

# The AAPG Century – Giant Fields through the Decades\*

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## Abstract

A giant oil field is generally estimated to contain in excess of 500 MMBOE estimated ultimate recovery. Since the late nineteenth century, at least four factors seem to control the frequency of discovery of giant oil and gas fields. These factors include concepts (e.g., geological models), technology, price, and access to drilling locations. The importance of understanding these factors drove creativity in the exploration process. In our efforts to understand common petroleum system parameters in these fields and, importantly, what is unusual about each field, leads to “Discovery Thinking” in our search for new oil and gas fields. In the mid- to late-nineteenth century the recognition of seeps focused exploration efforts. This was followed by recognizing the importance of anticlines. Petrophysical tools followed in the early 20th century as well as the application of seismic as an exploration tool. These tools continued to be developed and improved with time and processing advances in the 1970's significantly improved our ability to image the subsurface and characterize the reservoir. Advances in drilling technology have led us from the land to deep water. The integration of rock mechanics using geology, geophysics, and engineering in this decade led to new workflows for geologists, geophysicists, and engineers to complete wells in reservoirs previously considered too tight for economic production. This integration brought together intensive core analysis and new sample imaging techniques to characterize the pores in low-permeability rocks that we now recognize as basin-wide “unconventional” fields. Traditional roles in discovering giant fields over previous decades included the “rockers” (geologists well versed in reservoirs), the “trappers” (geophysicists mapping the geometry of accumulations), and the “sealers and the sourcers” (explorers following source rock and seals). More than ever, successful giant field discovery in the decade 2000 through 2010 was led by the “integrators.” If you know how to hammer, every problem is a nail. The enhancement of the tools including Basin analysis,

geochemistry, cutting-edge seismic imaging, and rock mechanics have become critical additions to the explorer's skill set. The ingenuity of combined disciplines continues to meet the demands of an energy hungry world. AAPG Memoir 113 documents the fifth decade of the Giant Fields series.

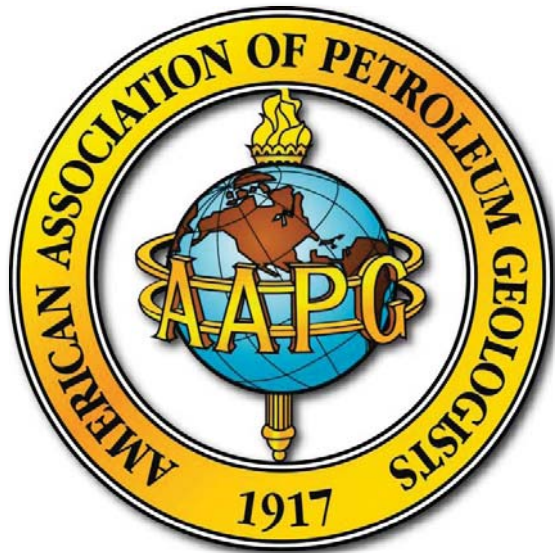
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<https://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html>. Website accessed May 2017.

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**Houston ACE**

**April 2, 2017**

**Robert K. Merrill and  
Charles A. Sternbach**



## Why Study Giant Fields?

- **Contribute prosperity and major wealth transfer for nations**
- **Provide significant infrastructure with economies of scale for smaller discovery developments**
- **Global supply tracks giant field output**
- **Giants keep getting bigger**
- **Provide insight into petroleum systems for exploration and development programs**

# Giant fields contribute 60% of Global Production since the 1960's

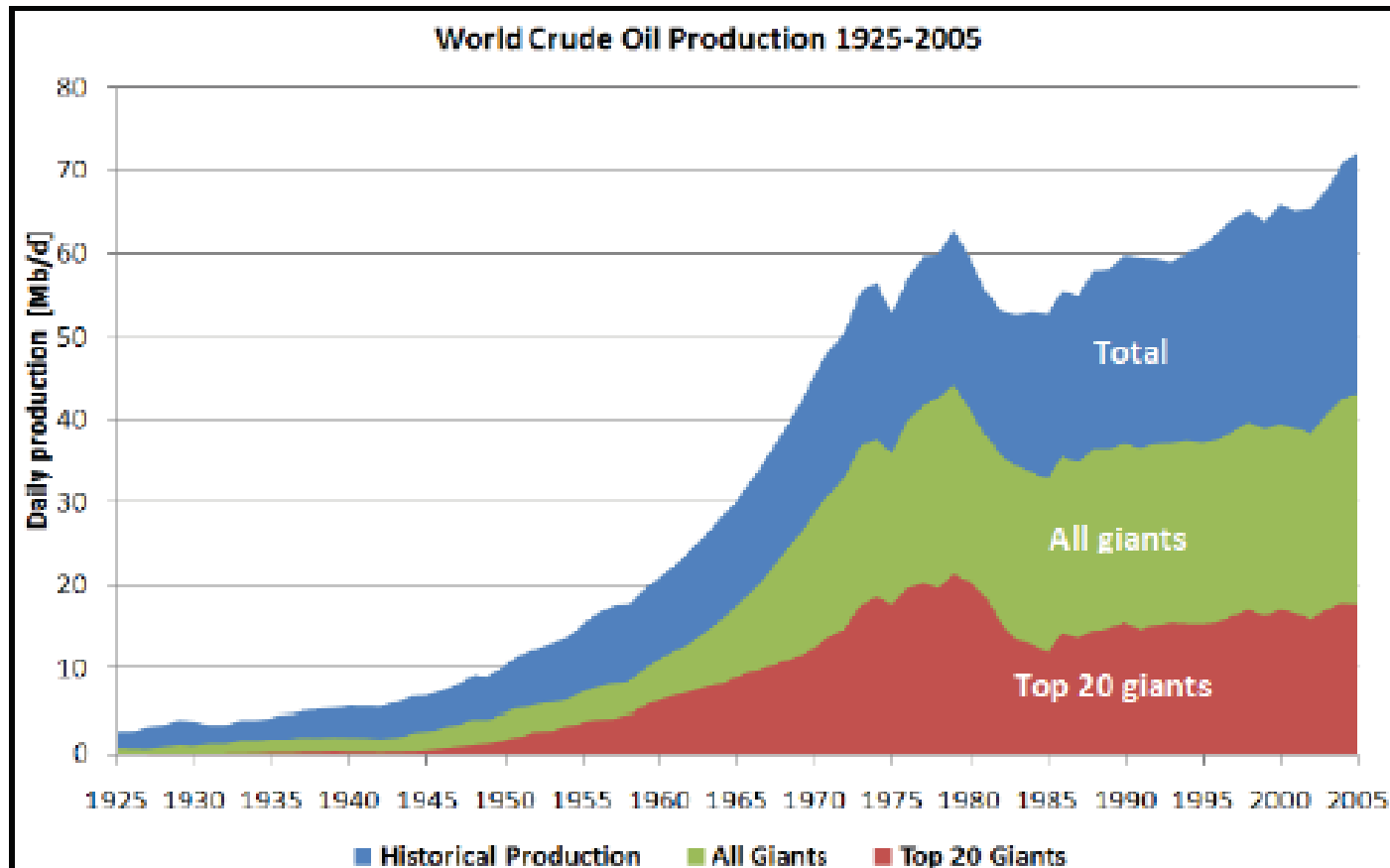
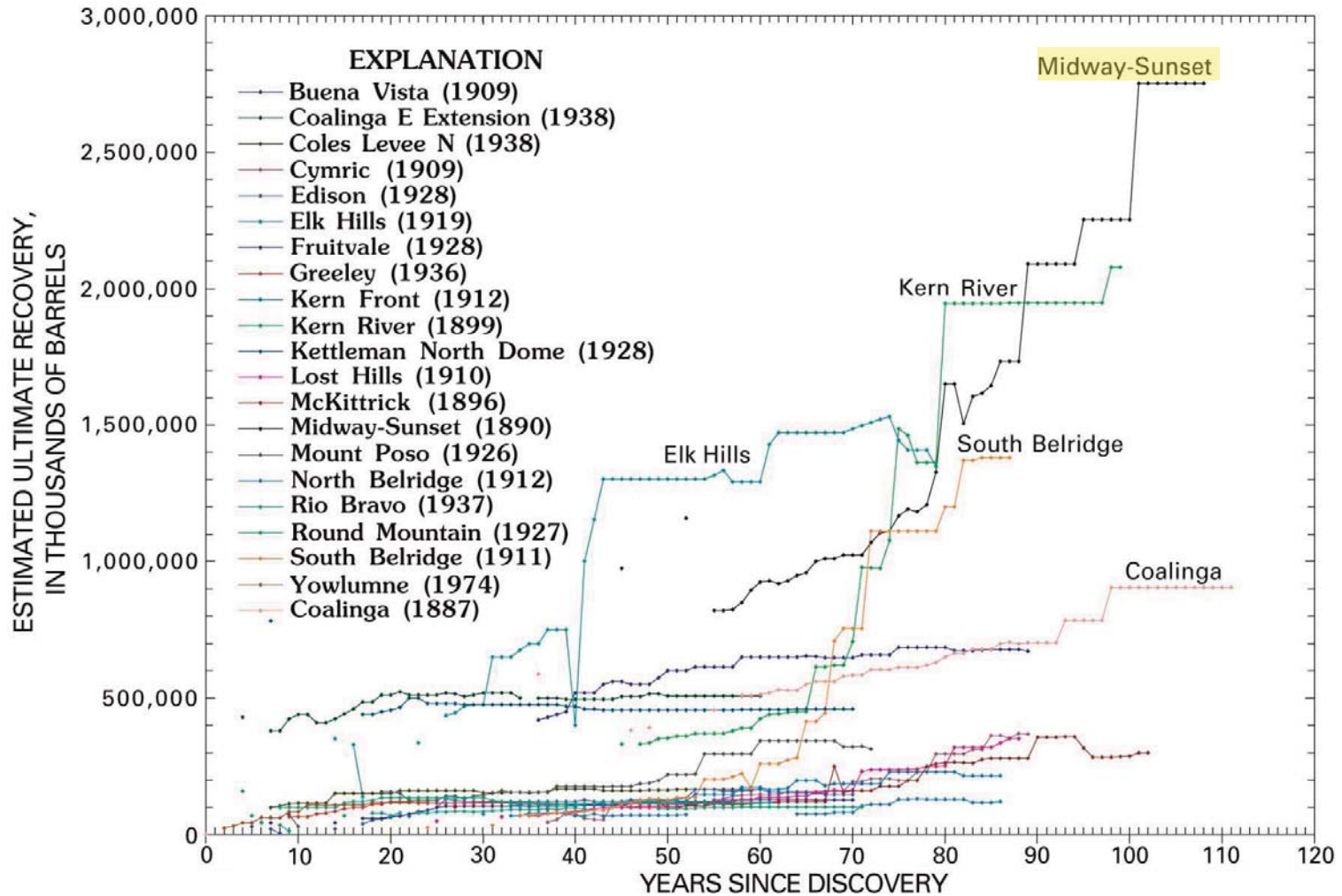


Figure 3.1 World daily oil production showing the contribution of giant fields (Kelley, et al, 2009, after Robelius, 2007, and Hook, et al, 2009).

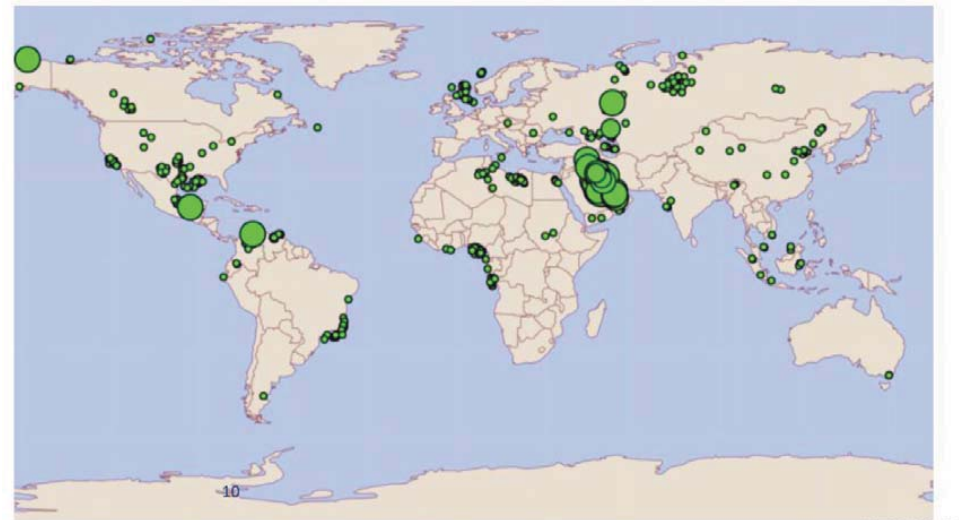
# Giants Keep Getting Bigger!



From: Tennyson, M.E., 2005, Growth history of oil reserves in major California oil fields during the twentieth century; U.S. Geol. Survey Bull. 2172-H, p.4

## What is a Giant Field?

- **Oil: Estimated Ultimate Recovery (EUR)  $\geq$  500 MMBO**
- **Oil and Gas: EUR  $\geq$  500 MMBOE**
  - ✓ **Gas conversion = 6000 cu ft per barrel**
- **Gas Field  $\geq$  3 tcf gas**
- **Supergiant Fields  $\geq$  5 Billion BOE**
- **Megagiant Fields  $\geq$  10 Billion BOE**



Dec 16, 2015  
Horn, 2011

Courtesy of Dick Bishop, 2016  
Lafayette Geological Society



**957 Giant Fields**  
**97 Super-giant Fields**  
**7 Mega-giant Fields**

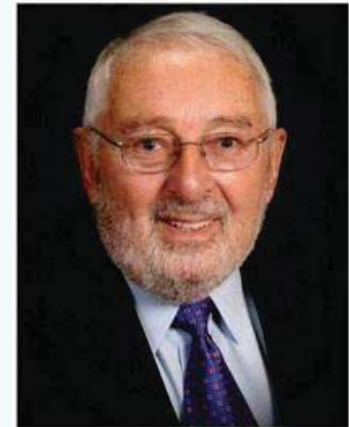
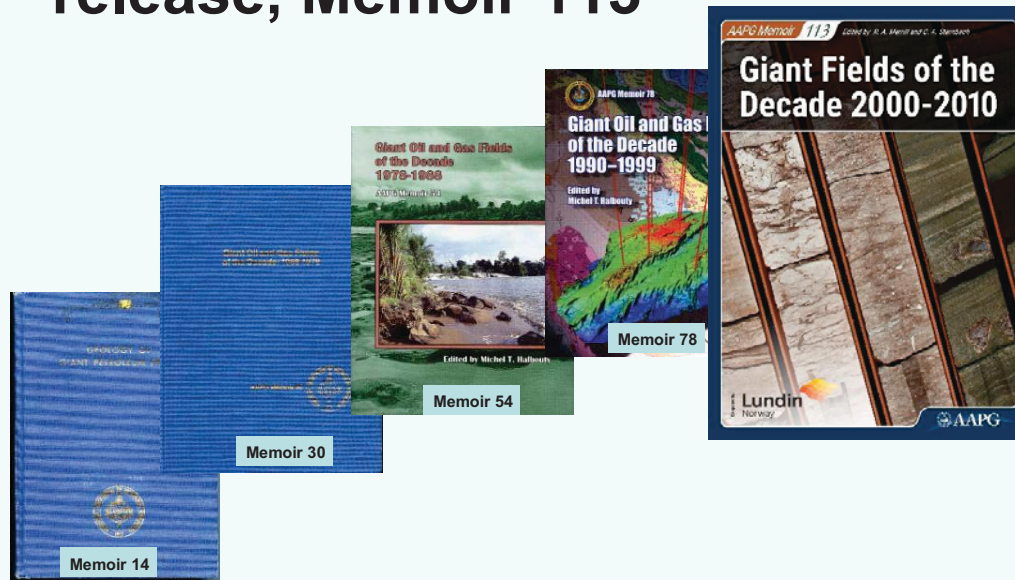
## **Future Giants Require**

- **Open access to exploration in remote and challenging areas**
- **Historical Explorers – “Rockers”, “Trappers” and “Sealers & Sourcers”**
- **Technological integration: The ingenuity of the combined disciplines**
  - ✓ **“Big Data” – Parallel processing & Neural networks**
  - ✓ **Understanding Reservoirs from the micro to macro scale**
  - ✓ **Mapping Traps and Migration paths**
  - ✓ **Geochemistry: Source Rock & HC Generation**
  - ✓ **Drilling and Completion practices**



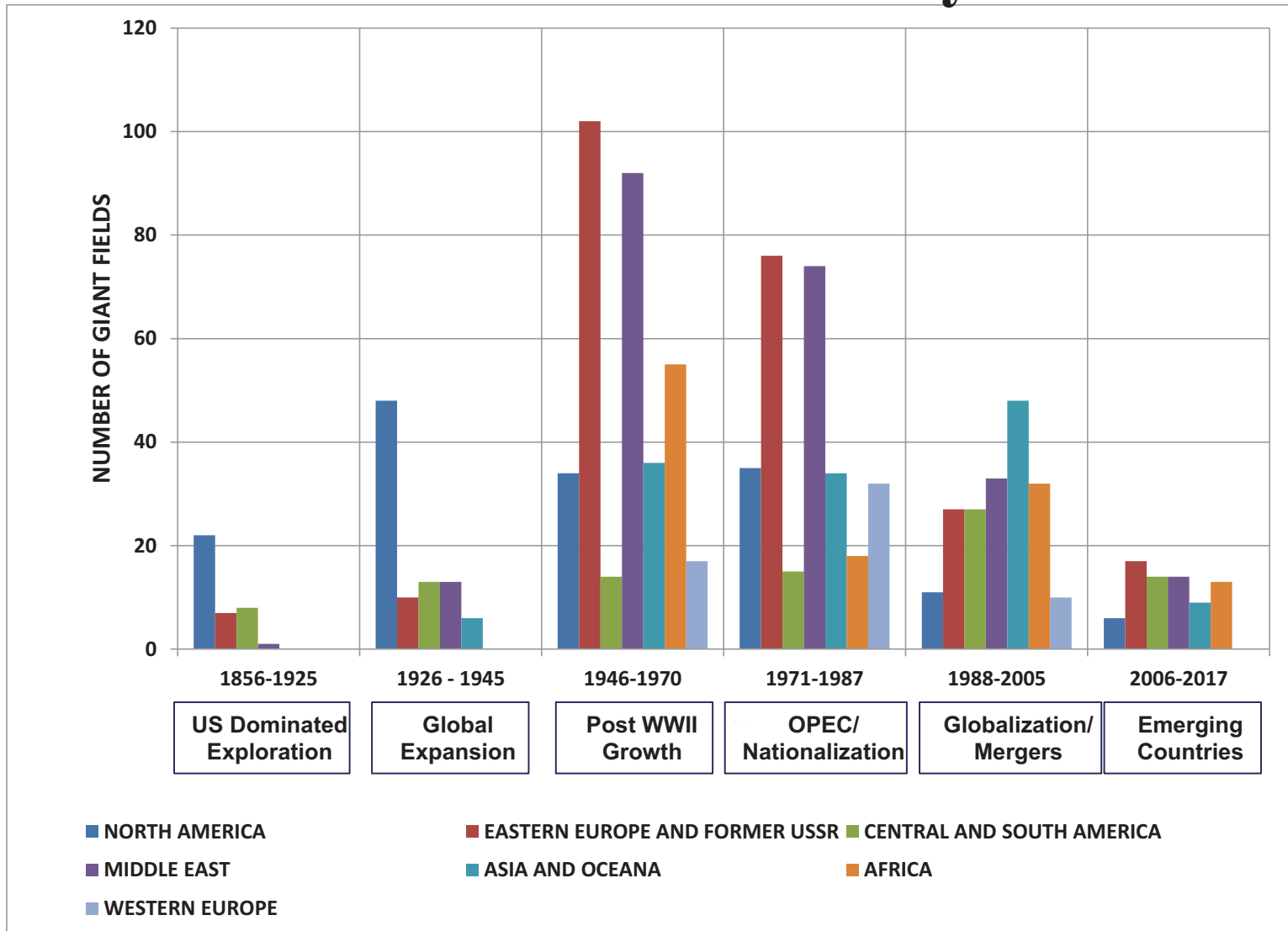
# Source Material

- Database of 1,062 Giant Fields (Mike Horn)
- IHS Support
- AAPG Archives going back 100 years - *Datapages*
- AAPG Giant Field Memoirs like the upcoming release, Memoir 113



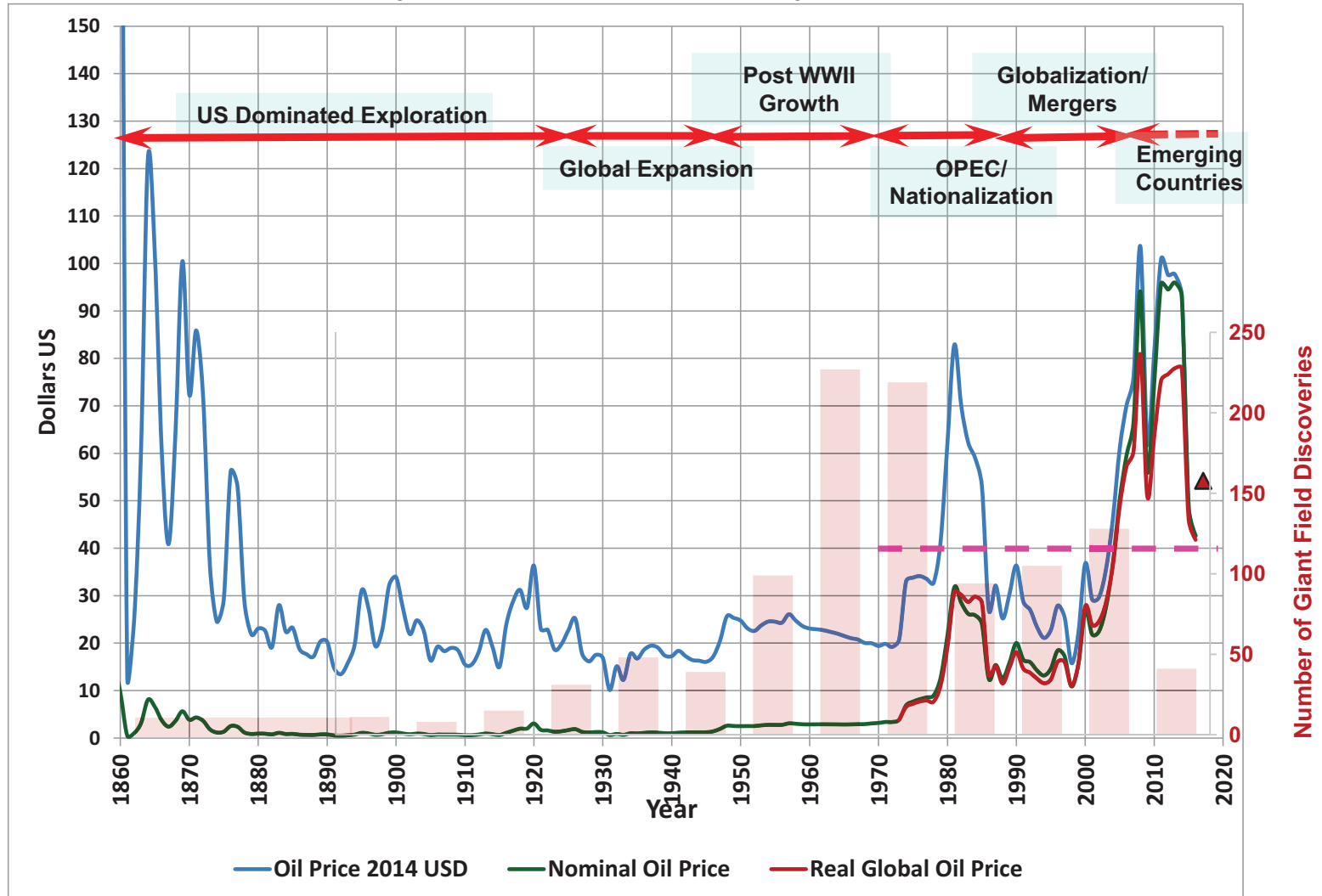
Mike Horn

# Where and When were they Found?

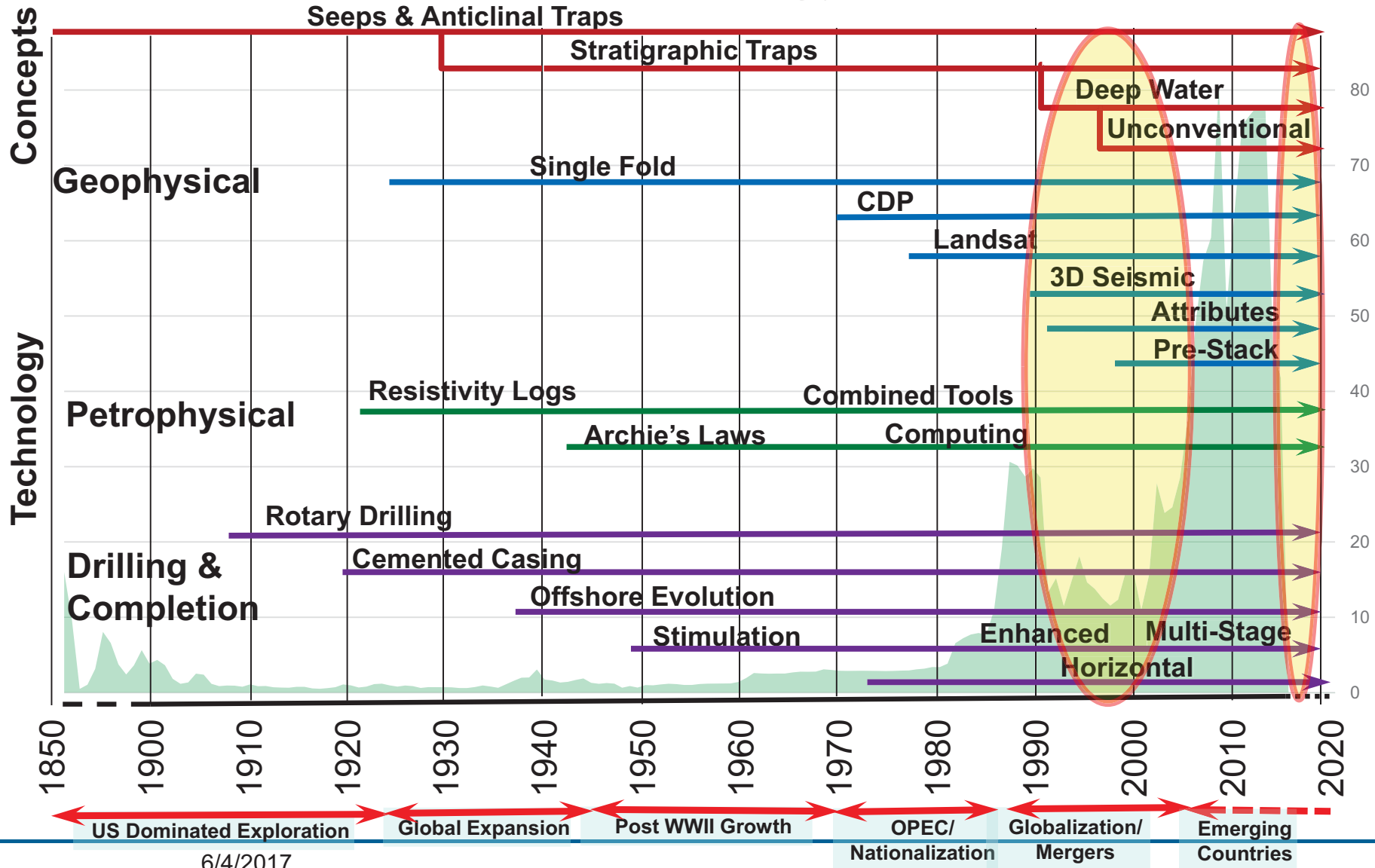


# Oil Price and Number of Giant Discoveries

Nominal = Inflation Adjusted \$; Real Global Price = Adjusted for US Dollar Value

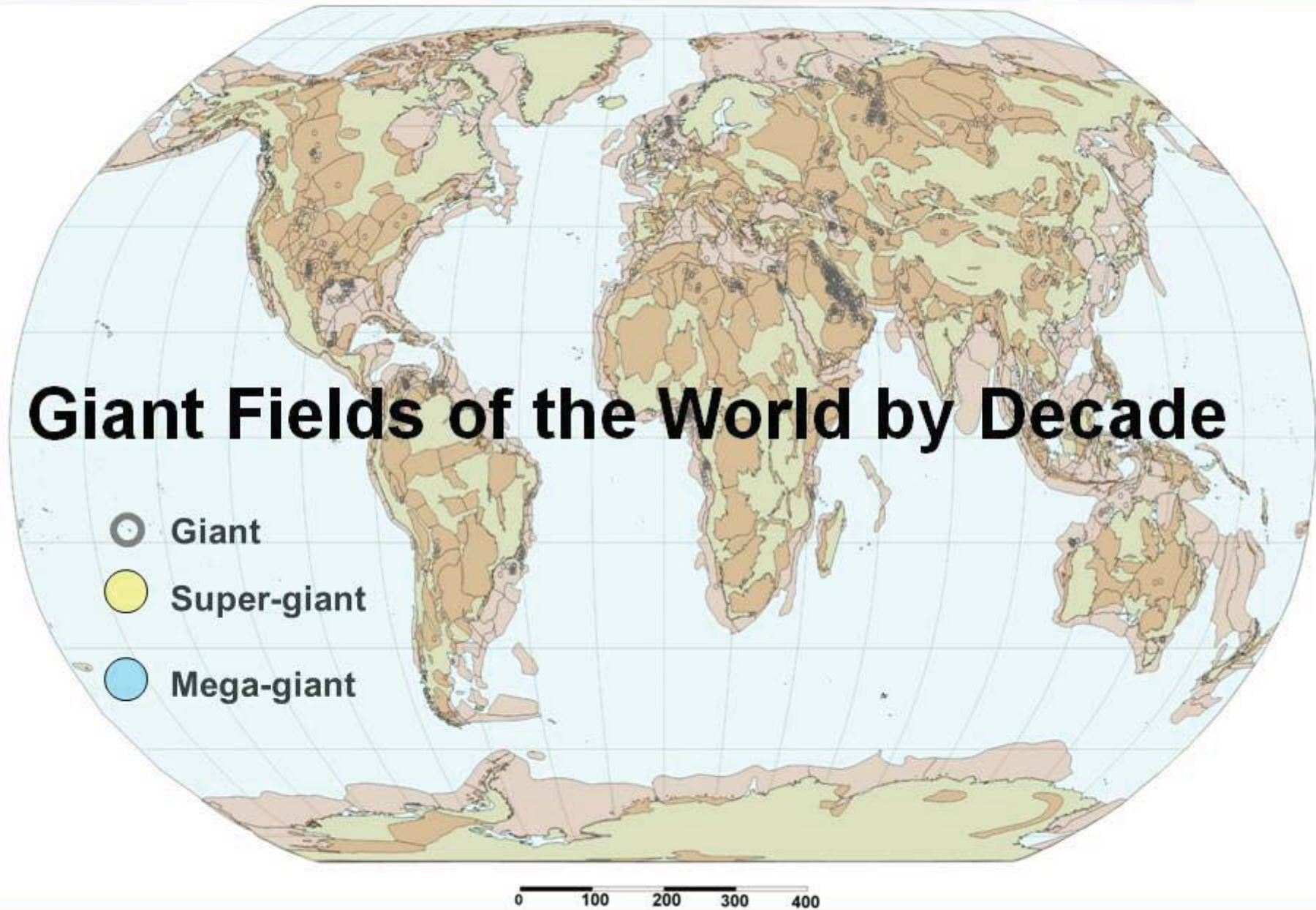


# Concept & Technology Evolution

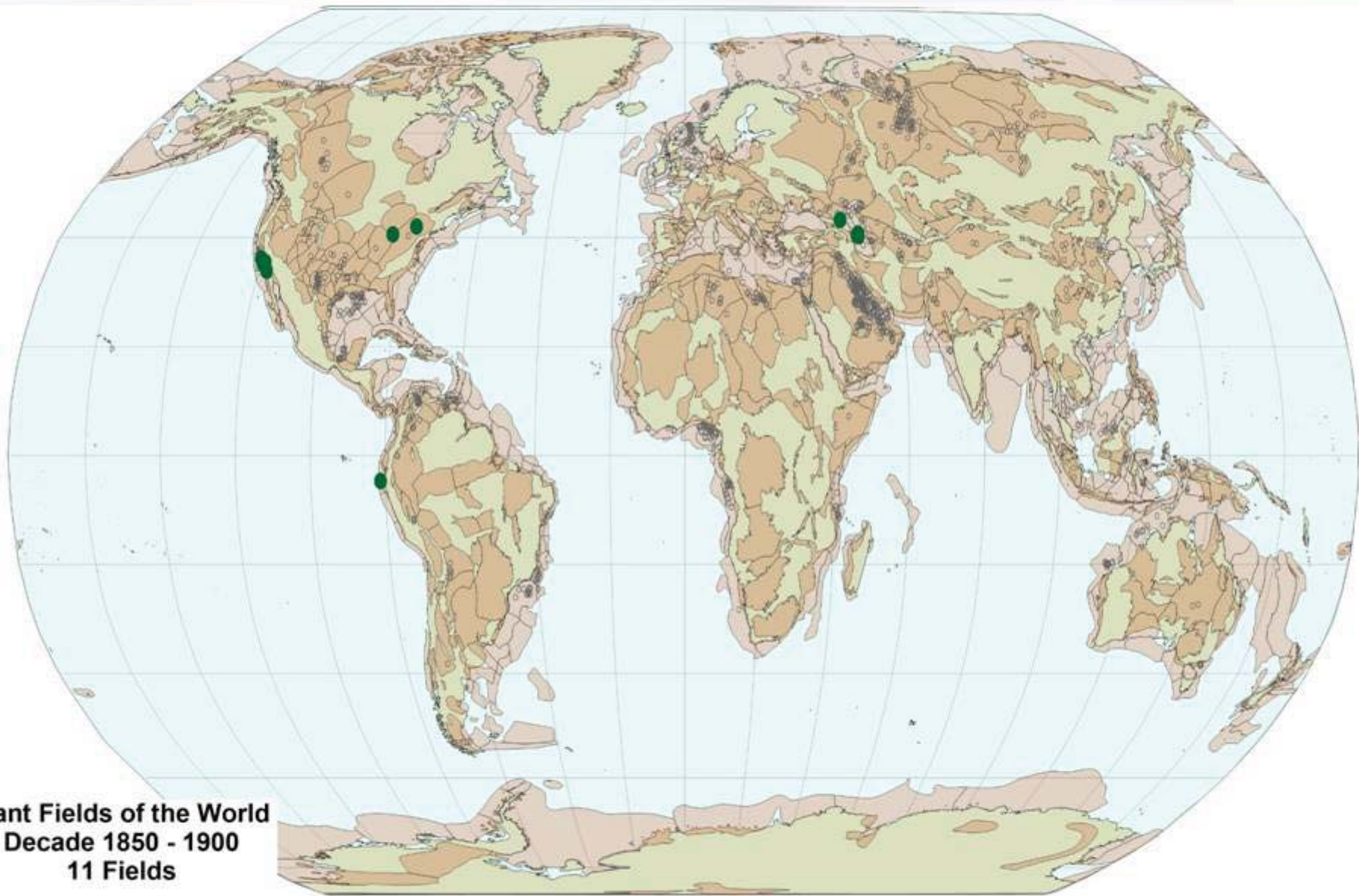


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# Giant Oil Fields Through the Decades

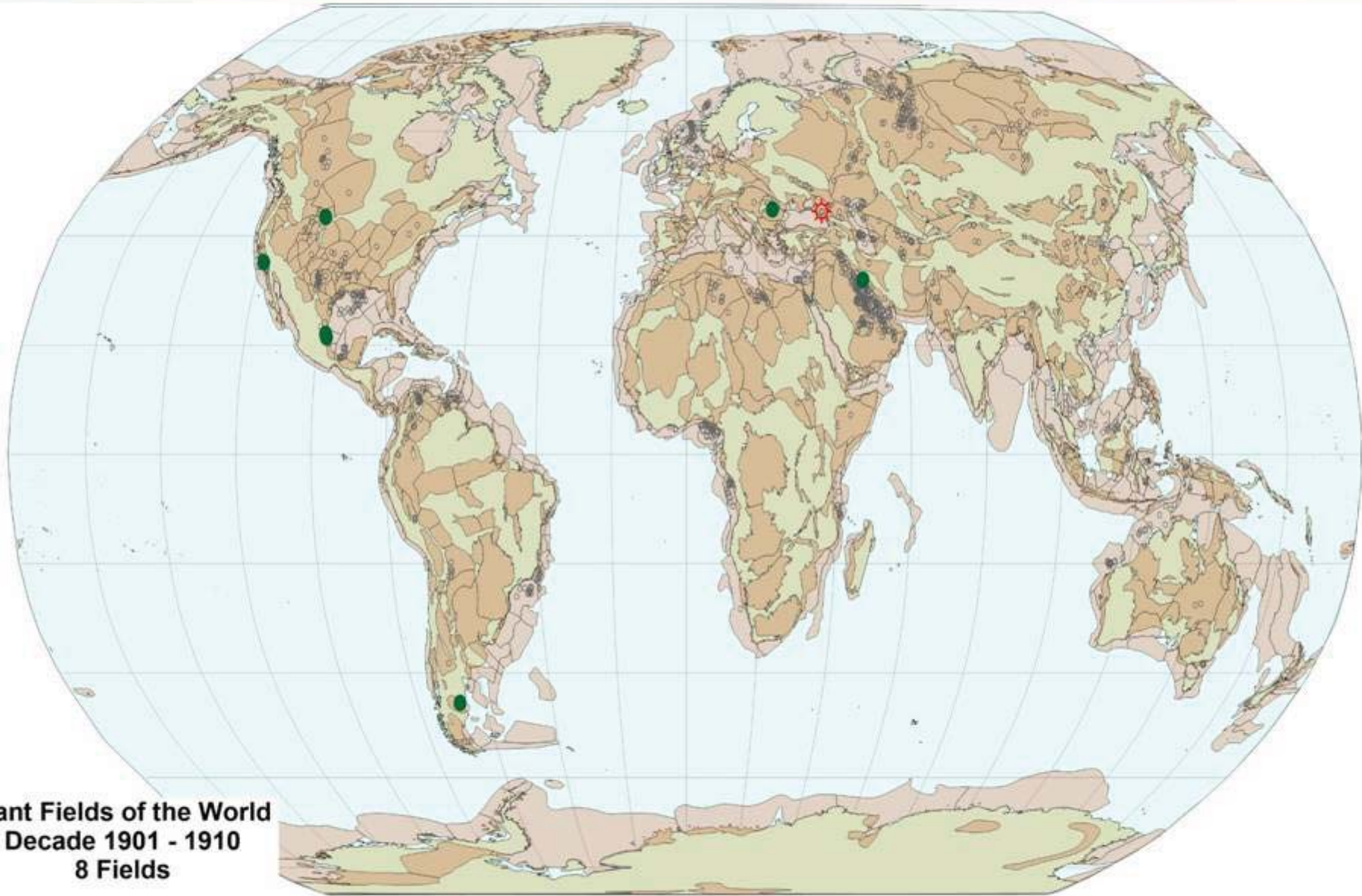


**Giant Fields of the World**  
**Decade 1850 - 1900**  
**11 Fields**

0 100 200 300 400

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# Giant Oil Fields Through the Decades

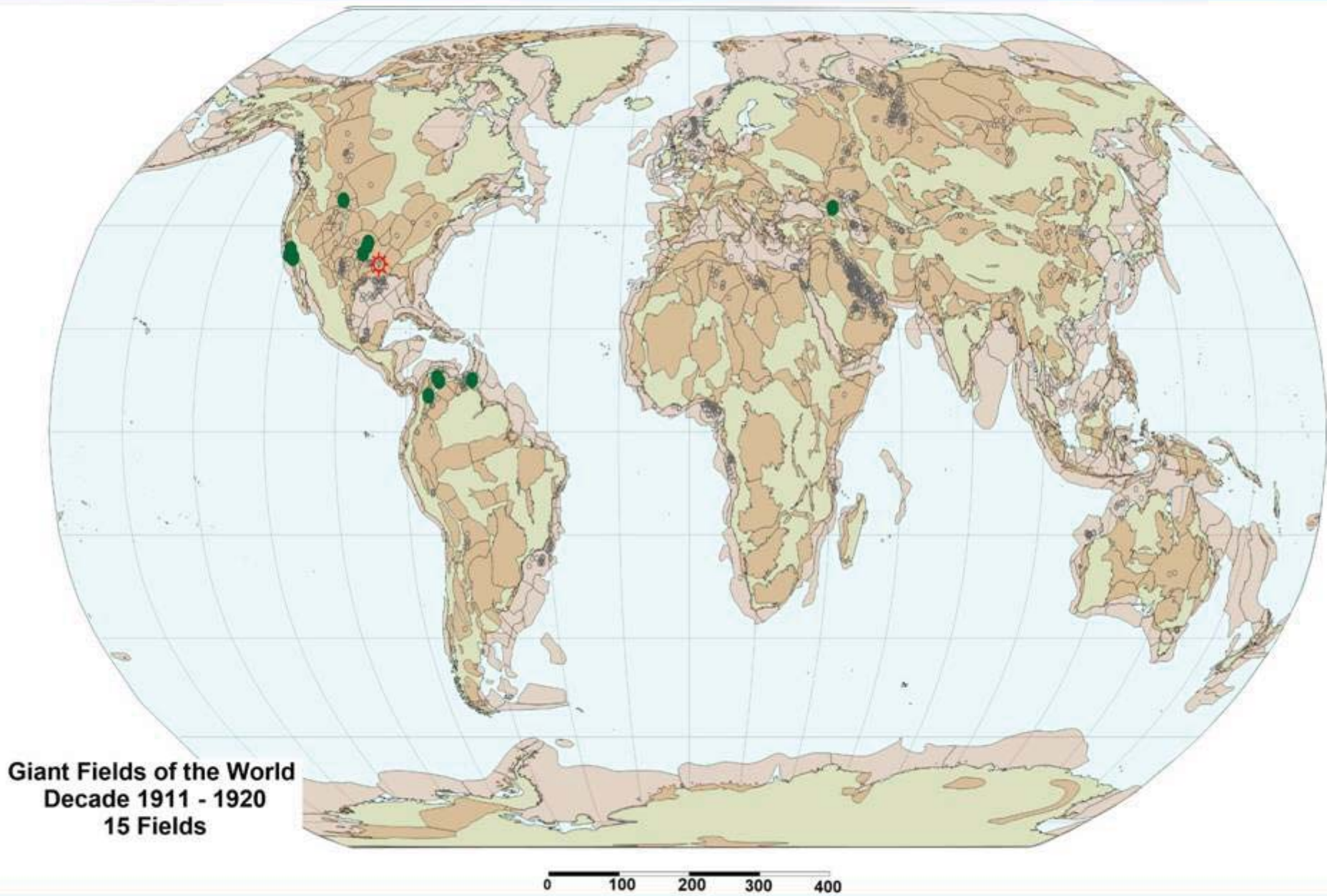


**Giant Fields of the World  
Decade 1901 - 1910  
8 Fields**

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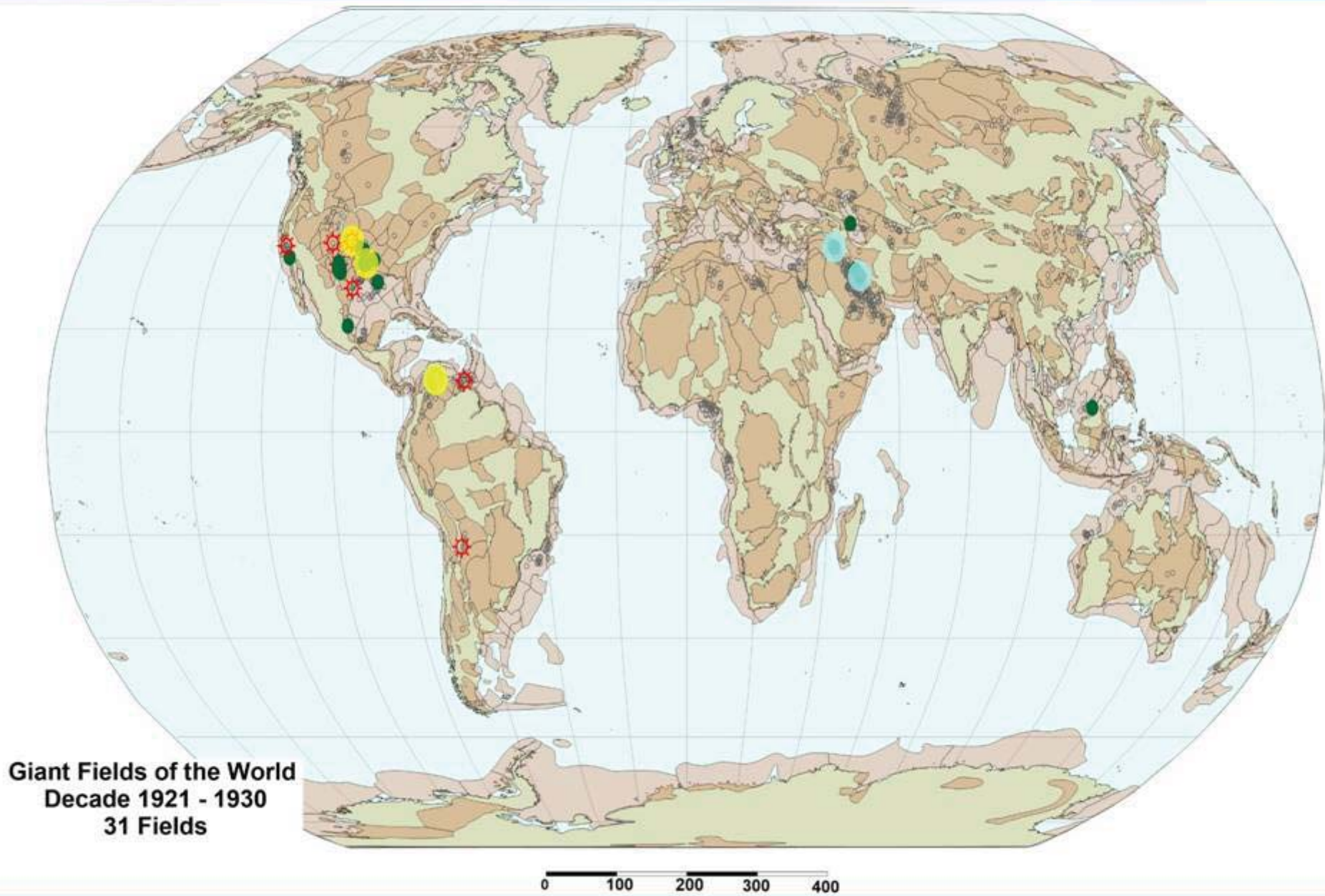
# Giant Oil Fields Through the Decades



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# Giant Oil Fields Through the Decades

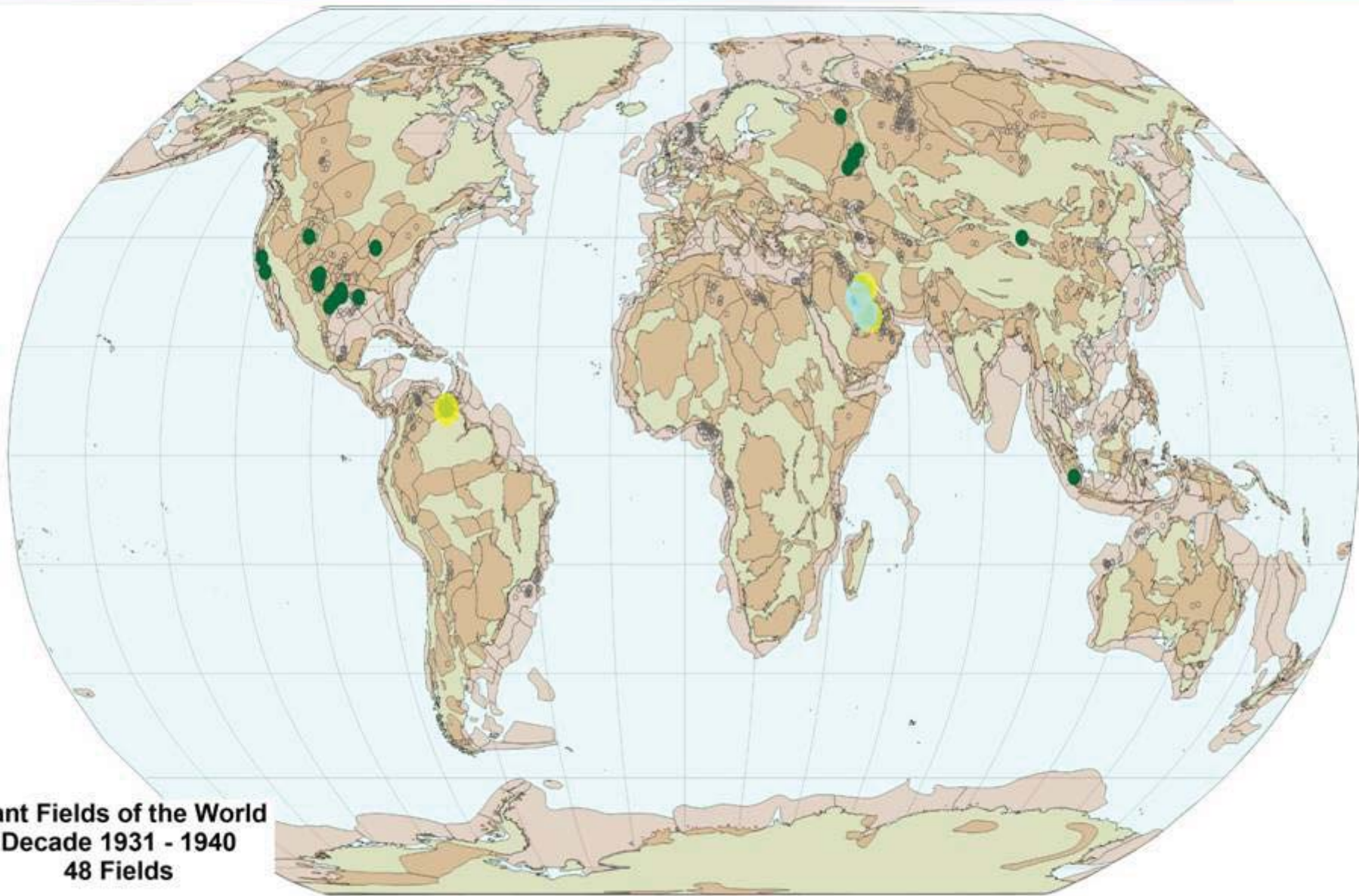


**Giant Fields of the World  
Decade 1921 - 1930  
31 Fields**

0 100 200 300 400

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# Giant Oil Fields Through the Decades

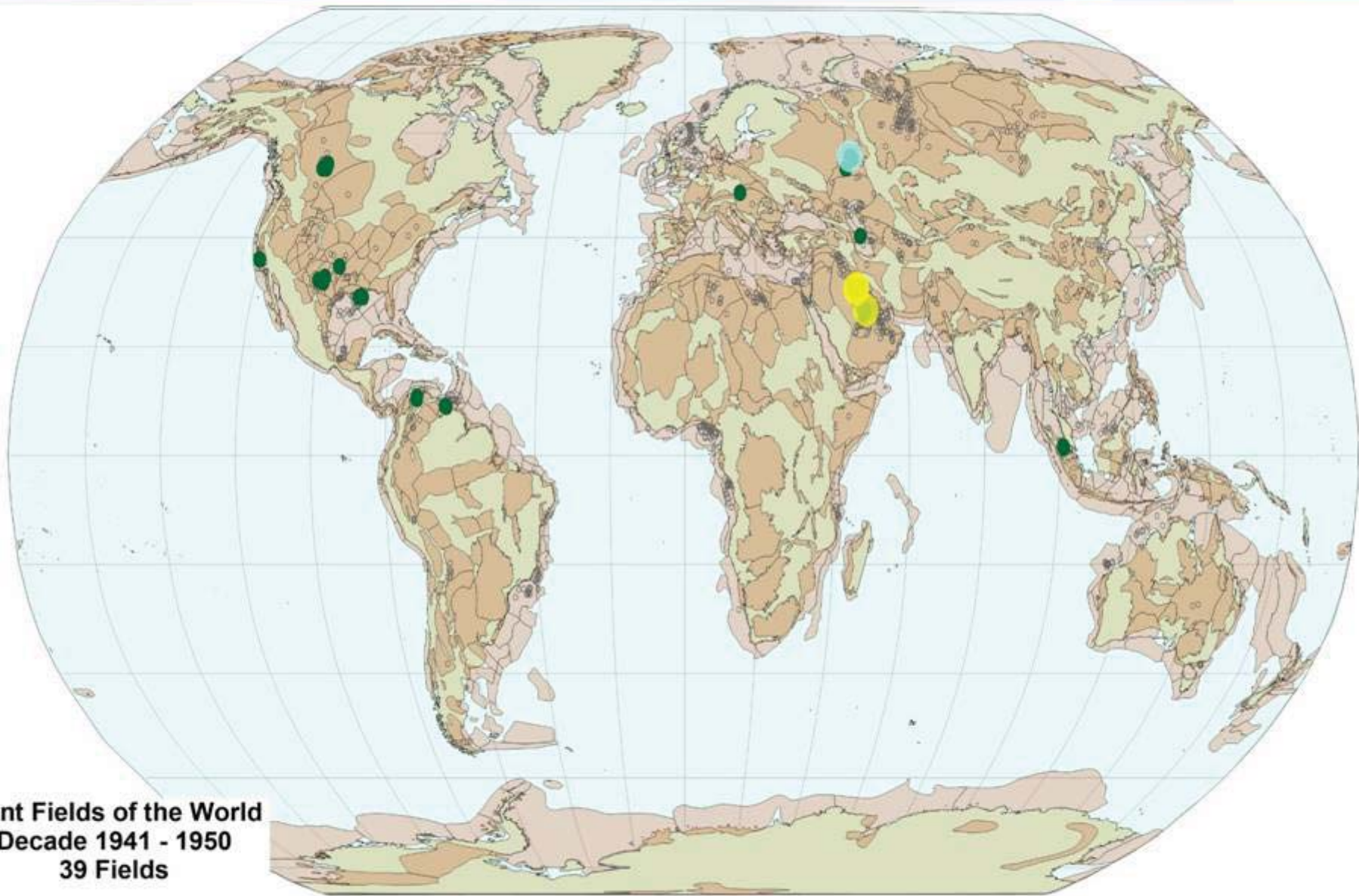


**Giant Fields of the World**  
**Decade 1931 - 1940**  
**48 Fields**

0 100 200 300 400

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# Giant Oil Fields Through the Decades

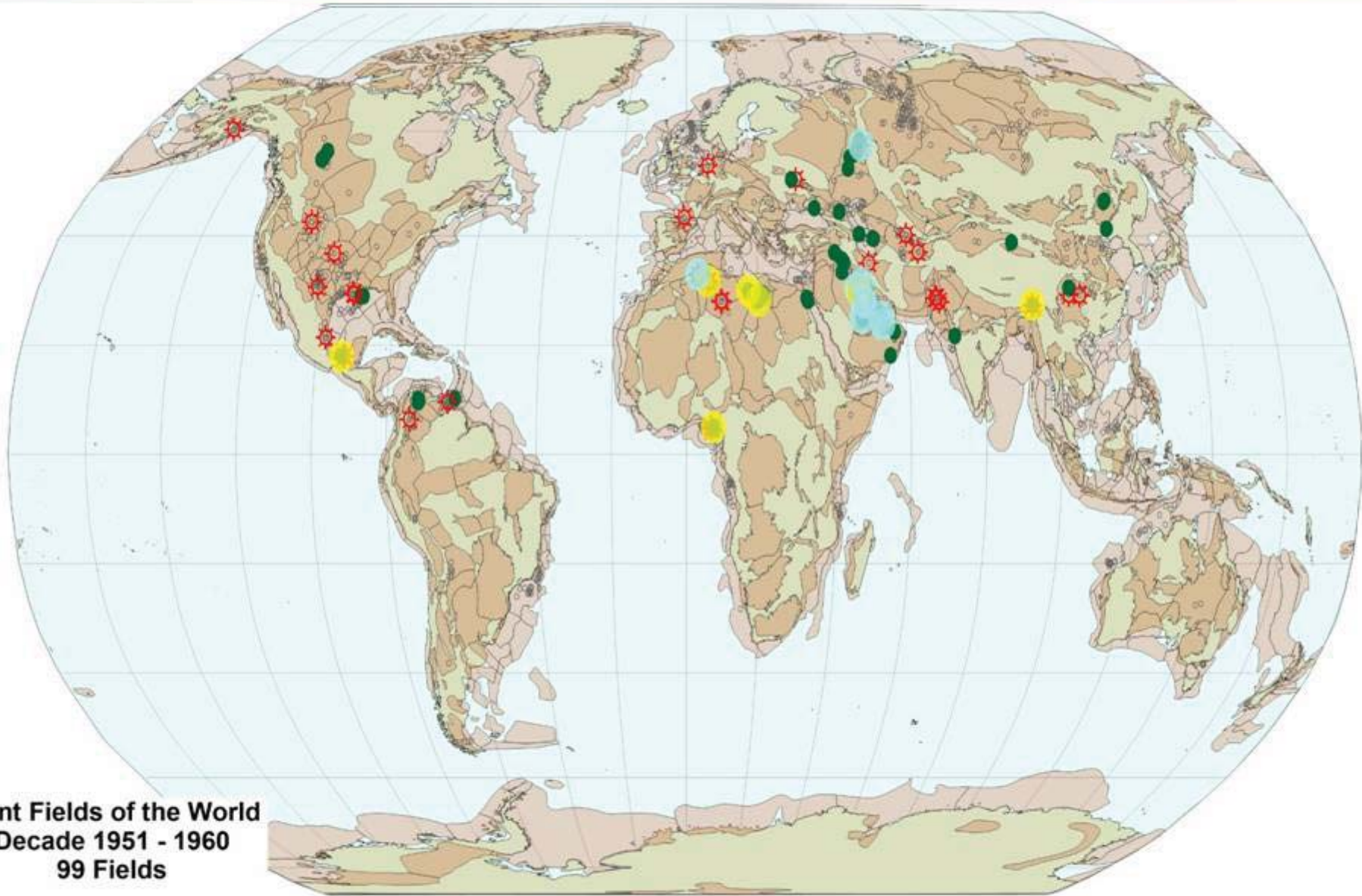


**Giant Fields of the World**  
**Decade 1941 - 1950**  
**39 Fields**

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# Giant Oil Fields Through the Decades

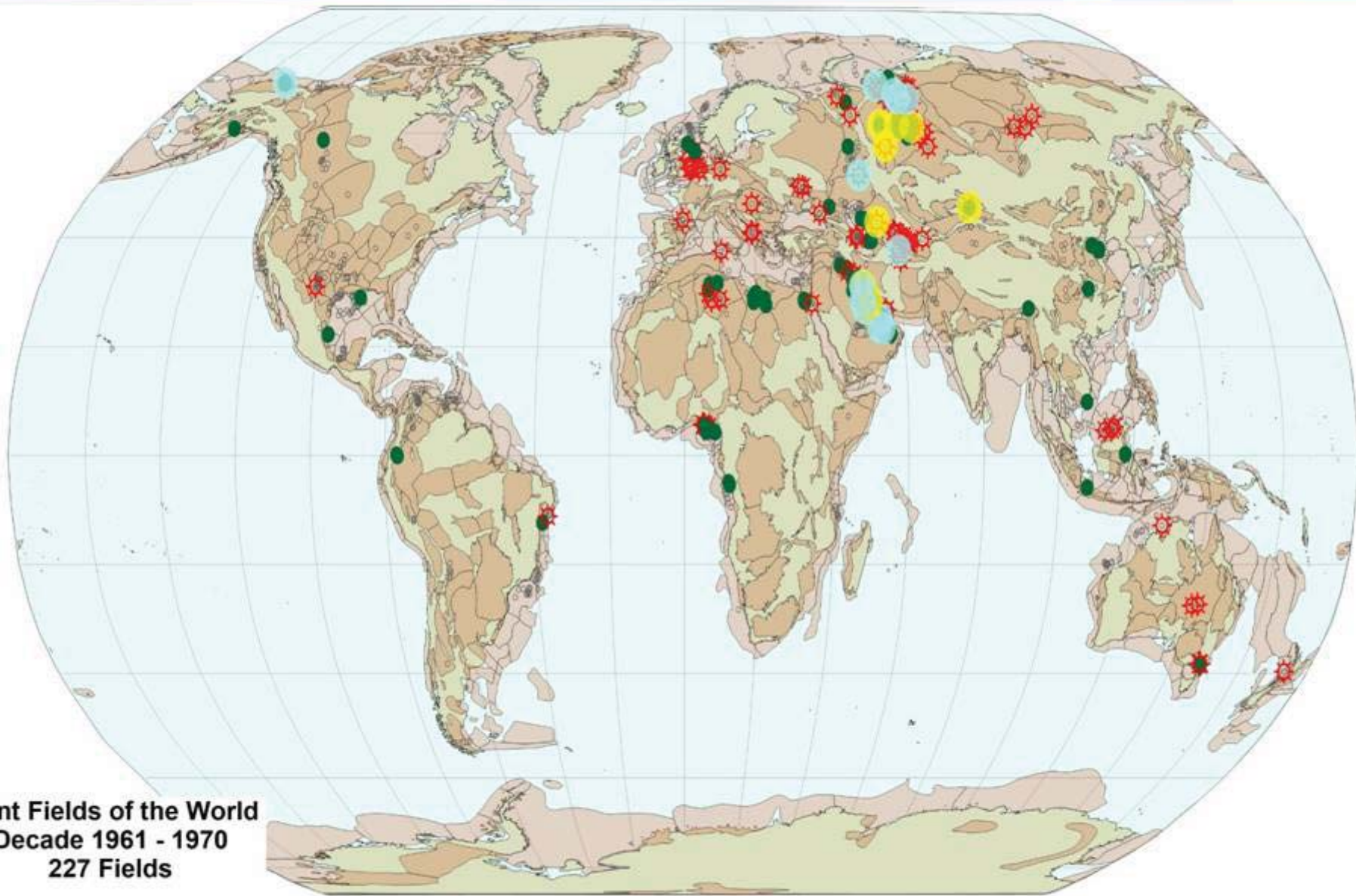


**Giant Fields of the World**  
Decade 1951 - 1960  
99 Fields

0 100 200 300 400

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# Giant Oil Fields Through the Decades

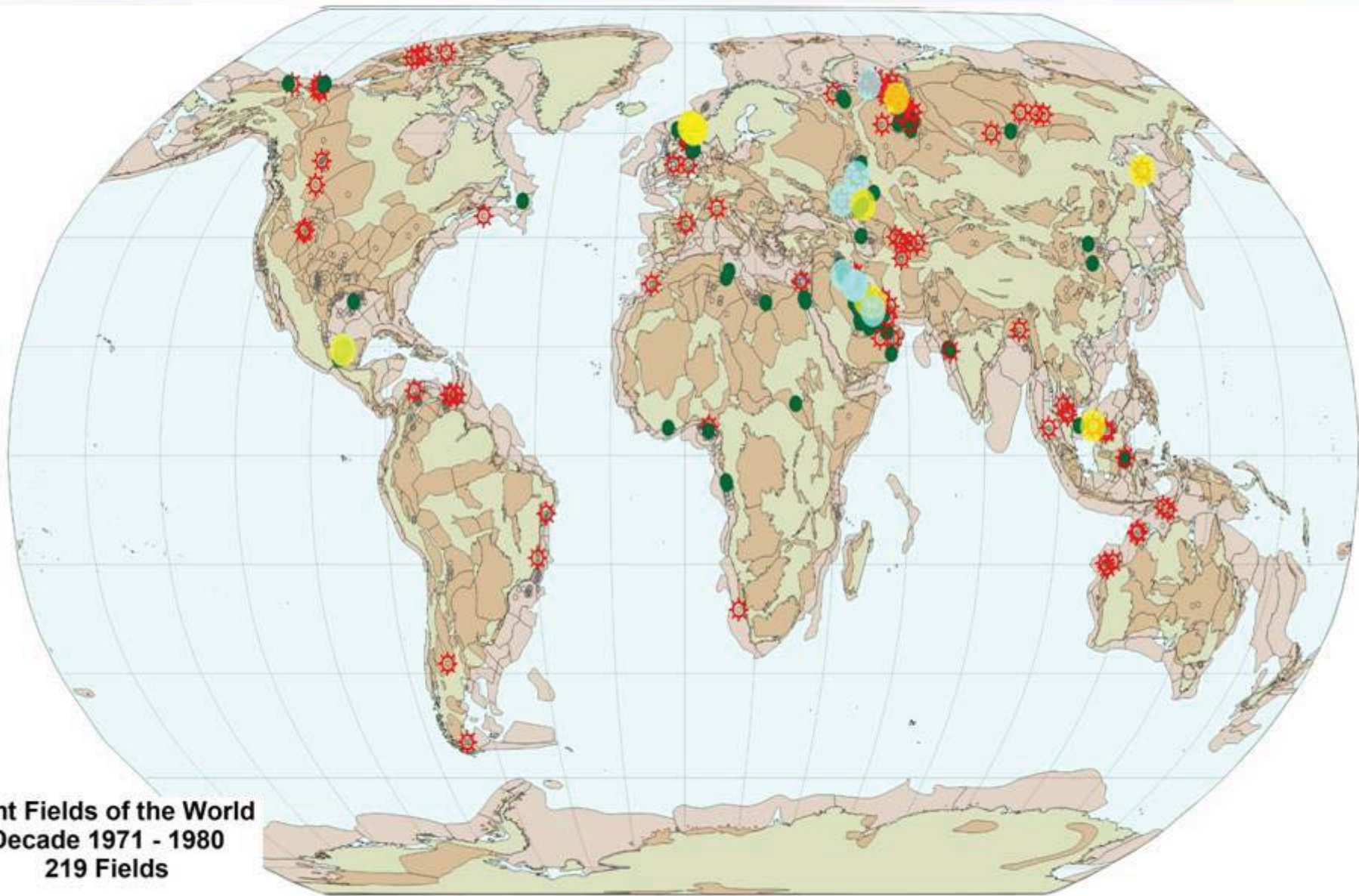


**Giant Fields of the World**  
Decade 1961 - 1970  
227 Fields

0 100 200 300 400

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# Giant Oil Fields Through the Decades

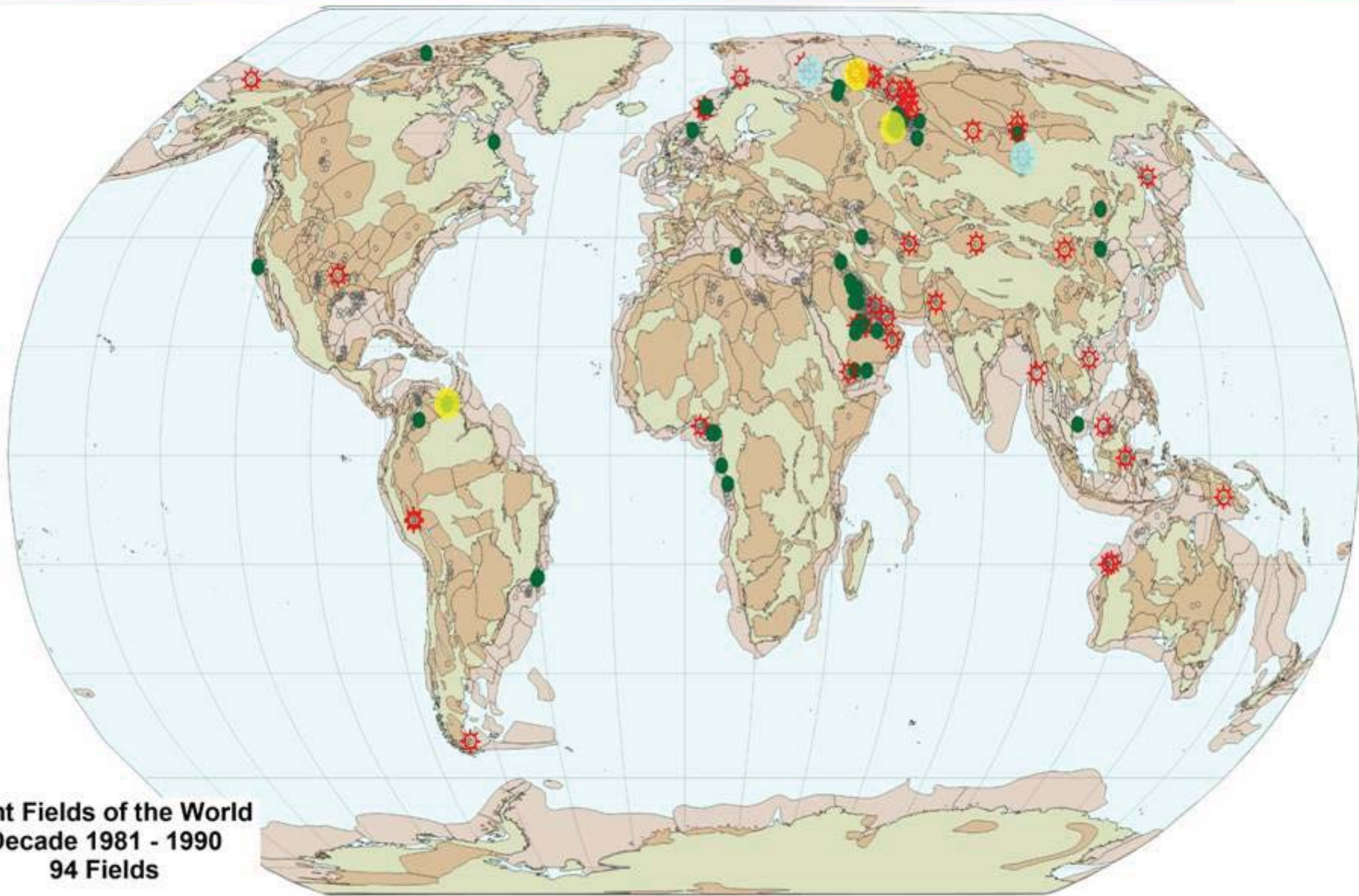


**Giant Fields of the World**  
**Decade 1971 - 1980**  
**219 Fields**

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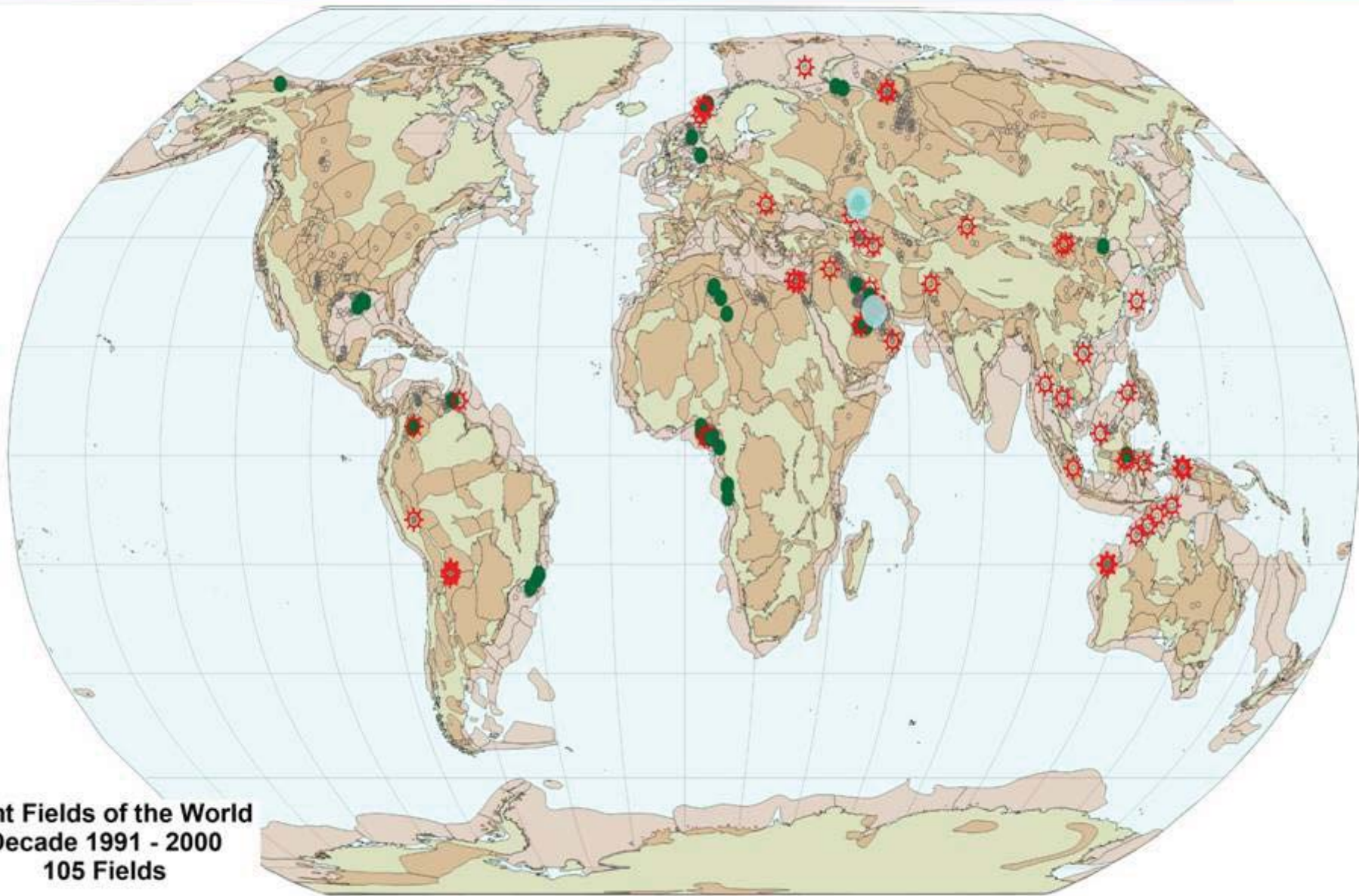
# Giant Oil Fields Through the Decades



**Giant Fields of the World**  
Decade 1981 - 1990  
94 Fields



# Giant Oil Fields Through the Decades

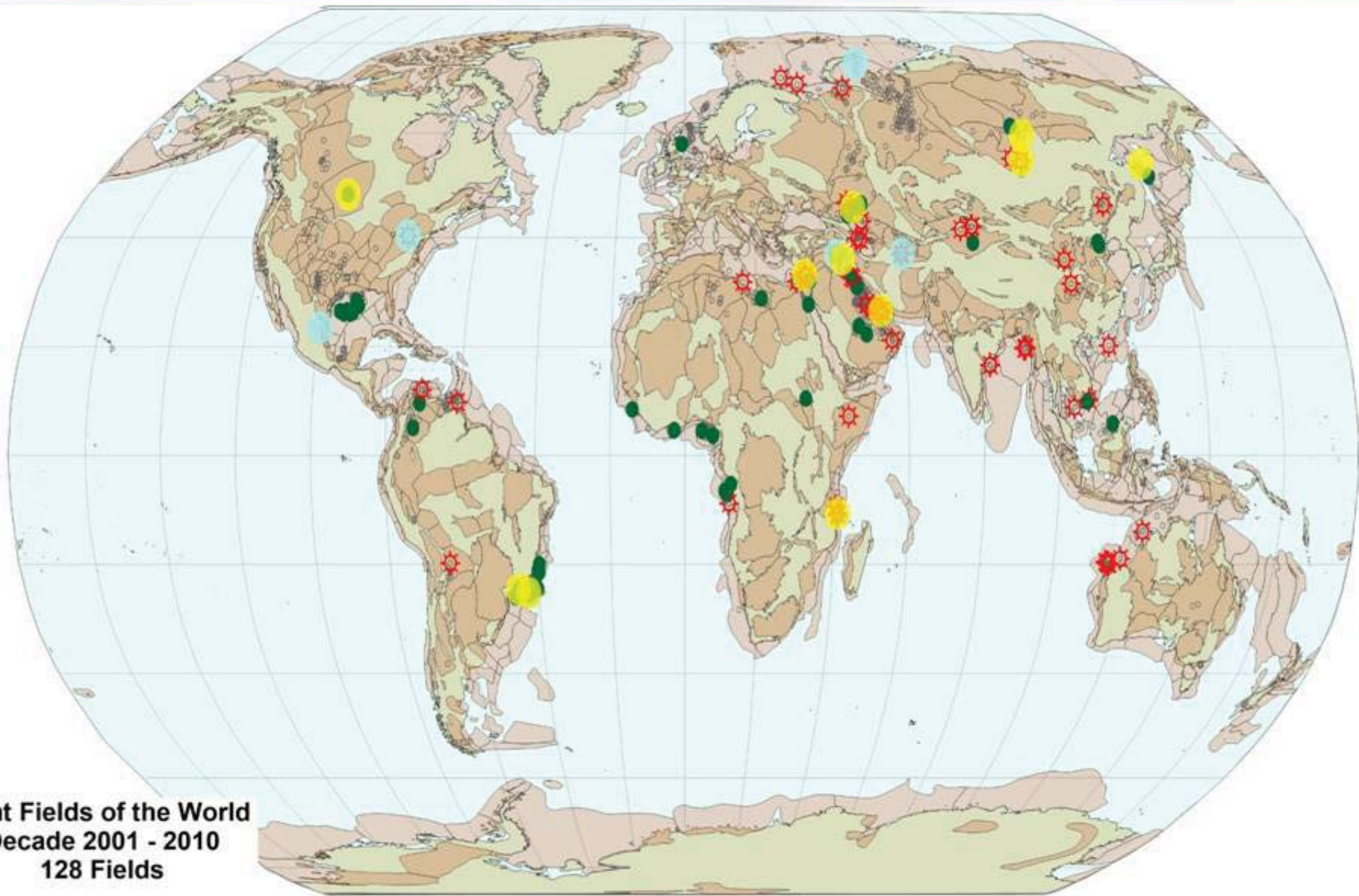


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Houston ACE 2017



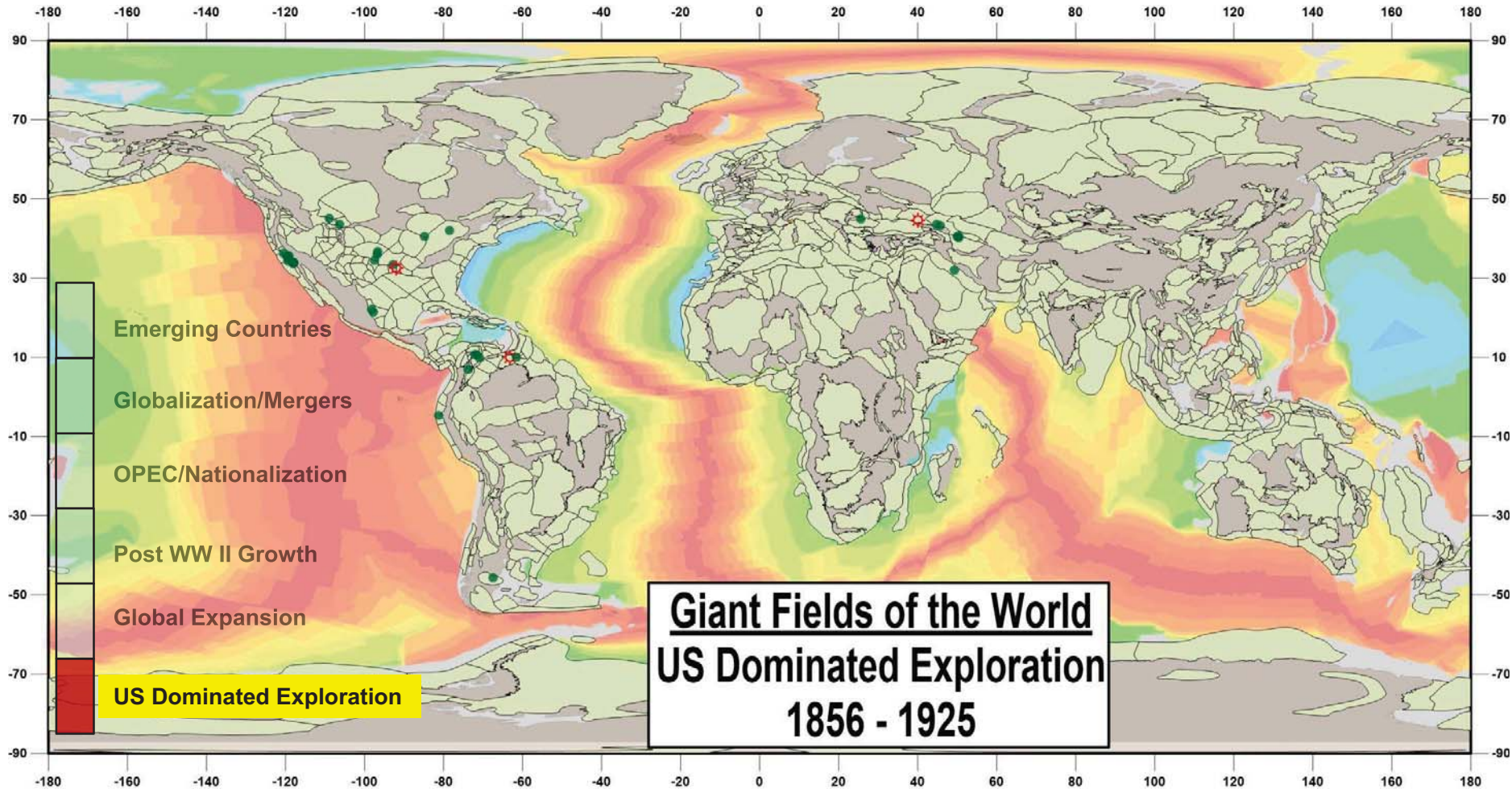
# Giant Oil Fields Through the Decades



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Houston ACE 2017

# US Dominated Exploration 1856 – 1925



# US Dominated Exploration

## ➤ Prior to 1900

- ✓ Emerging concept of where to drill – Seeps and Anticlines

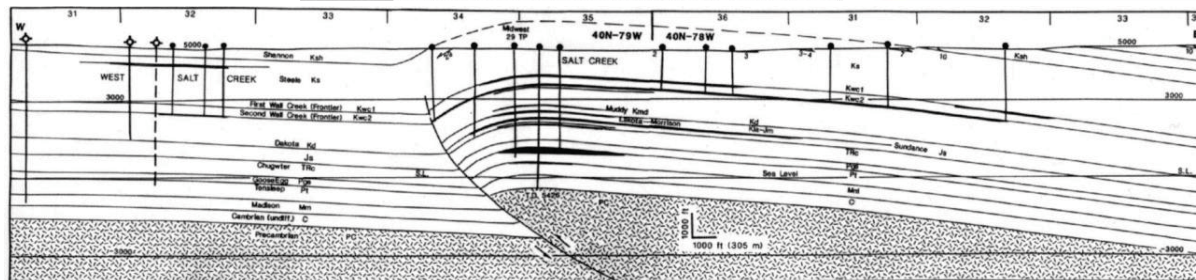
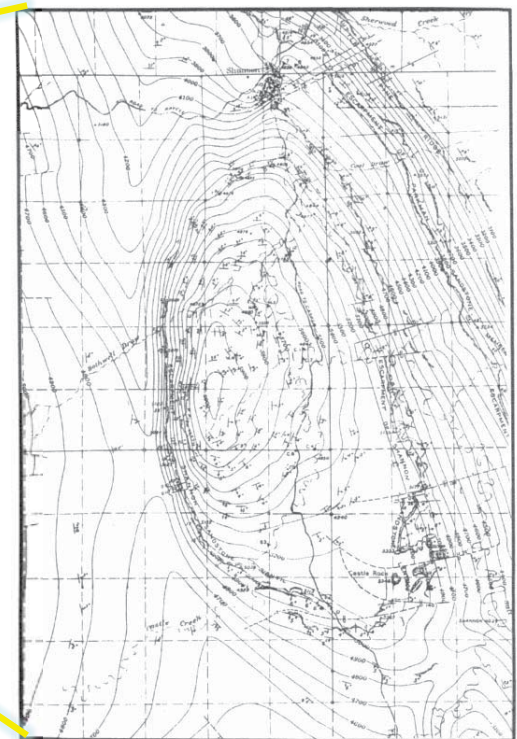
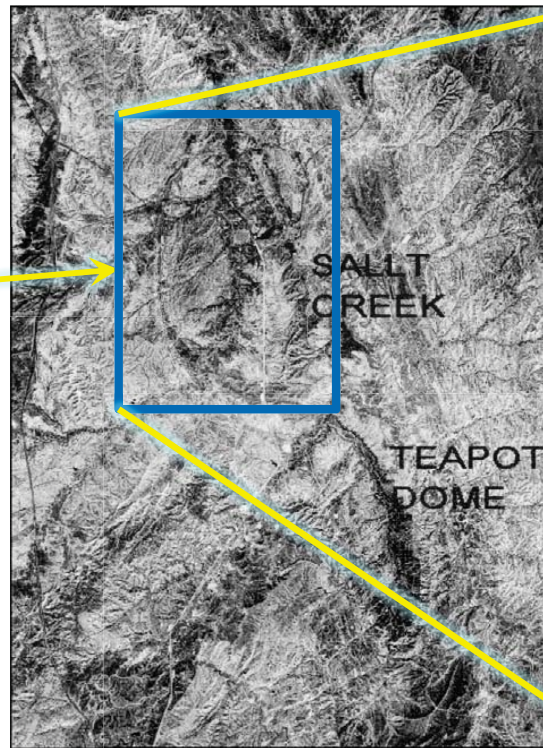
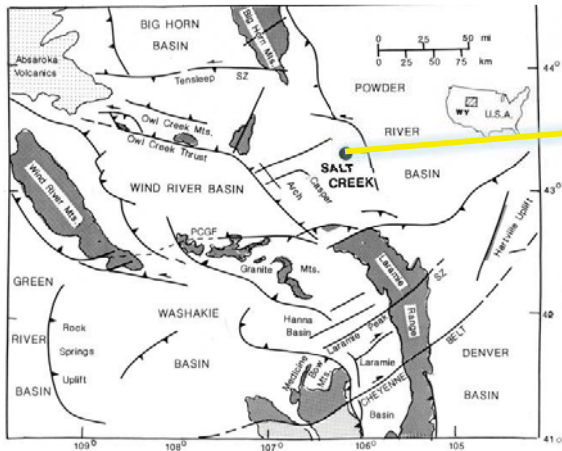
## ➤ 1900 – 1925

- ✓ Surface mapping of Anticlines
- ✓ 1914 First 1D seismic
- ✓ 1921 Reflection seismography
- ✓ First resistivity log
- ✓ 1919 Cementing casing
- ✓ Rotary Drilling



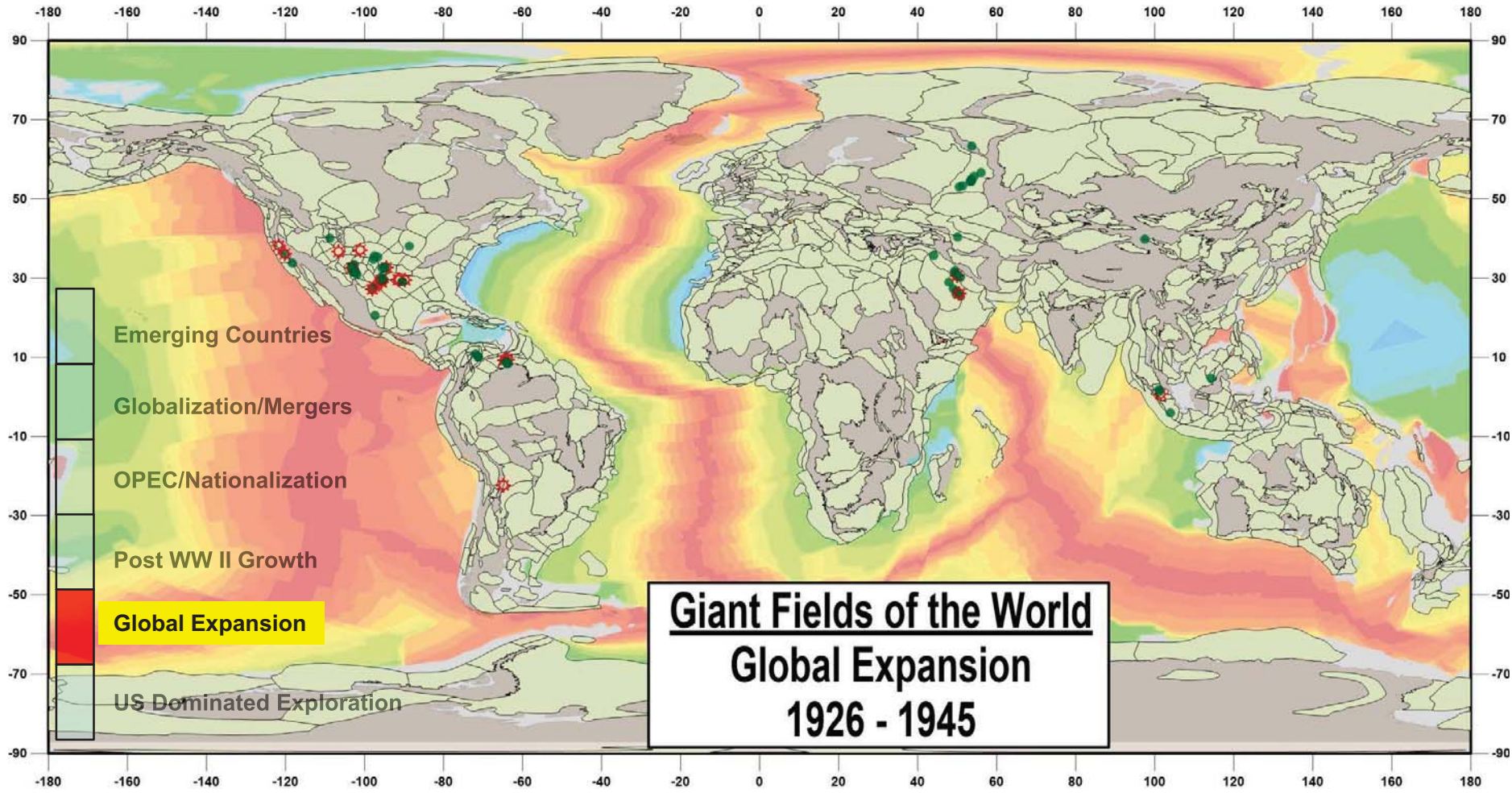
Courtesy Robbie Gries, 2016

# Salt Creek, Field, Wyoming, USA



Adapted from: Stone, D.S., 2006

# Global Expansion 1926 – 1945

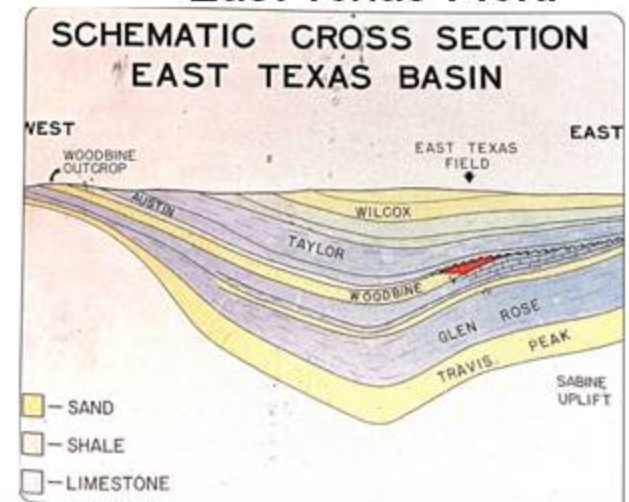


# Global Expansion

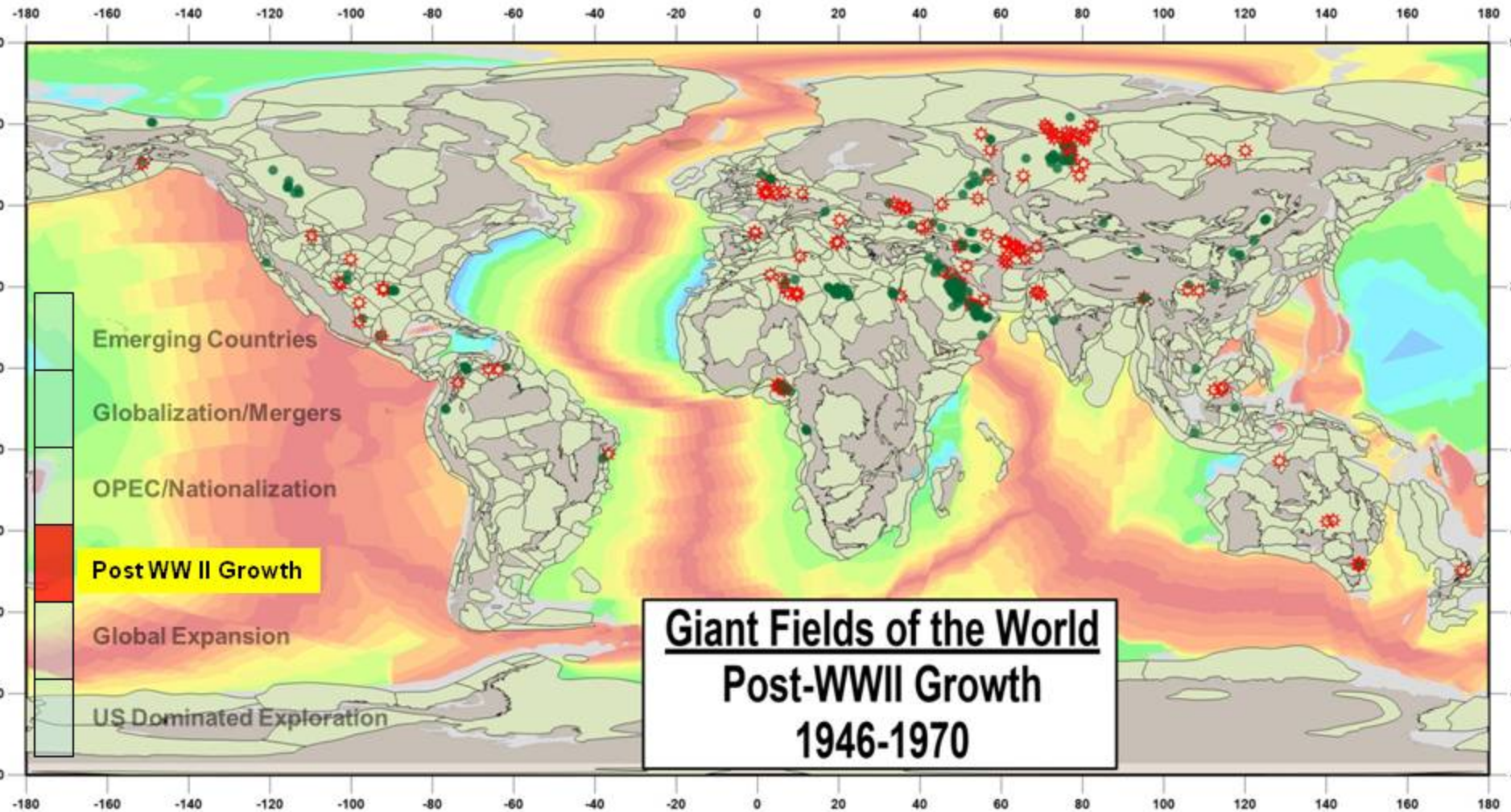
- **1926 – 1935**
  - ✓ **1928 Reflection seismic**
  - ✓ **1930 Stratigraphic traps**
- **1935 – 1945**
  - ✓ **1938 First offshore drilling**
  - ✓ **Evolution of petrophysical logs**
  - ✓ **1941 Archie's laws**
  - ✓ **Three cone roller bit**
  - ✓ **1941 Diamond bit**
  - ✓ **Multiple bullet-shot casing perforator**
  - ✓ **Texas RRC – Controlled & cooperative development**



**East Texas Field**



# Post WWII Growth 1946 - 1970



## Post WWII Growth

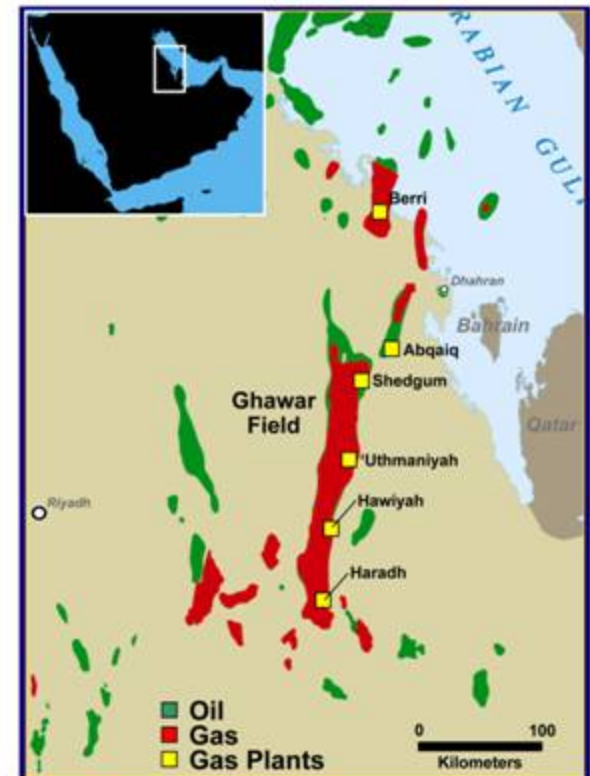
### ➤ 1945 – 1960

- ✓ Petrophysical logs evolve
- ✓ 1947 – Kermac #16 drilled 10 miles offshore Louisiana
- ✓ 1949 –Hydraulic Fracturing license to Haliburton issued by Stanolind
- ✓ 1954 Jackup drilling

### ➤ 1961 – 1970

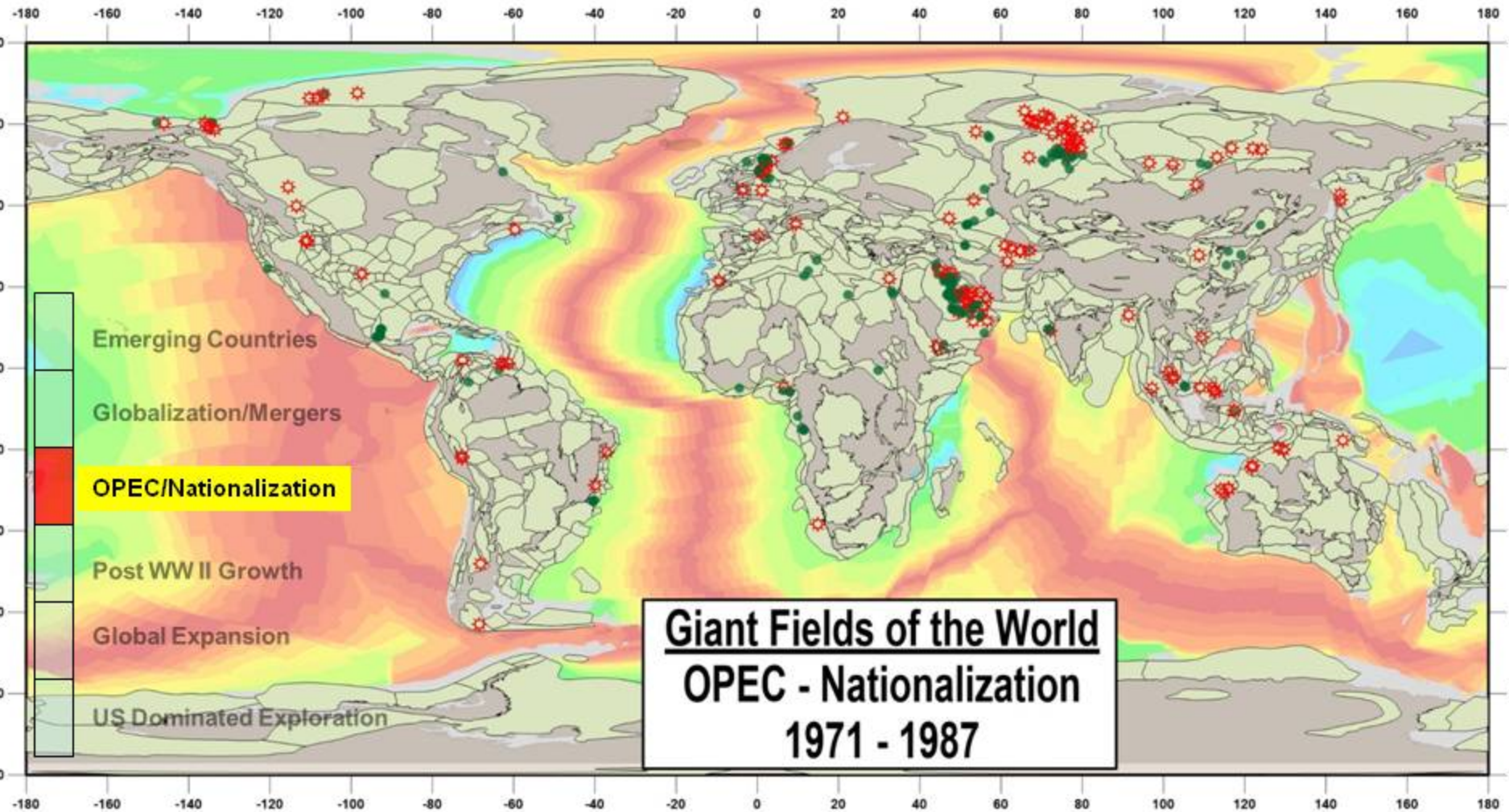
- ✓ Digital computers enable 2D seismic, log analysis, & data management
- ✓ 1965 “Bright Spots”
- ✓ Semisubmersible drilling rig
- ✓ Measurement while drilling

### ➤ 1970 – First Giant Fields Memoir 14



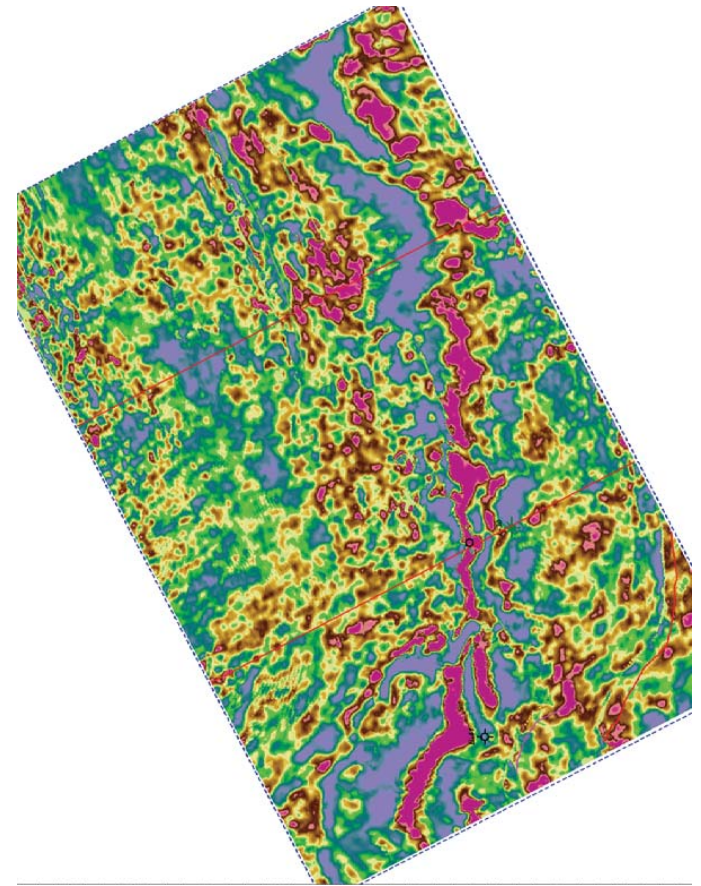


# OPEC & Nationalization 1971 – 1987

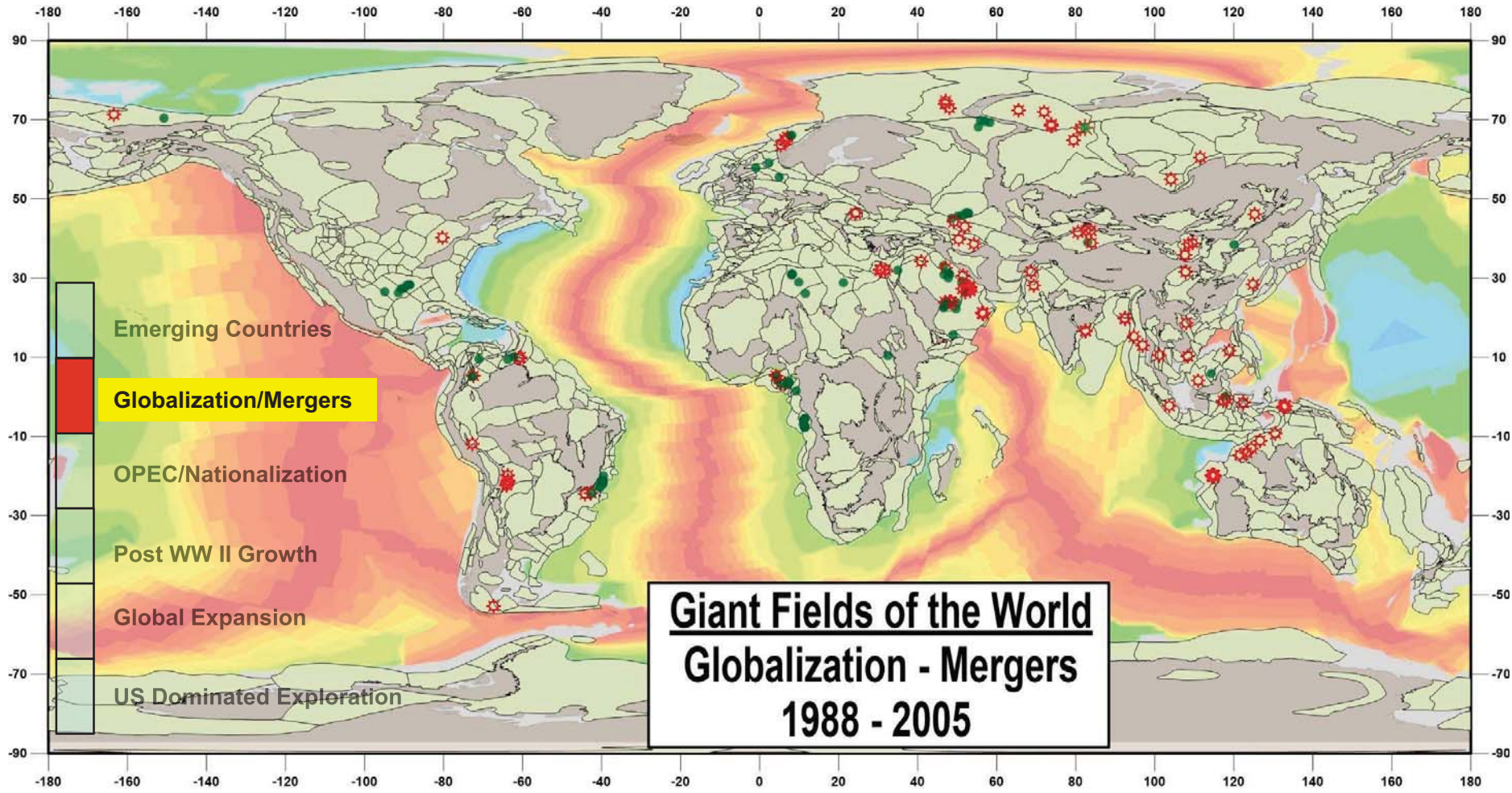


## **OPEC & Nationalization**

- **Arab Oil Embargo**
- **Seismic technology evolves**
  - ✓ **Seismic data in color**
  - ✓ **Seismic response & interval attributes**
  - ✓ **Seismic stratigraphy**
  - ✓ **3D seismic emerges**
- **Petrophysics**
  - ✓ **1977 first logging truck equipped with a computer**
  - ✓ **1978 Digital sonic tool (SDT)**
- **Geochemistry**
- **Directional Drilling**
- **1980 - Giant Fields Memoir 30**

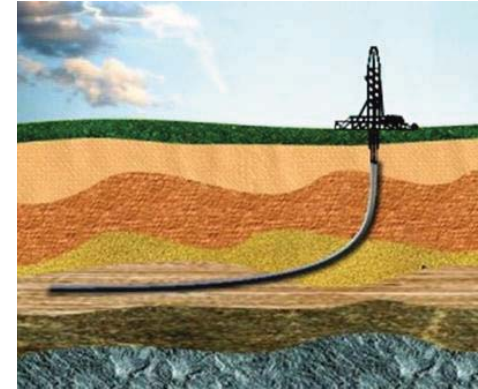


# Globalization & Mergers 1988 – 2005



## Globalization & Mergers

- **Seismic attribute analysis matures**
- **Horizontal drilling & Staged hydraulic fracturing**
- **First subsalt discovery**
- **1999 – First dual activity drill ship**
- **Deep water drilling matures**
- **Giant Fields Memoir 54 – 1992**
- **Giant Fields Memoir 78 – 2003**

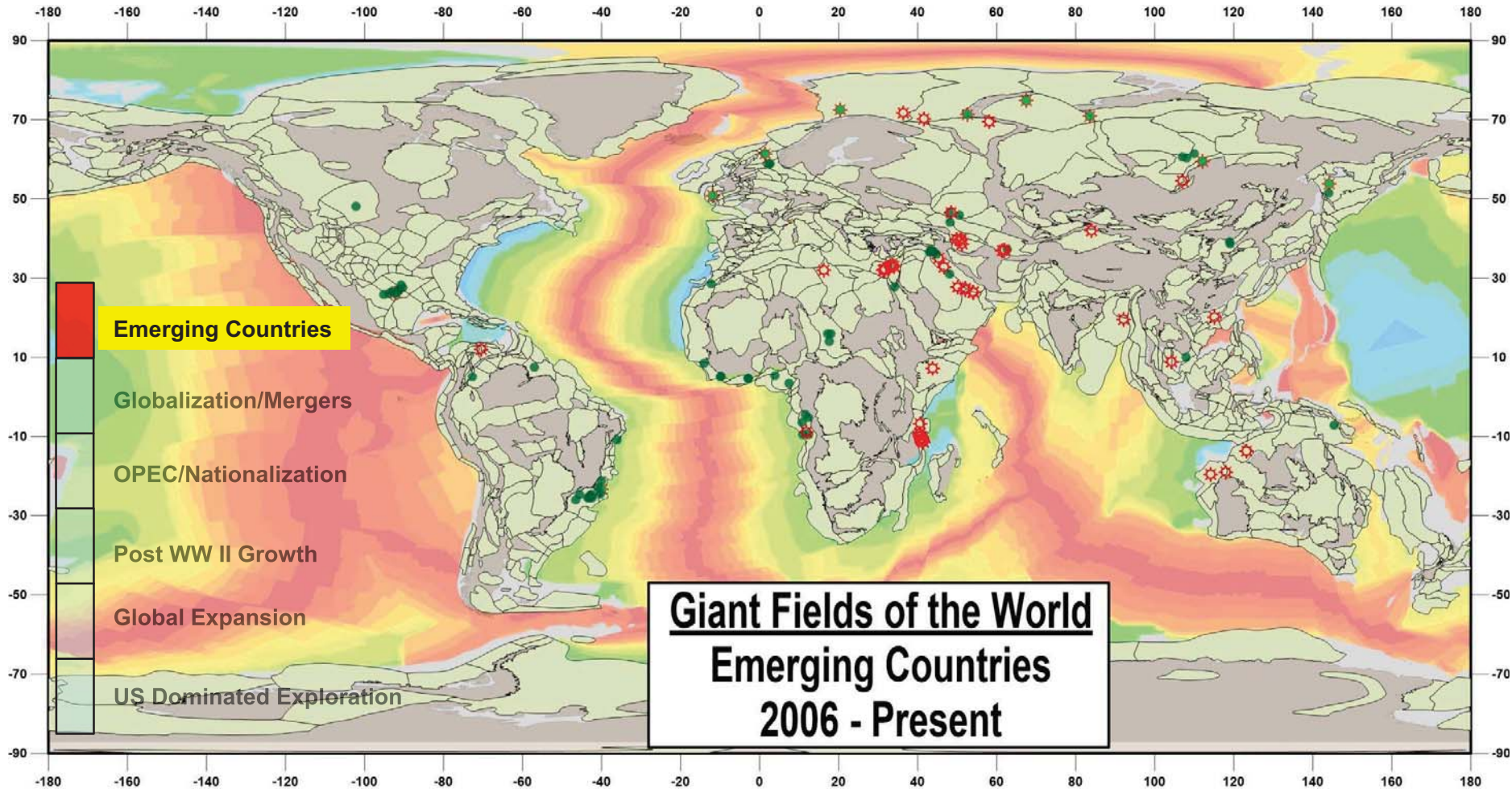


*From: Rigzone*



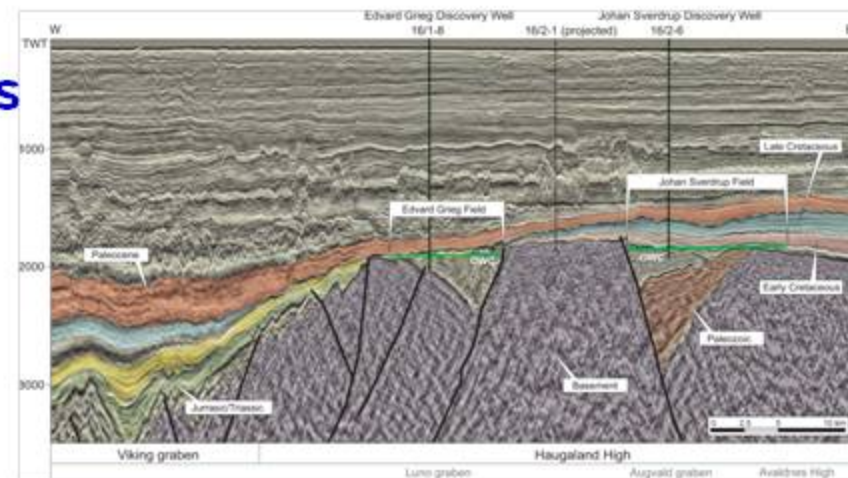
*Discover Enterprise from: 1999 Oil & Gas Journal*

# Emerging Countries 2006 – Present



# Emerging Countries

- **Seismic technology**
  - ✓ **Processing algorithms evolve**
  - ✓ **Multi-attribute analysis matures**
  - ✓ **Spectral decomposition and elastic inversion**
- **Subsalt drilling becomes common**
- **New turbidite plays**
- **Source Rocks become reservoir targets**
  - ✓ **Horizontal drilling**
  - ✓ **Multi-stage fracs**
  - ✓ **Microseismic**
- **Giant Fields Memoir 113**



From: Ronnevik, in press



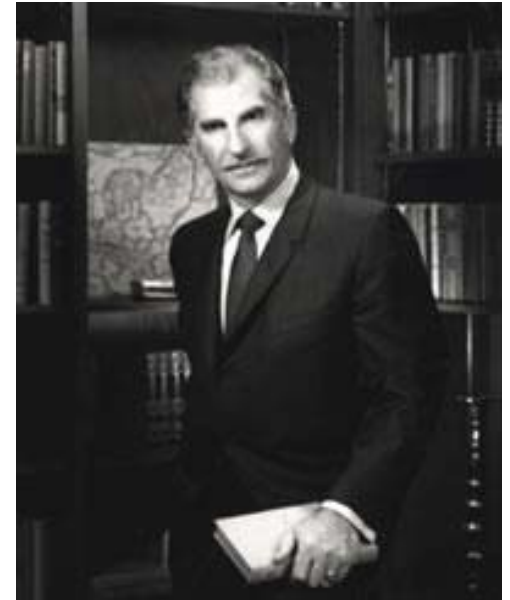
From: Zagorski, in press

## The Usual, and the Unusual

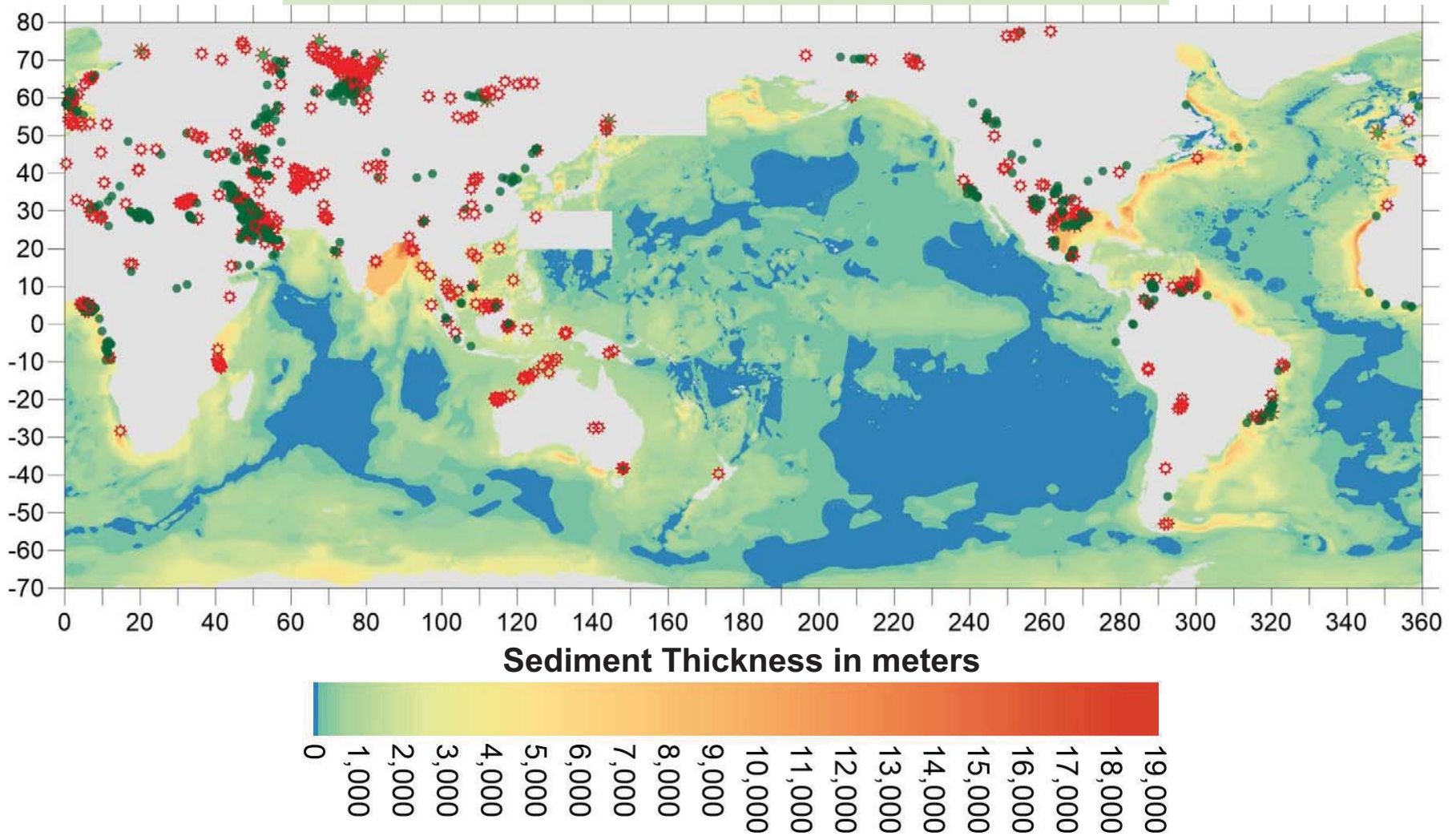
“As we make it a point to learn how these giant fields formed, we should study the modes of occurrence of the accumulations, the types of trap, how each trap formed and how it was found, the age of the reservoir and the age, or ages, of the sediments in which the petroleum generated and from which it was expelled and migrated to the trap.

***We should ask ourselves: first, what is usual about each of these accumulations? And second, what is unusual? Then we must concentrate on the unusual, for commonly it is that unusual aspect which is the key to accumulation.***

Prejudiced ideas should be discarded, for it is these old, ingrained, hard-nosed prejudices which also stifle exploration; old prejudices must not be tolerated in our thinking of the future.” M.T. Halbouty (1970, Memoir 14)



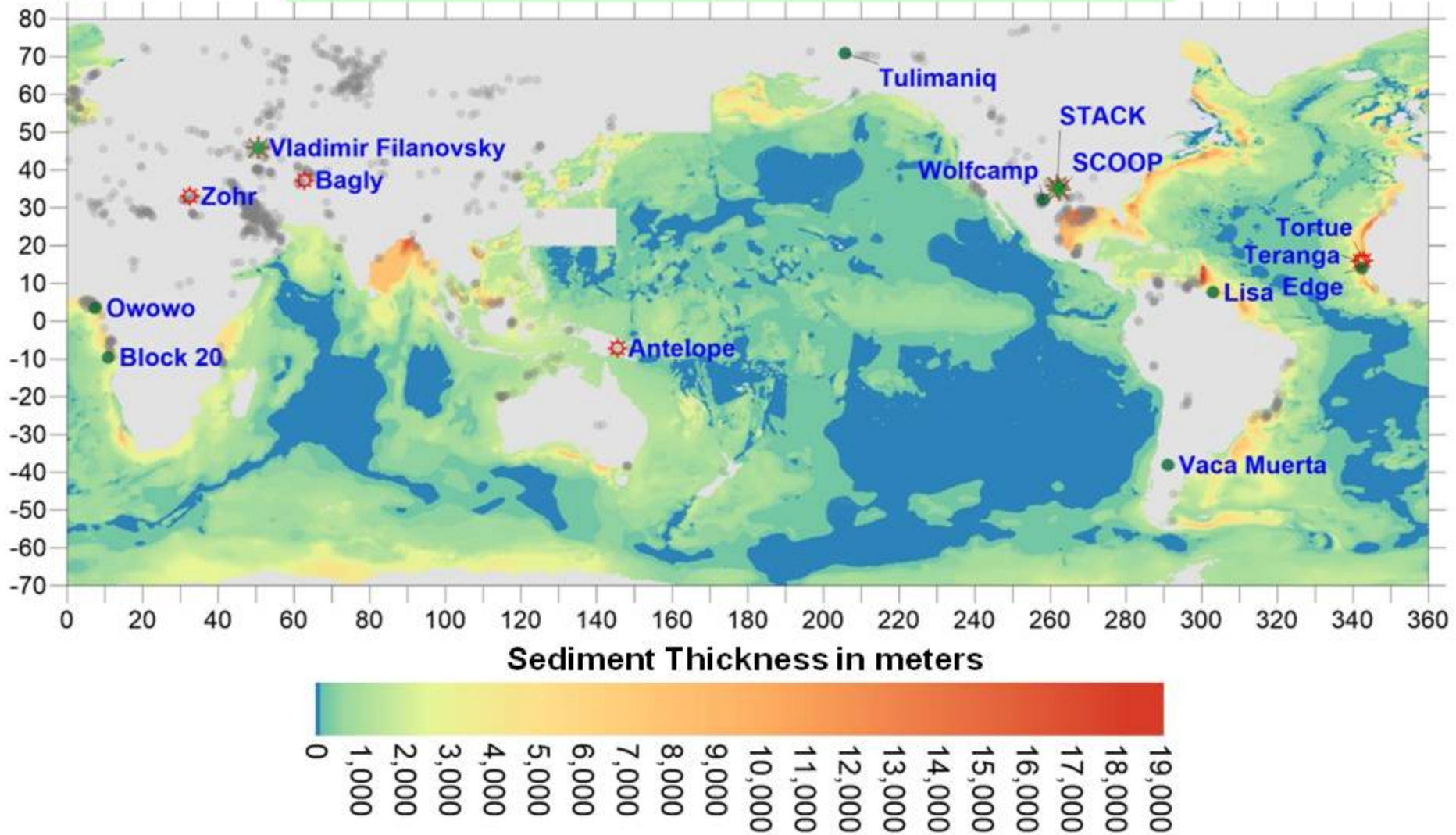
# Where We Have Been



<https://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html>



# The Journey Continues



<https://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html>