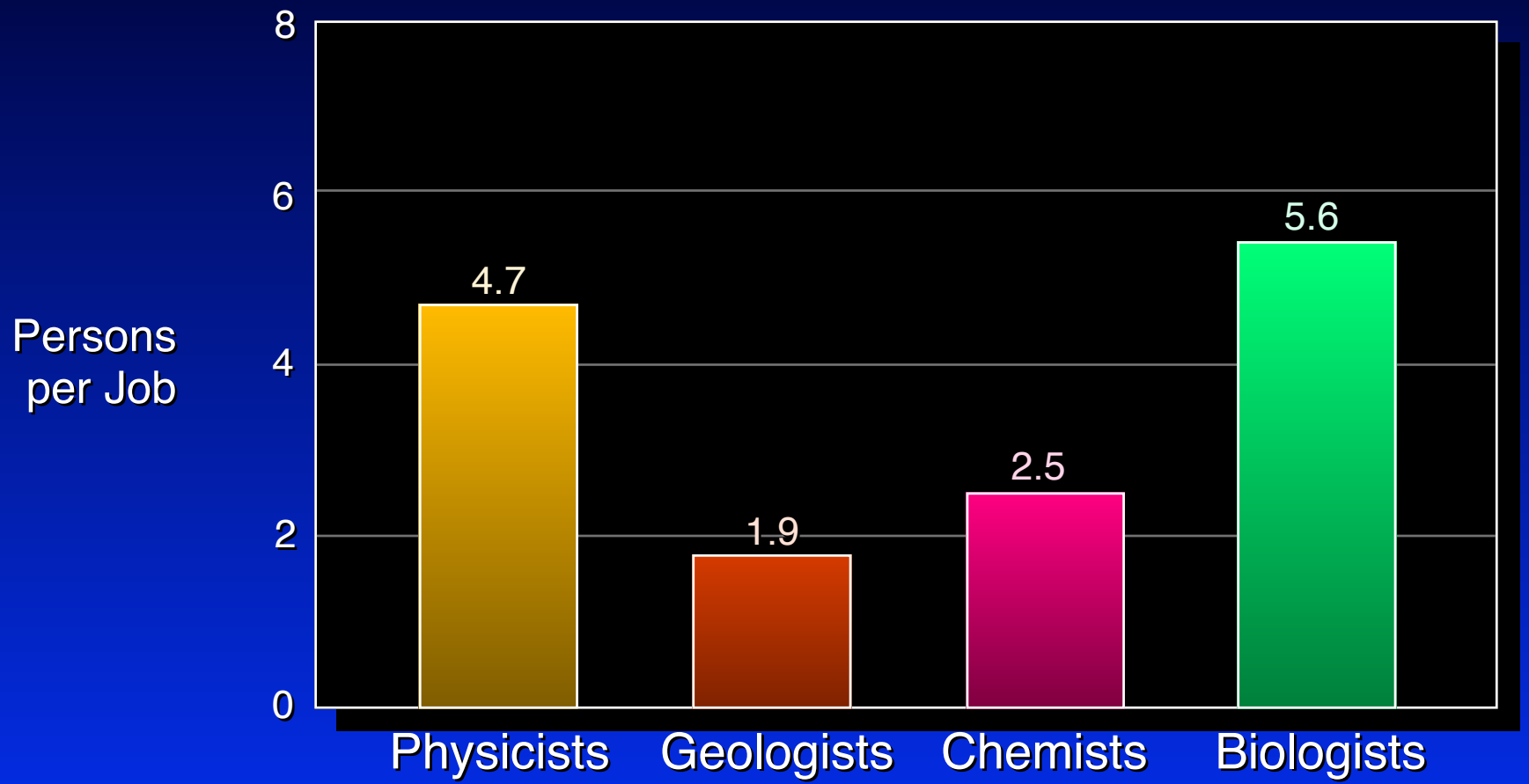
Bachelor's Degrees, 1970-1994



John Holbrook, *Palaios,* Dec. 1997 | Occupational Outlook Handbook, US Bureau of Labor Statistics

Job Competitiveness

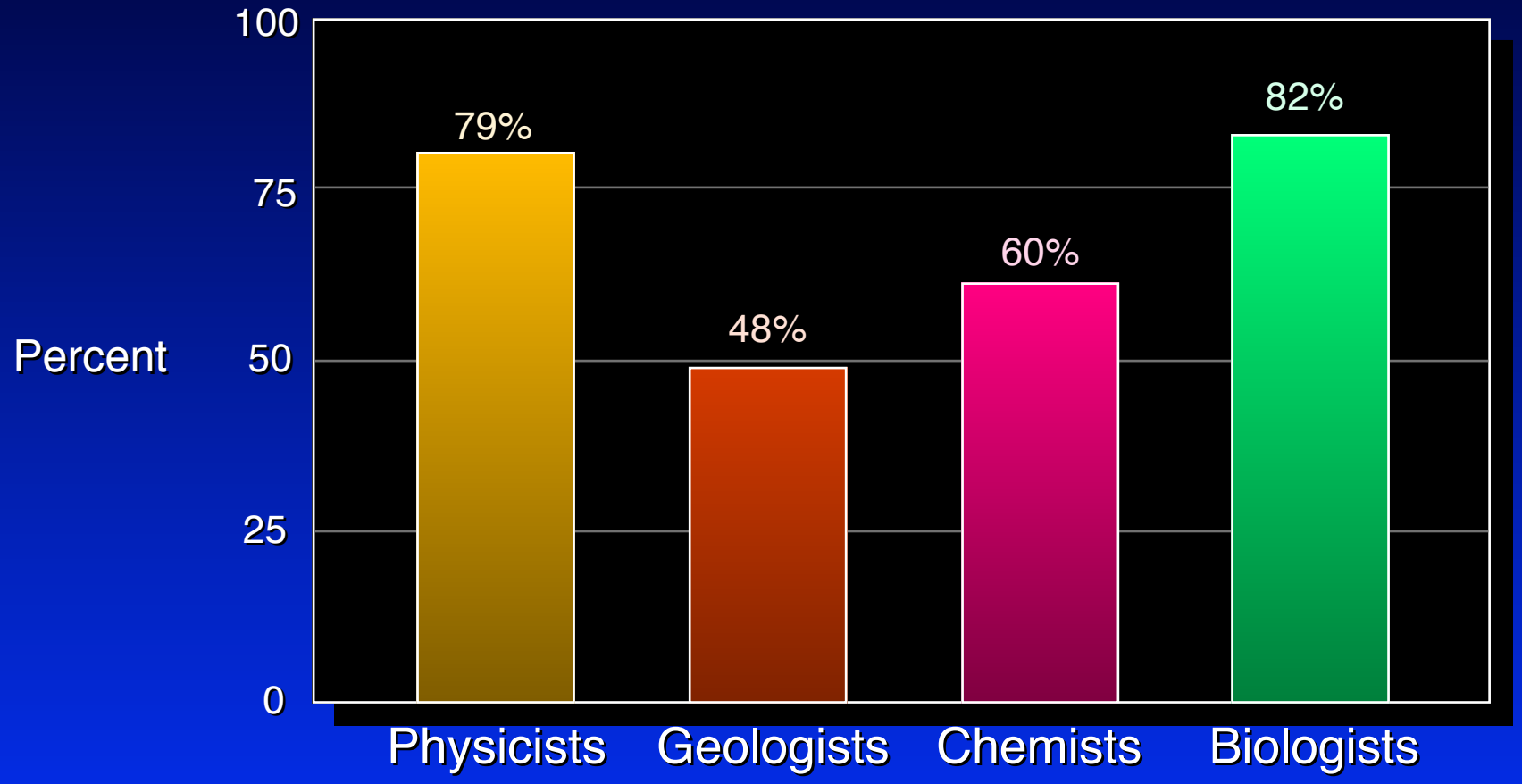
1970-1997 BS Degrees/1997 Jobs



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

Employed Outside Initial Discipline

1970-1997 BS Degrees/1997 Jobs



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

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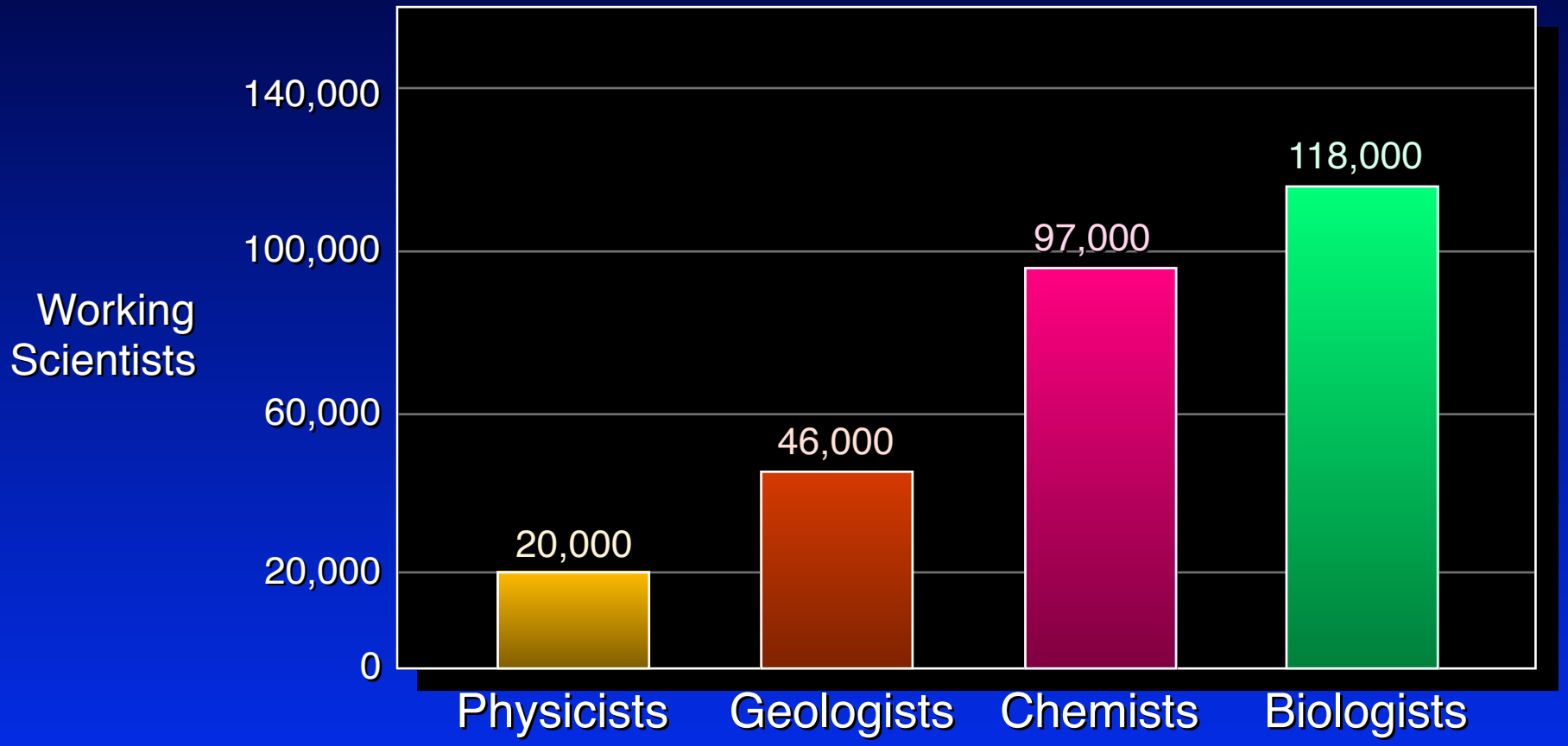
Demand

Employed Natural Scientists, 1997, USA



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

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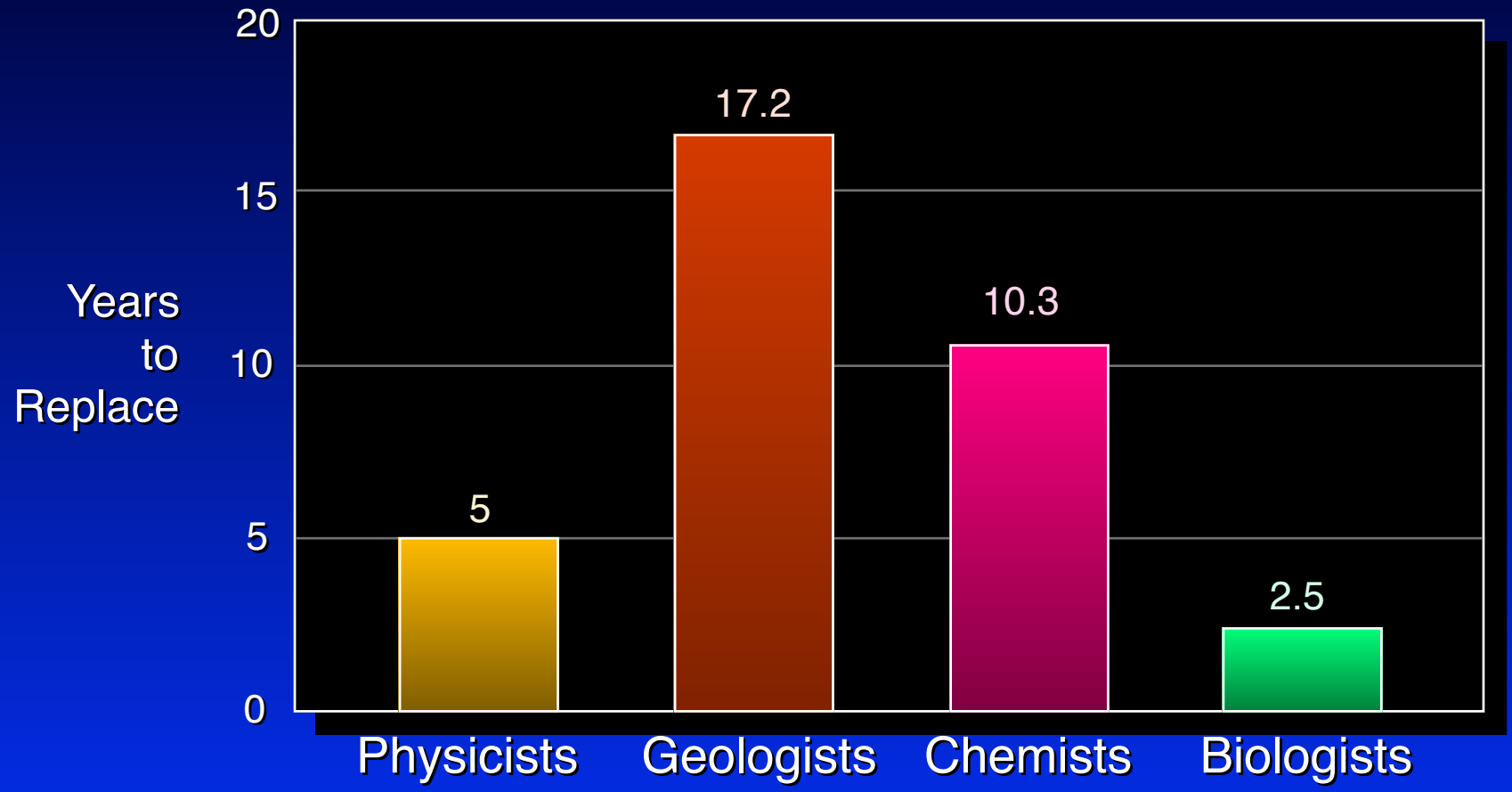
Job Competitiveness

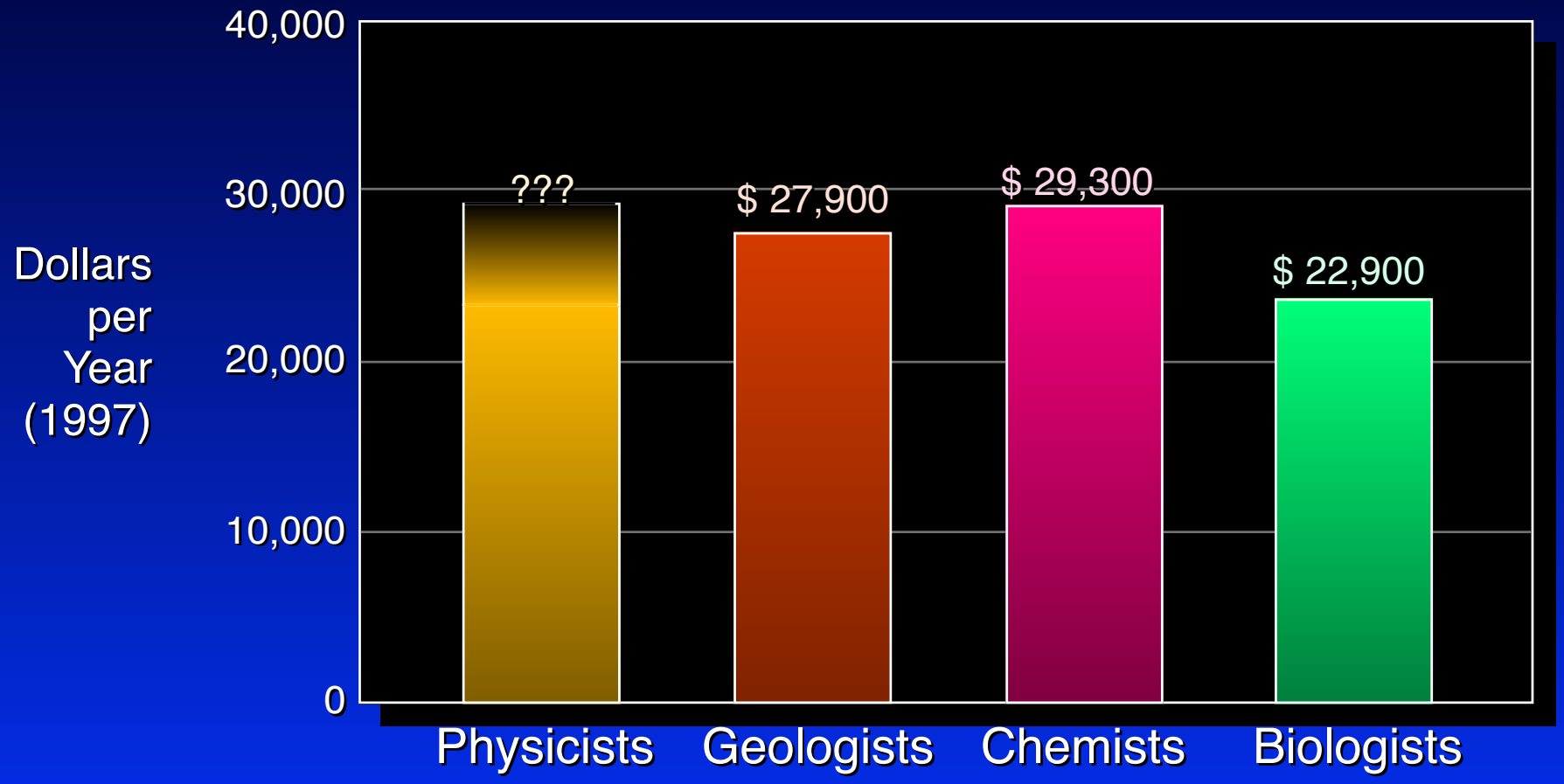
Years to Replace Currently Employed Scientists



John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

Compensation

Average Salary – Bachelor's Degree, USA



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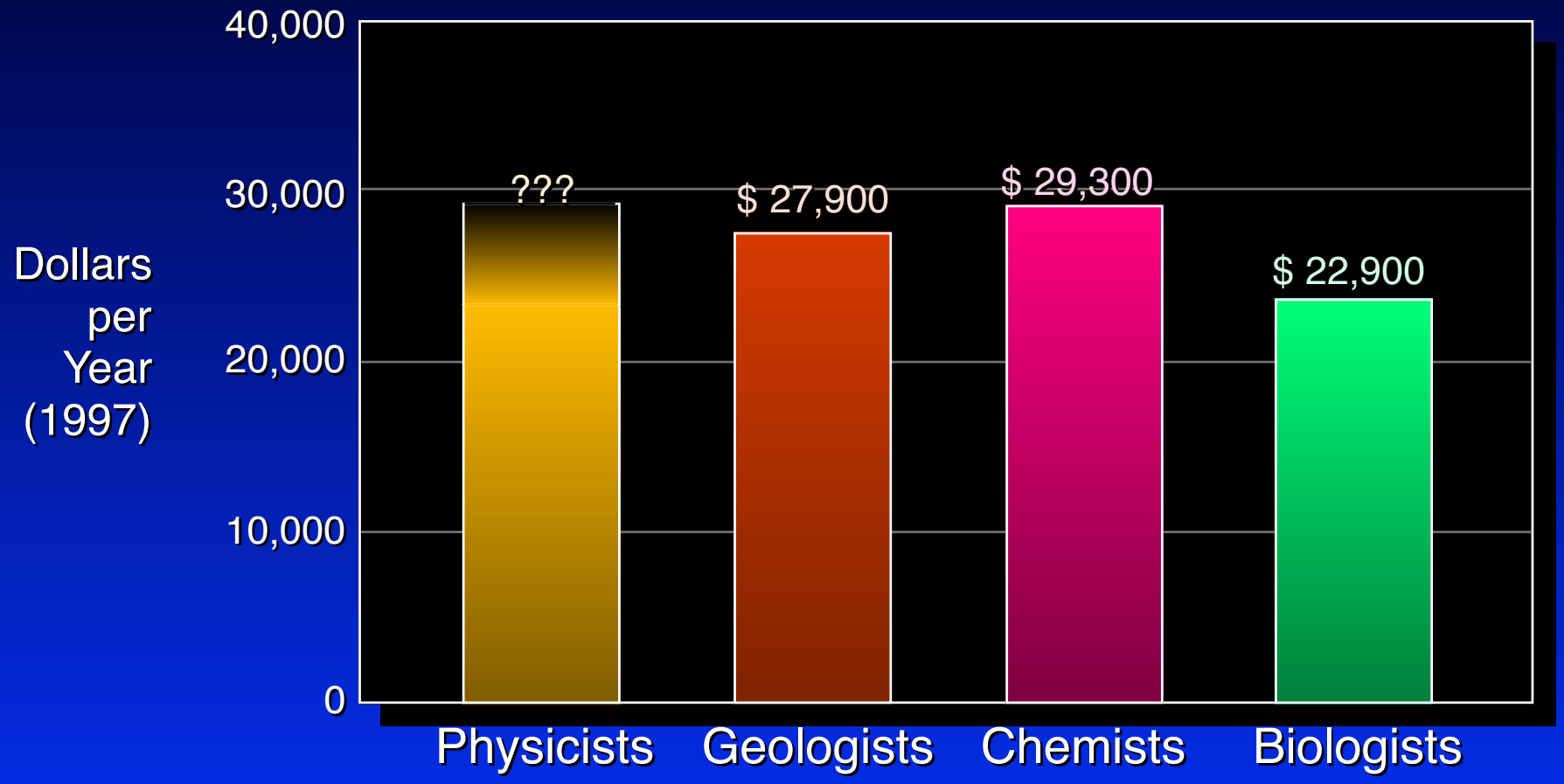


John Holbrook | Occupational Outlook Handbook
Palaios, Dec. 1997 | US Bureau of Labor Statistics

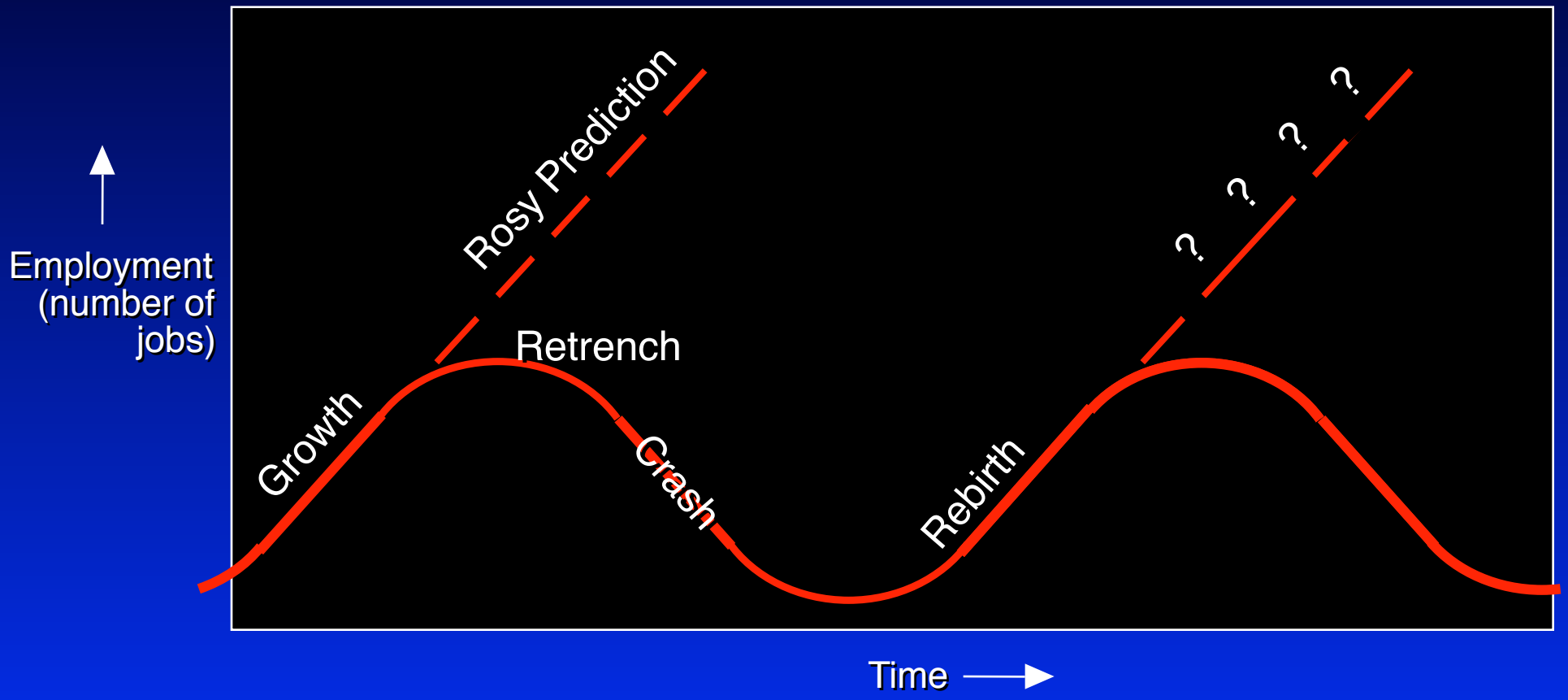
Geoscience Careers

Survival Training

- Strong basic-discipline training
- Constant updating and expansion of skills and knowledge
- Competitive-edge in several skills
  - Quantitative
  - Workstation (computer)
- Excellent communication skills
  - Oral, written, graphical

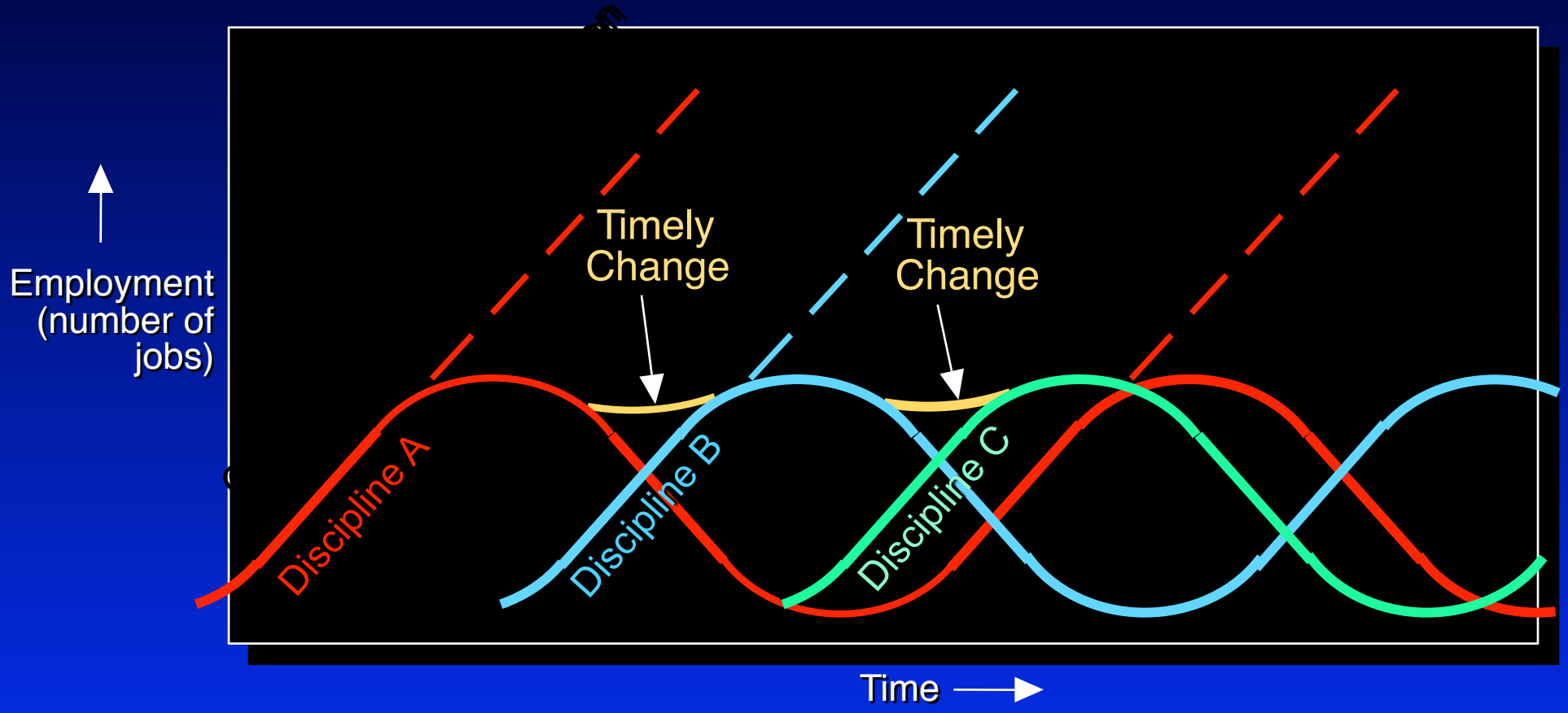
Cyclic Job Market

Typical of Today's Global Industries



Cyclic Job Market

Continuous Learning Facilitates Timely Changes



Society Needs our Expertise

Resource Assessment:	Fossil fuels Stratigraphic minerals
Environmental Quality:	Water supplies Waste management
Catastrophe Management:	Landslides, Floods, Tidal Waves Bolide Impacts
Climate Change:	Documentation Coastal management

Future of Sedimentary Geology

Geologic EmploymentAreas

- Mineral Resources
  - International Exploration
  - Petroleum Reservoir Management
- Environmental
  - Climate Change Study
  - Geologic HazardAssessment
  - Flow Unit Characterization
    - Water Supply Protection
    - Waste Containment

Job Market Expectation

By Employers

Assume: Self-motivated
Computer- Literate
Well-educated
Team Player
Excellent Communicator

Job Market Expectation

By Employers

Expectation:

- Immediate Impact
- Bottom Line Focus
- High Productivity
- Continuous Training
- Problem Solving

Job Market Readiness

Student Preparation

Education: Broadly Based
Balance of Theory
and Application

Thesis: Targeted

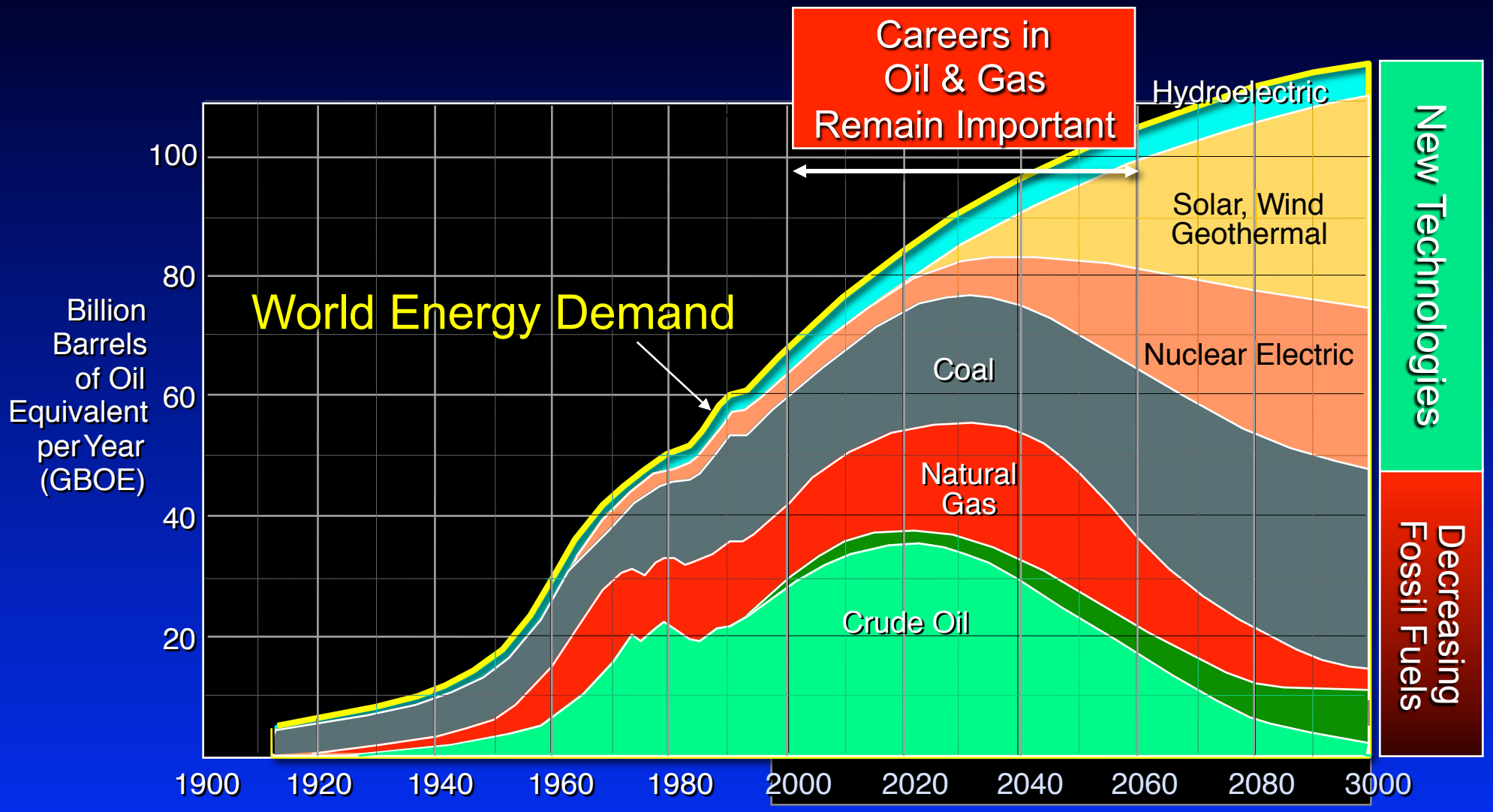
Job Market Readiness

Student Preparation

Skills: Problem Solving
Computer Workstation

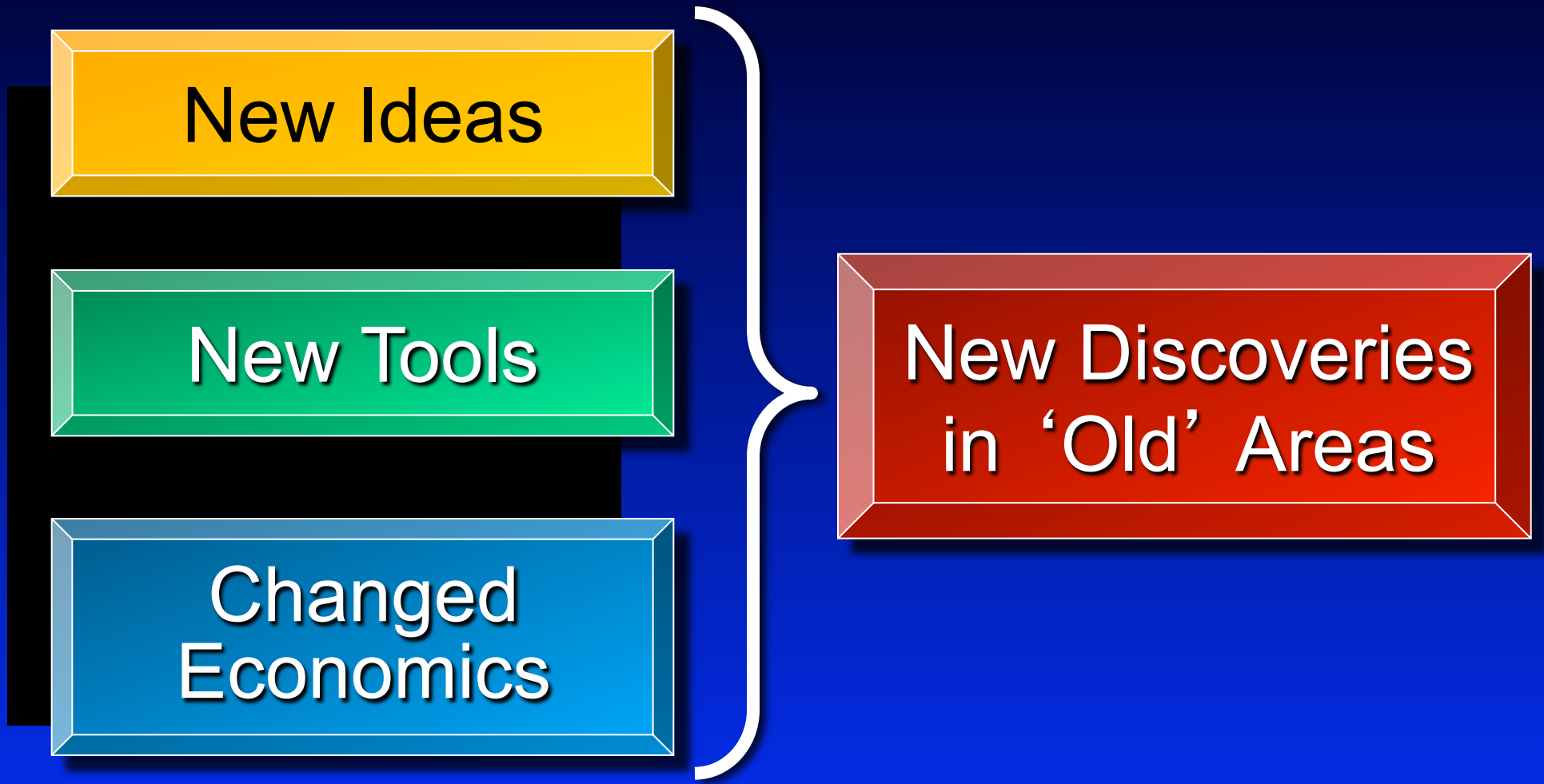
Traits: Self-motivated
Proactive

Projected World Energy Supplies



after Edwards,
AAPG 8/97

‘Never-Say-Never’ to Exploration Areas



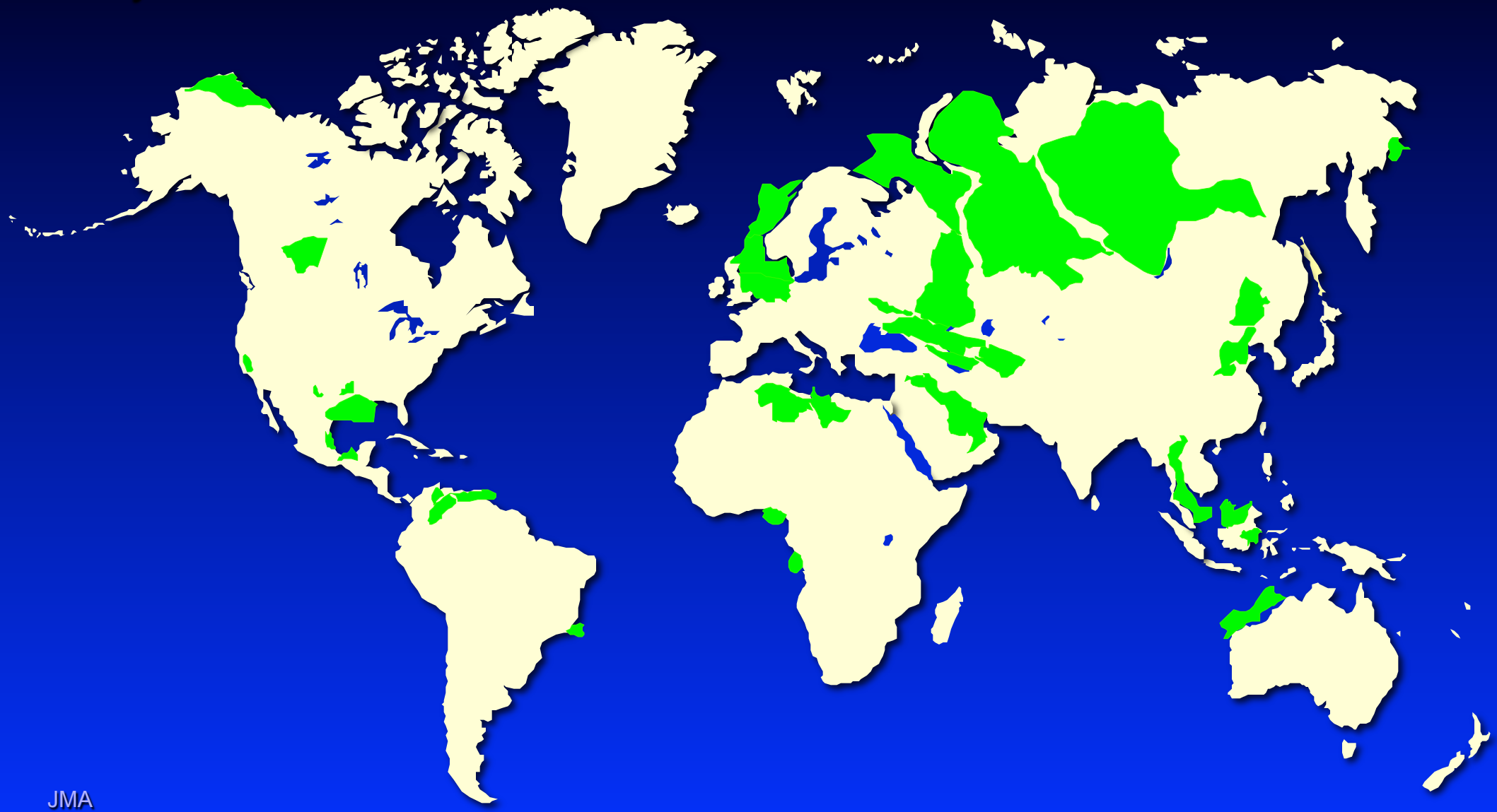
The Future for the Oil Industry

- Dominant fuel source for 30-60 more years
- Higher efficiency demands high precision and better resolution
- Increased emphasis on enhanced recovery/production scale sedimentology
- People provide the competitive edge (as everyone has the same tools)

- Jobs for the best geoscientists

Largest Hydrocarbon Basins

by Ultimate Potential



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Computer Simulation and History Matching