

Distinguished Lecturer Program

Primary funding is provided by

**The SPE Foundation through member donations
and a contribution from Offshore Europe**

The Society is grateful to those companies that allow their
professionals to serve as lecturers

Additional support provided by AIME



Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

Distinguished Lecturer Program

First-Ever Environmental Characterization of Hydraulic Fracturing for Shale Oil and Gas Production

Daniel Tormey, Ph.D., P.G.
Principal Technical Consultant

dantormey@aol.com

(818) 317-7716

Los Angeles, California

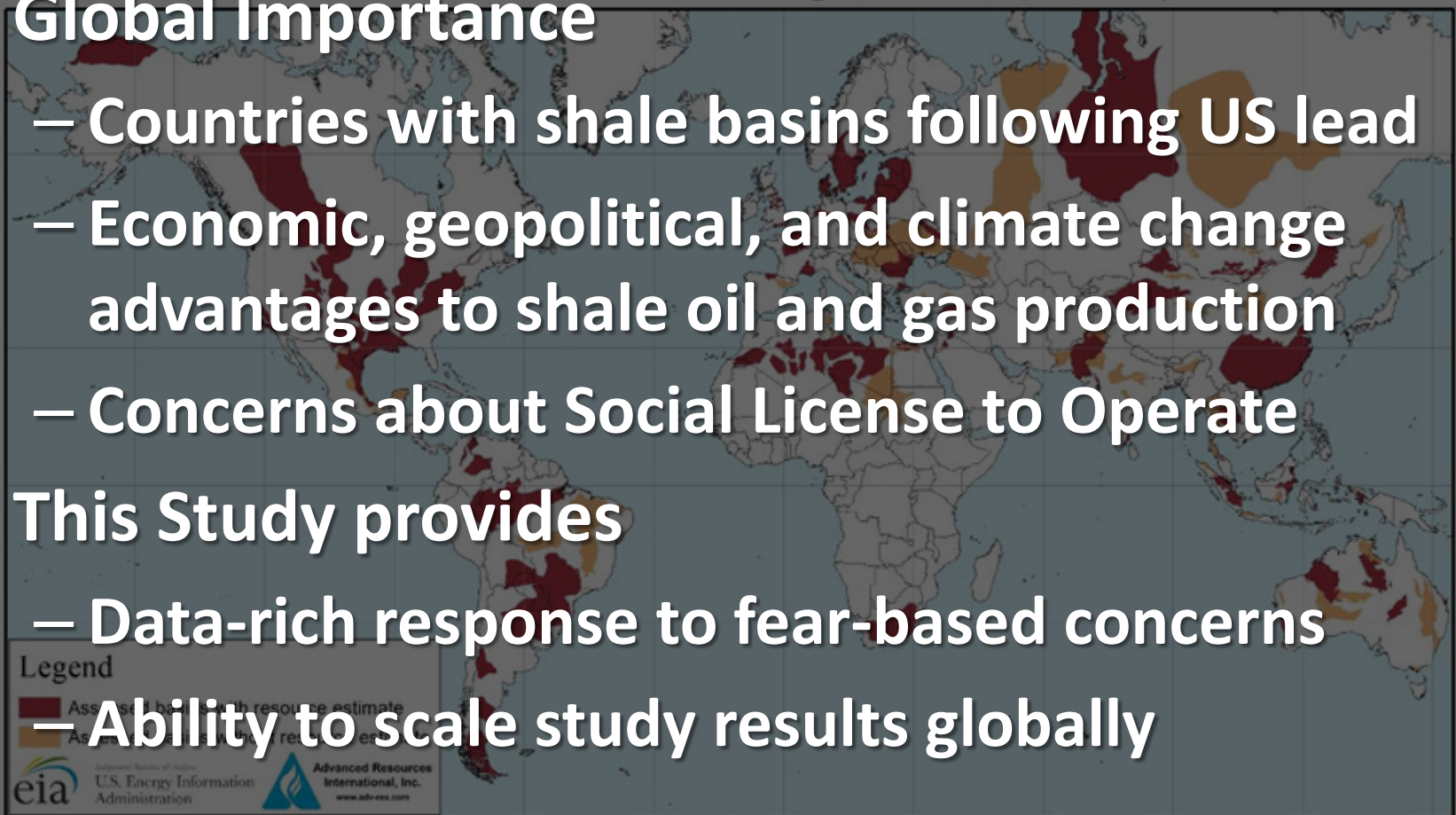


Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

Local Study With Global Implication

- **Global Importance**
 - Countries with shale basins following US lead
 - Economic, geopolitical, and climate change advantages to shale oil and gas production
 - Concerns about Social License to Operate
- **This Study provides**
 - Data-rich response to fear-based concerns
 - **Ability to scale study results globally**

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies

Hydraulic Fracturing Environmental Study

- Largest urban oil field in the world, in the center of Los Angeles, California
- Feasibility and environmental impacts of hydraulic fracturing
- Peer-reviewed, data-driven information on the effects of hydraulic fracturing

Concerns of a diverse urban community required a comprehensive study design

Los Angeles Basin is the richest in oil worldwide by size



A need for coexistence

Environmental Baseline:

**Venice Beach,
California in 1930's**

**Urban growth overlain on
Historic oil development**

Comprehensive Measurements before, during, and after hydraulic fracturing:

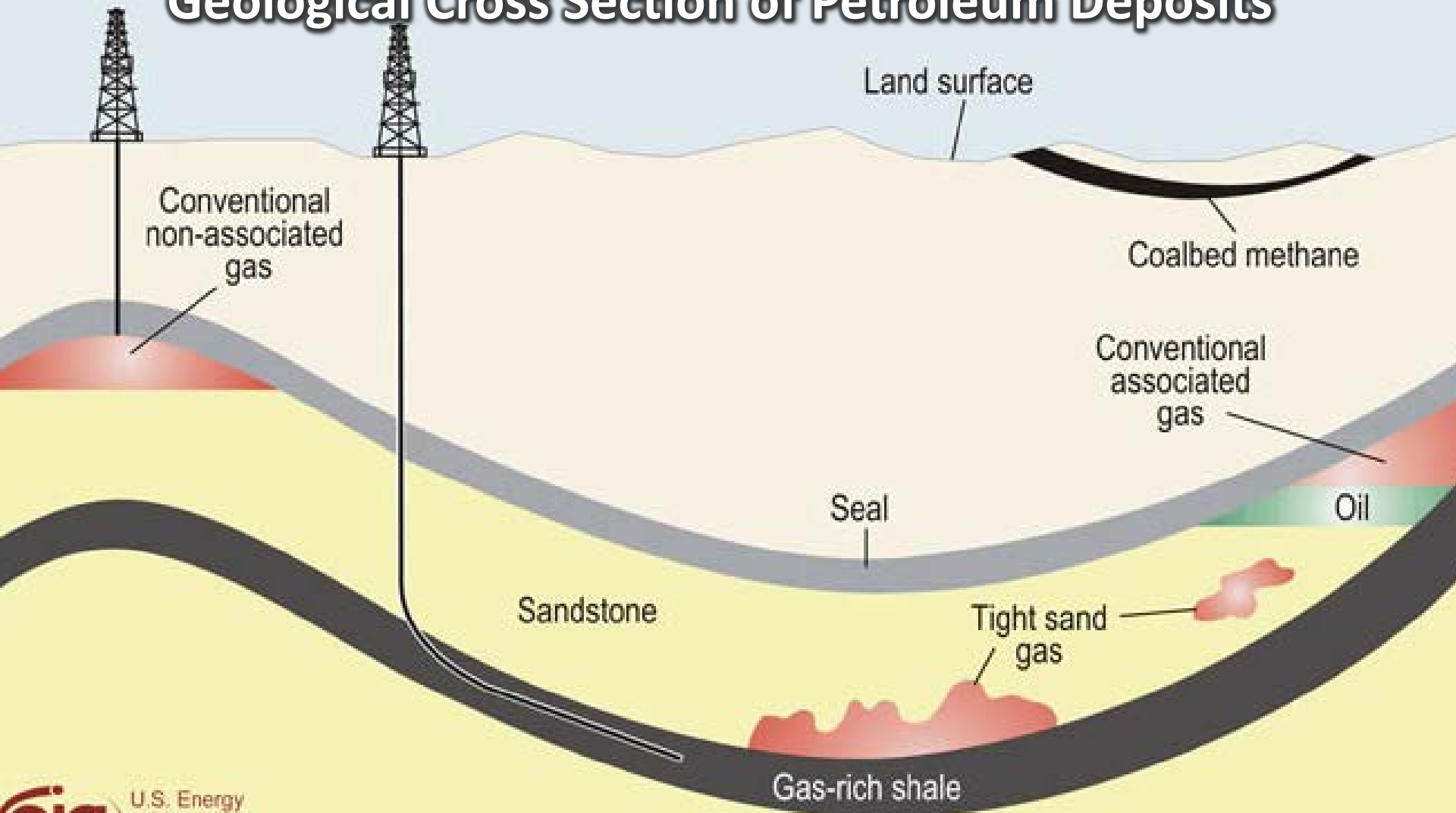
- ✓ Hydrogeology
- ✓ Water Use
- ✓ Water Quality
- ✓ Containment of Fractures
- ✓ Well Integrity
- ✓ Slope Stability
- ✓ Subsidence
- ✓ Ground Movement
- ✓ Induced Seismicity
- ✓ Methane
- ✓ Air Emissions
- ✓ Noise
- ✓ Vibration
- ✓ Community Health*

Results applicable to other parts of the world

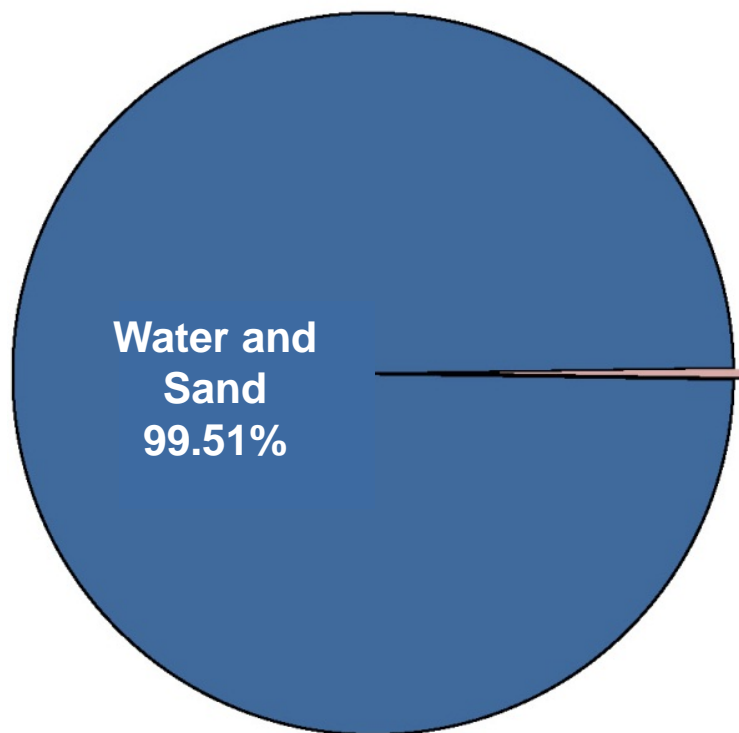
www.eenews.net/assets/2012/10/11/document_ew_01.pdf

Hydraulic Fracturing of Shales

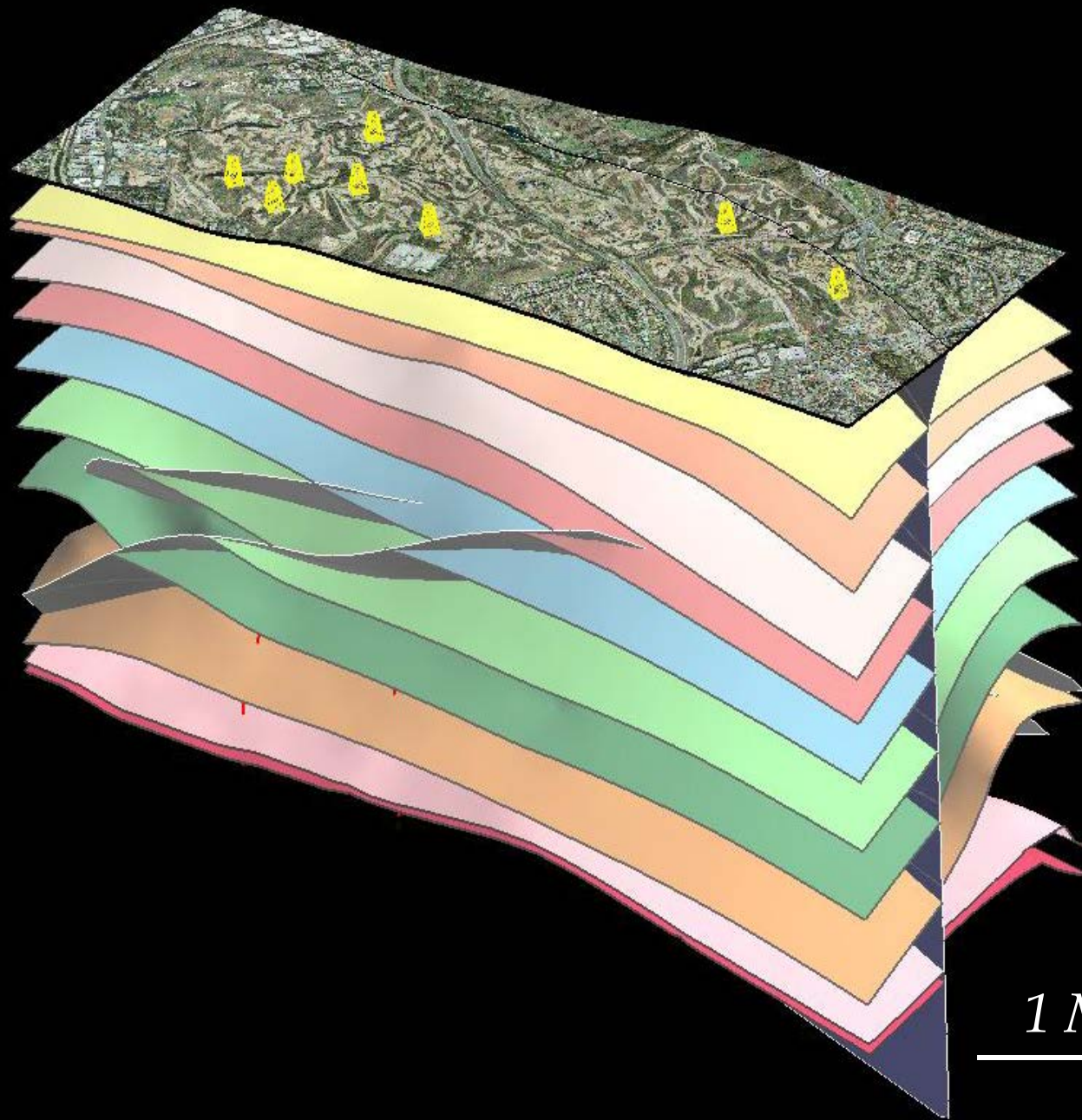
Geological Cross Section of Petroleum Deposits



Fluids Used in Hydraulic Fracturing



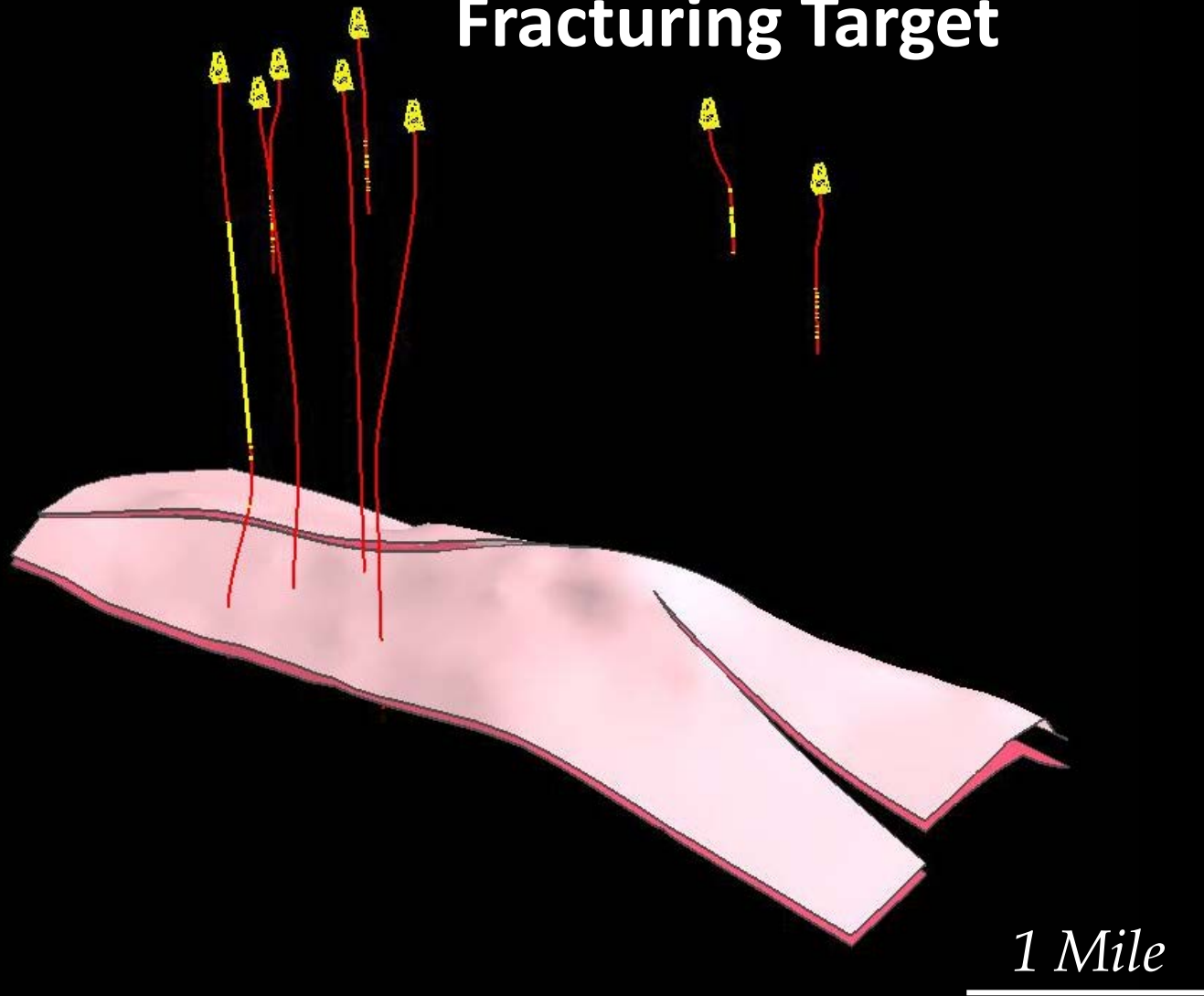
Full Report: <http://www.hydraulicfracturingdisclosure.org/fracfocusfind/>



**Oil Field
consists of
shales and
sandstones,
folded and
faulted**

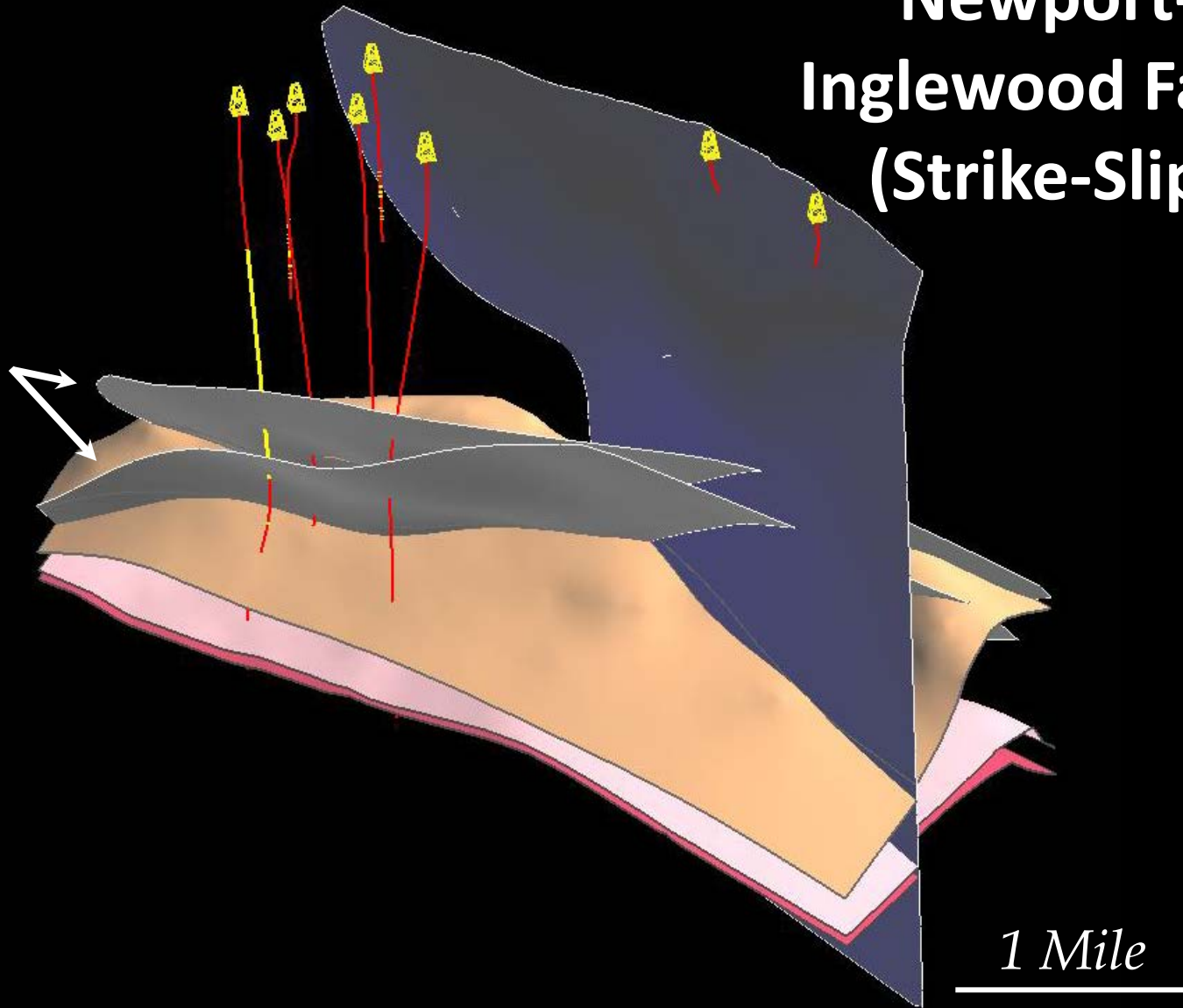
1 Mile

Nodular Shale: Fracturing Target



Newport- Inglewood Fault (Strike-Slip)

Thrust
Faults

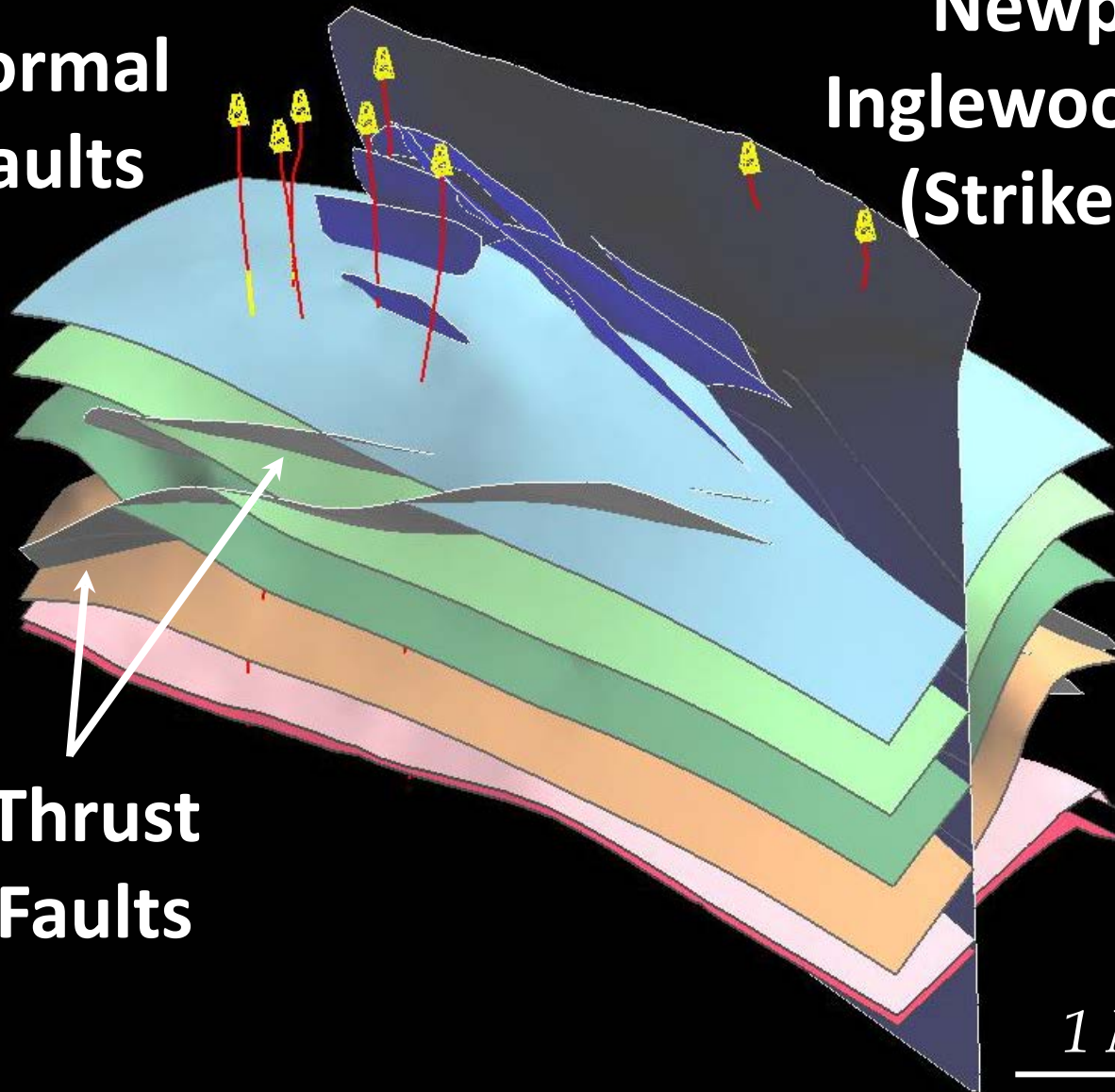


1 Mile

**Normal
Faults**

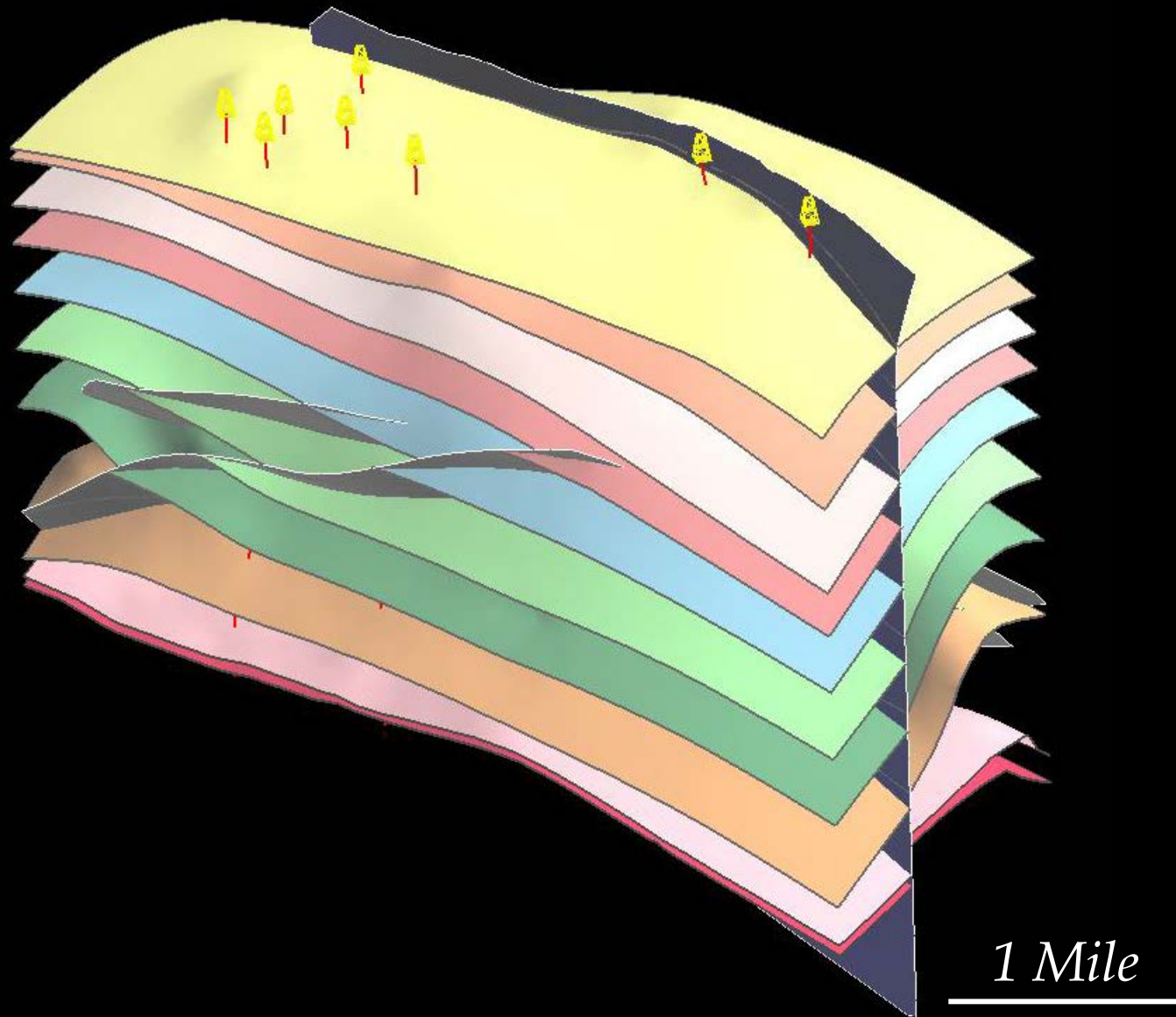
**Newport-
Inglewood Fault
(Strike-Slip)**

**Thrust
Faults**

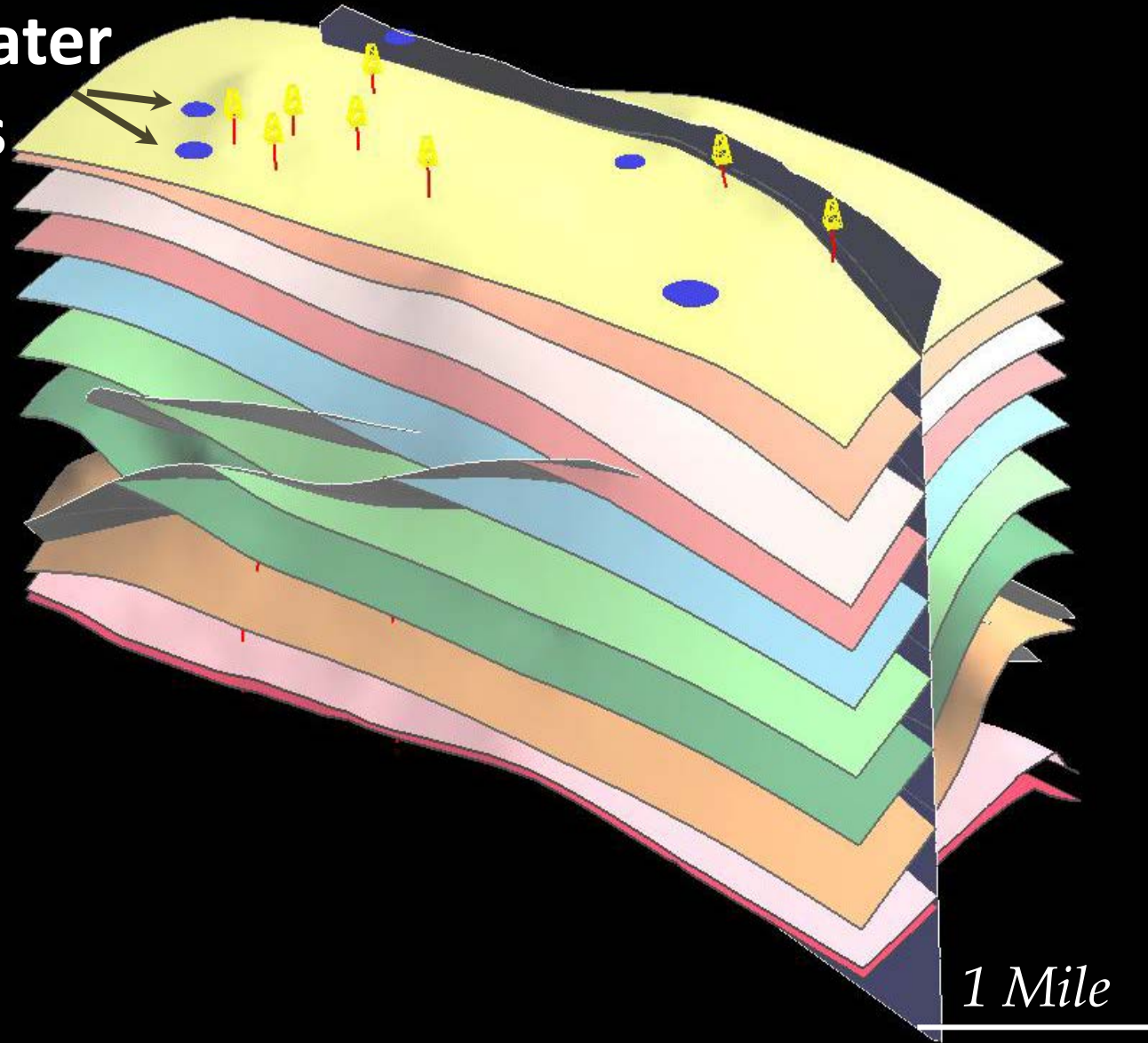


1 Mile

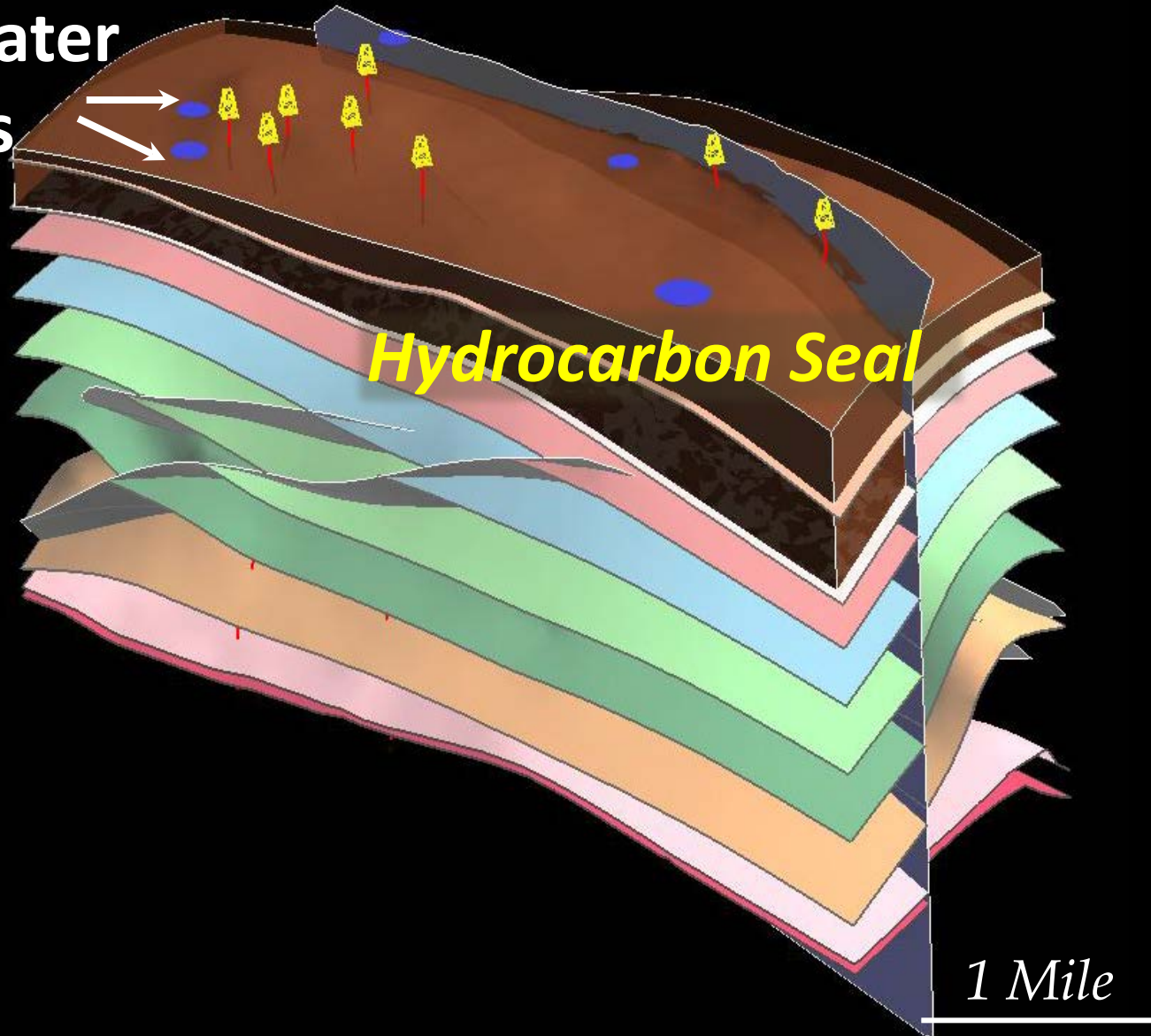
Base of Fresh Water



Discontinuous Groundwater Lenses



Discontinuous Groundwater Lenses



Discontinuous Water Bodies

Newport Inglewood Fault

Pico Surface (Freshwater Base)

Hydraulic Fracturing
~2,500 m
below Base of Fresh
Water

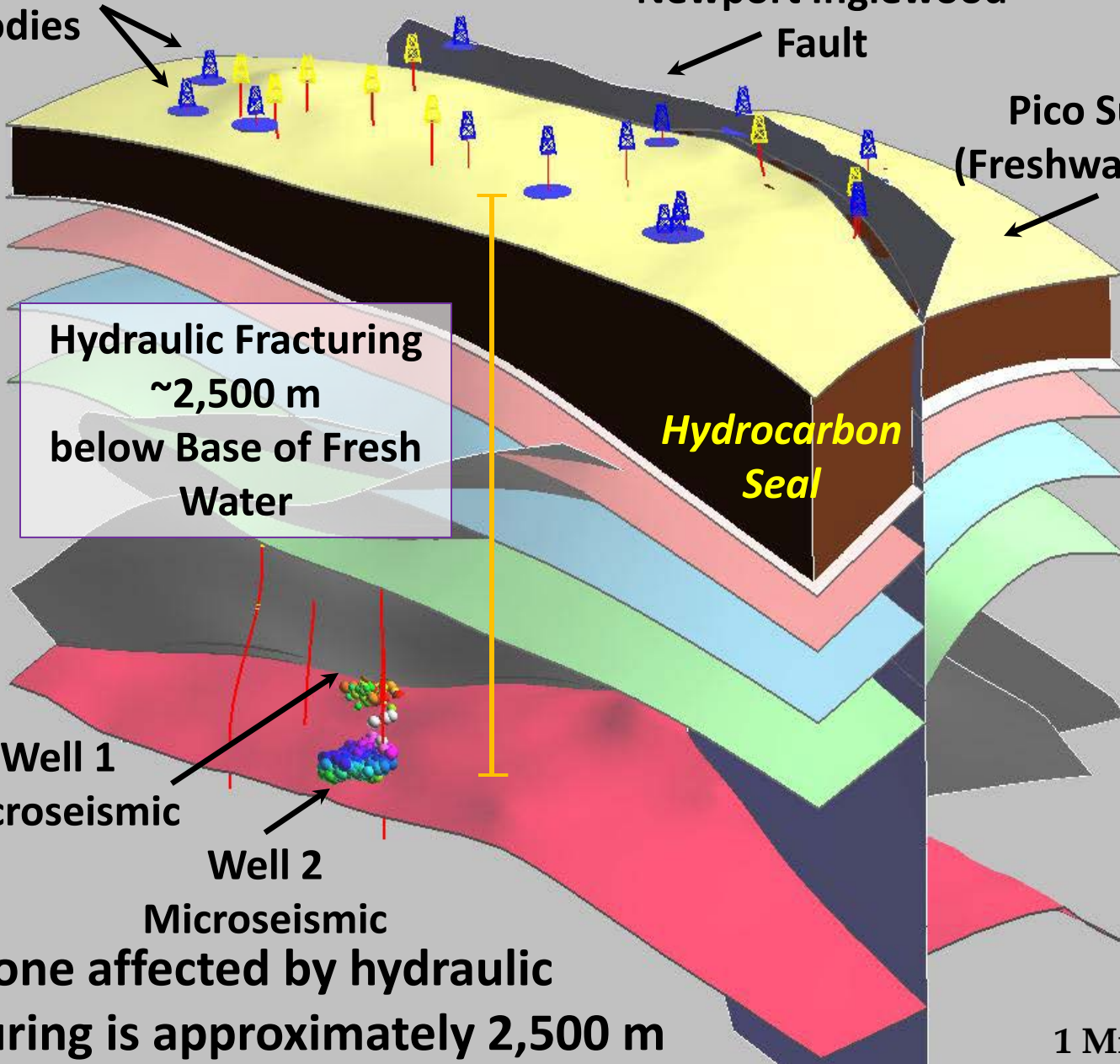
Hydrocarbon Seal

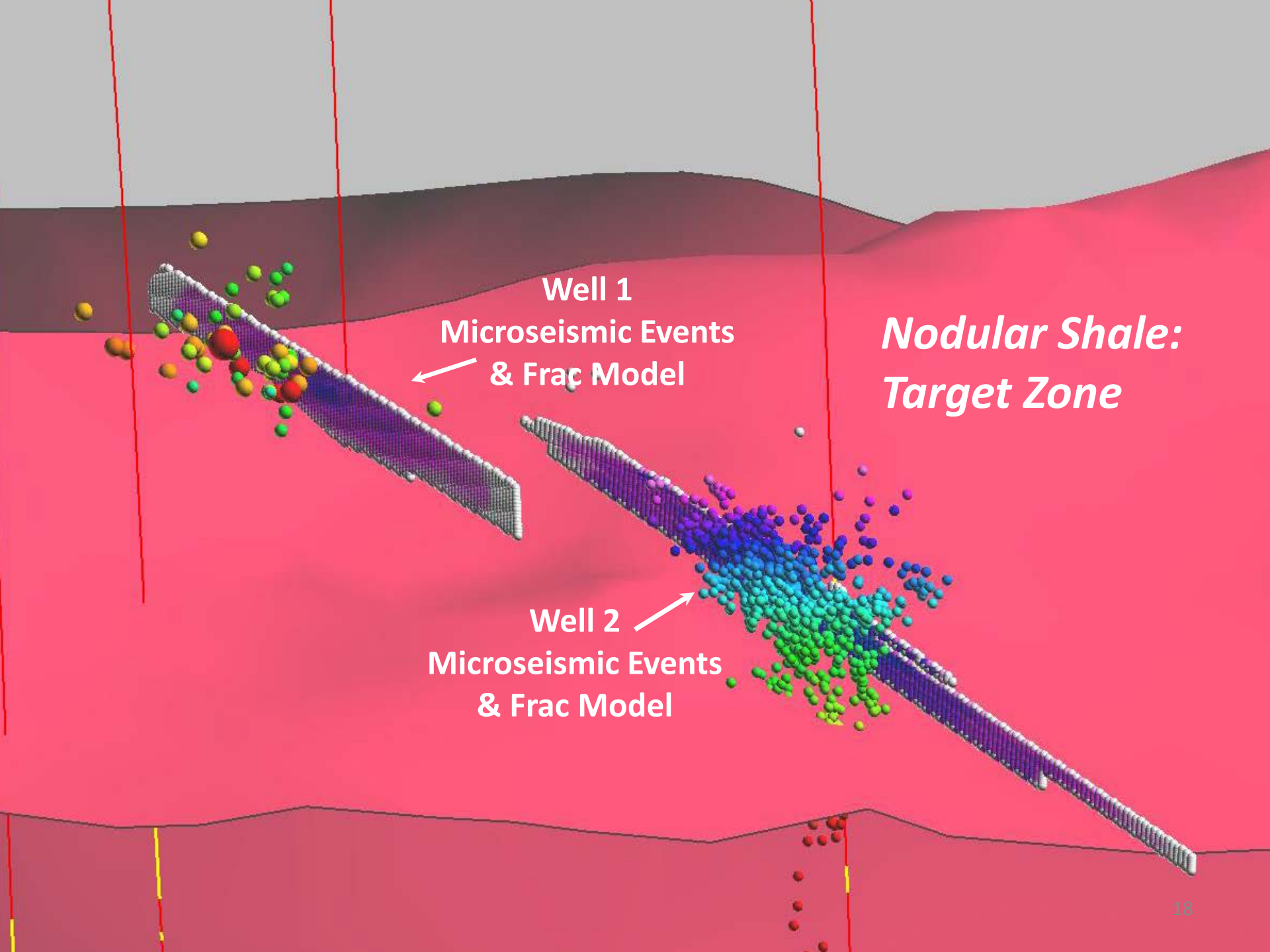
Well 1
Microseismic

Well 2
Microseismic

The zone affected by hydraulic fracturing is approximately 2,500 m feet beneath fresh water (1 ½ miles)

1 Mile



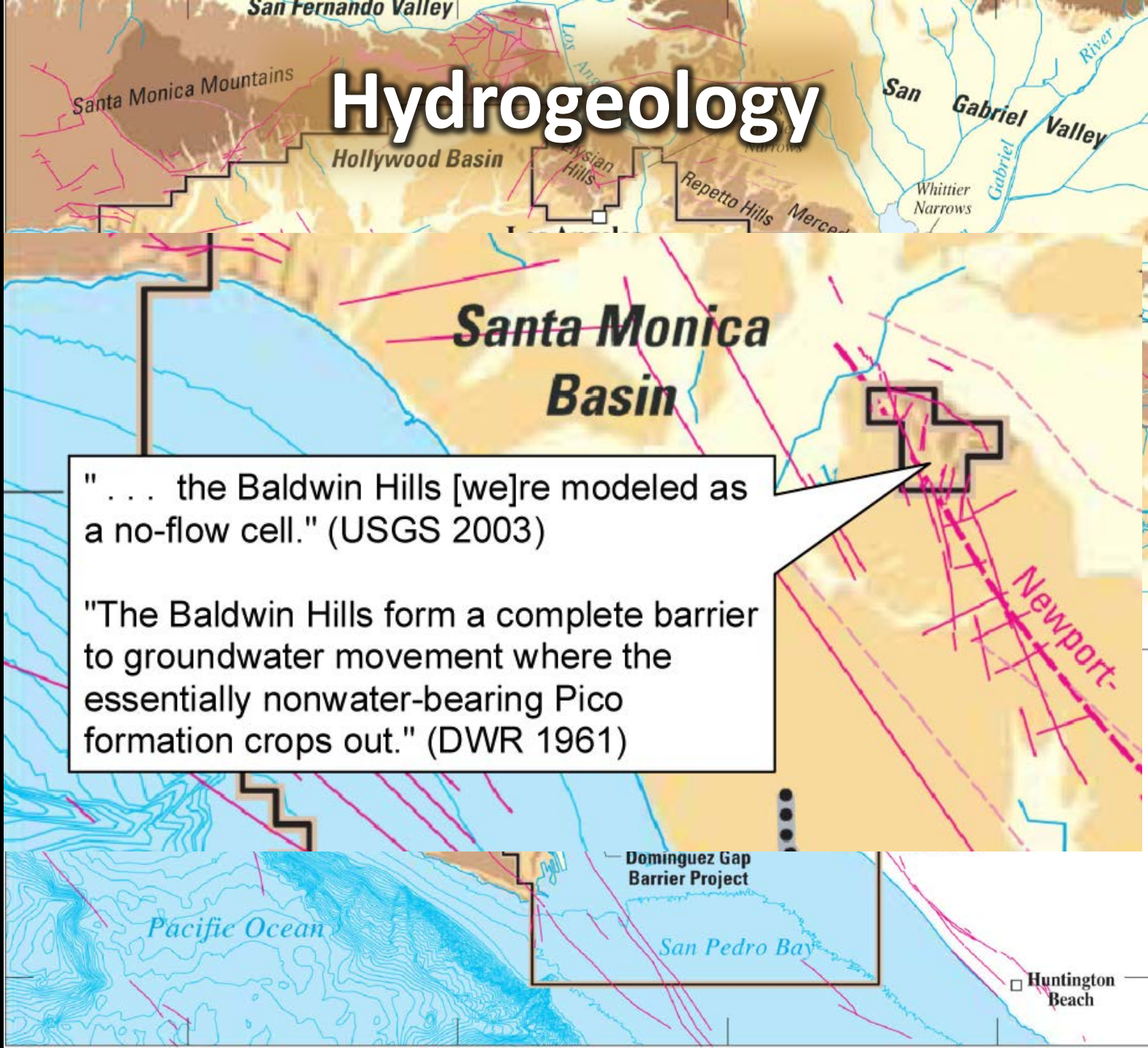


Well 1
Microseismic Events
& Frac Model

*Nodular Shale:
Target Zone*

Well 2
Microseismic Events
& Frac Model

Hydrogeology



"... the Baldwin Hills [we]re modeled as a no-flow cell." (USGS 2003)

"The Baldwin Hills form a complete barrier to groundwater movement where the essentially nonwater-bearing Pico formation crops out." (DWR 1961)

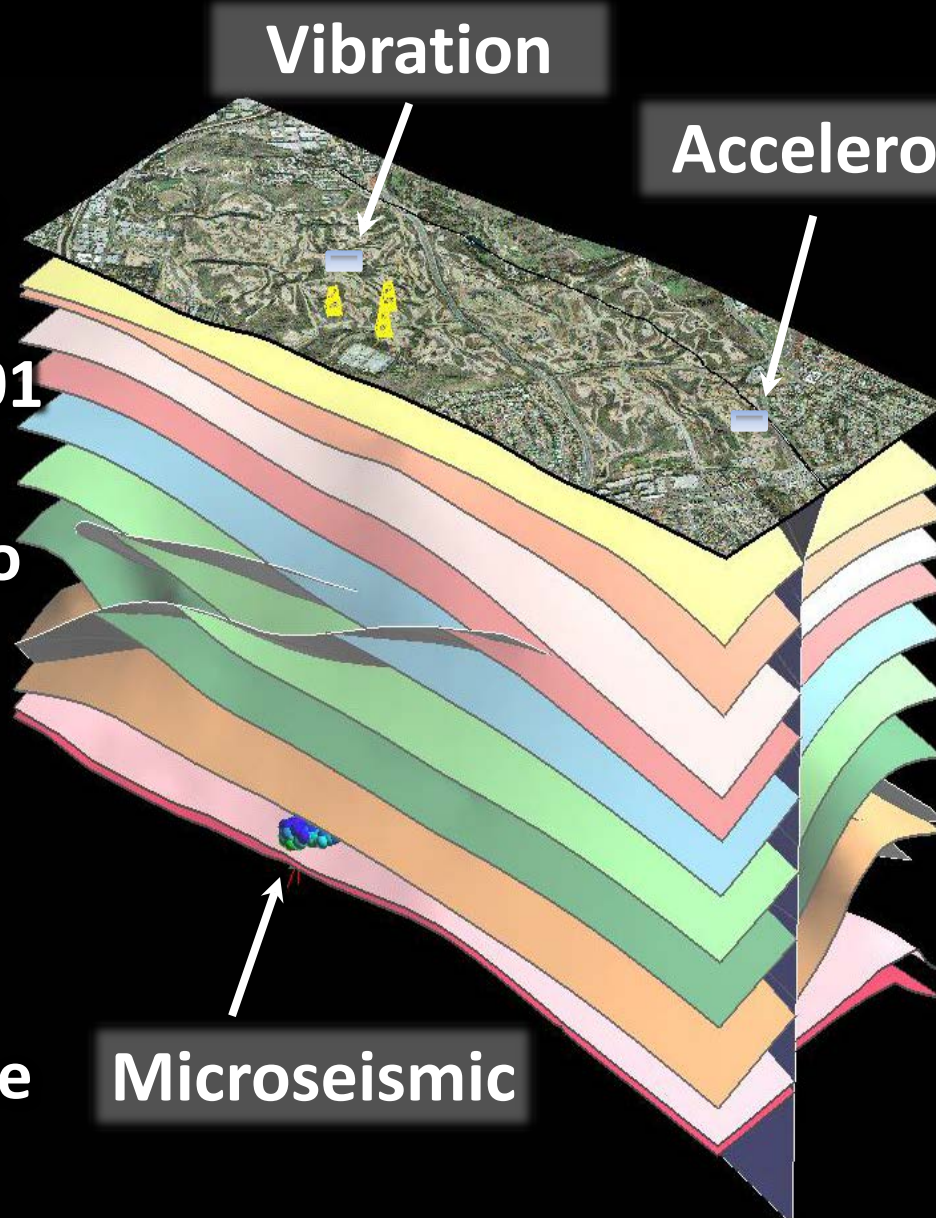
Water Quality

- **2/3 of water for the vicinity of Oil Field comes from 560 km (350 miles) away**
- **Remainder is from sources greater than 1.5 miles away**
- **All public water is:**
 - **Tested quarterly and reported**
 - **Must meet drinking standards**

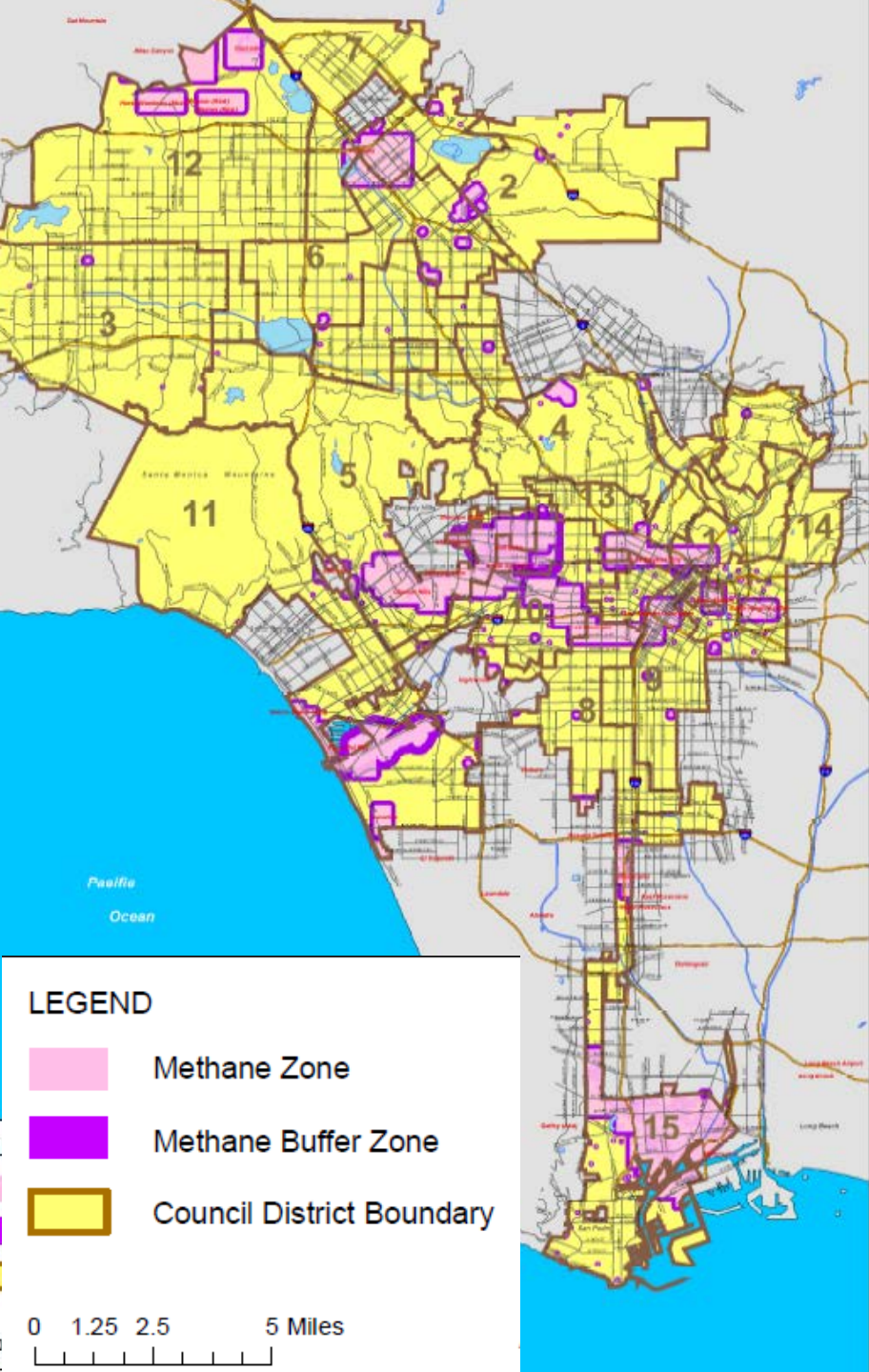
Further Information: <http://www.westbasin.org/water-reliability2020/groundwater/overview>

Ground Movement and Induced Seismicity

- Microseismic effects:
Richter M 0.01 to 0.001
- Insufficient to induce tectonic earthquakes
- Tectonic quakes have deeper source

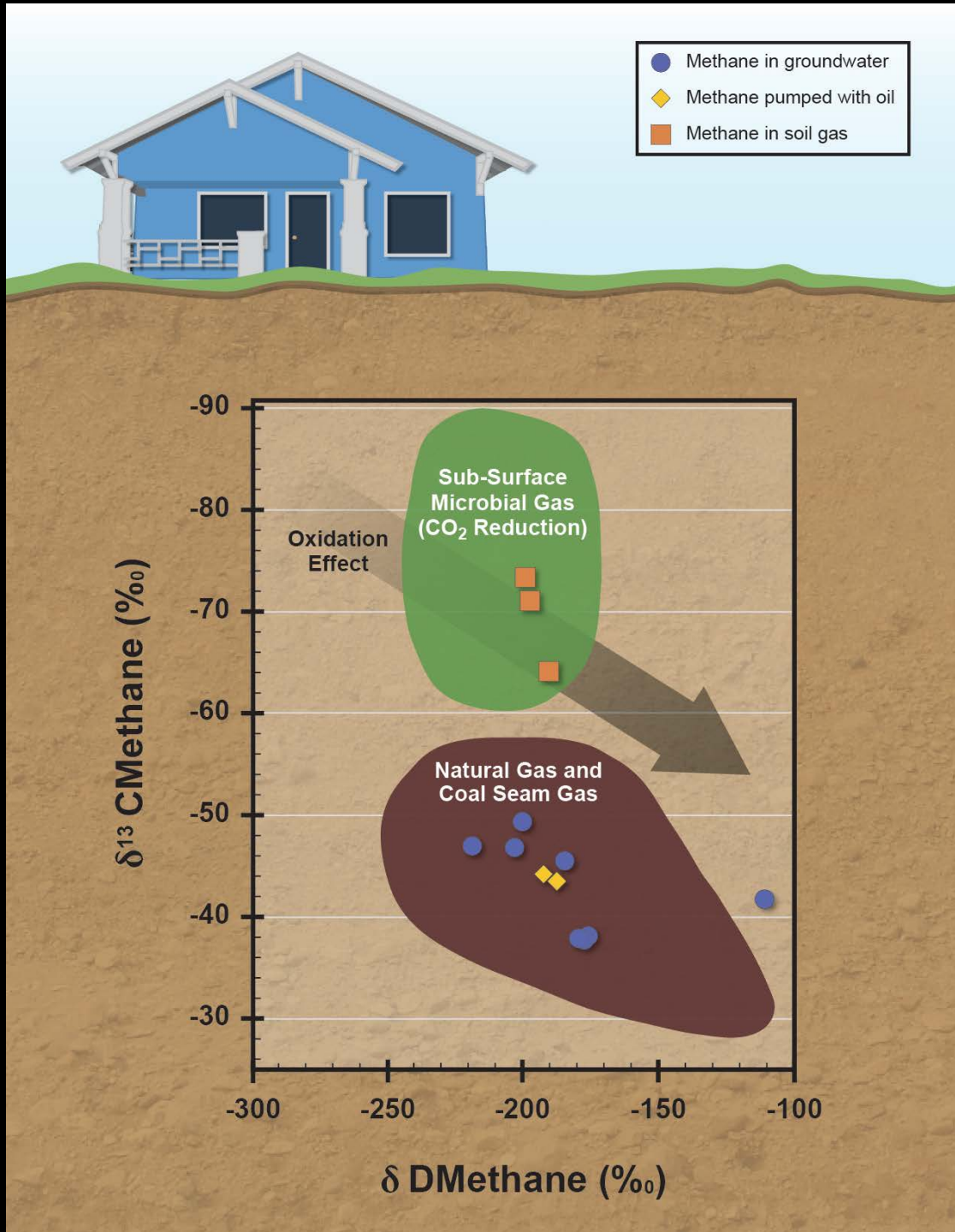


- Induced seismicity linked to injection at few sites
- Field has operated a water flood since 1971 without seismicity



Methane Migration

- Oil Field is adjacent to known “Methane Zone”
- Methane in shallow soil gas is biogenic
- Methane detected in groundwater has been thermogenic
- No change due to hydraulic fracturing



Measurements before, during, and after hydraulic fracturing did not detect effects to:

- ✓ Hydrogeology
- ✓ Water Use
- ✓ Water Quality
- ✓ Containment of Fractures
- ✓ Well Integrity
- ✓ Slope Stability
- ✓ Subsidence
- ✓ Ground Movement
- ✓ Induced Seismicity
- ✓ Methane (soil gas and groundwater)
- ✓ Air Emissions
- ✓ Noise
- ✓ Vibration
- ✓ Community Health*

***Study Provides Data-Rich Source
Responding to Public Concerns***

Application of the Study So Far

- **First Study to address all environmental concerns of hydraulic fracturing quantitatively; finding no new adverse effects compared to current oil and gas operations**
- **Local public agency with jurisdiction over the Oil Field did not require additional protective measures for hydraulic fracturing**
- **State public agency relying on the Study for independent review of hydraulic fracturing (Tormey on Steering Committee)**
- **Federal public agency relied on the Study as basis for evaluating Hydraulic Fracturing**

Distinguished Lecturer Program

Your Feedback is Important

Enter your section in the DL Evaluation Contest by
completing the evaluation form for this presentation
Visit SPE.org/dl



Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

