Monterey Shale Potential

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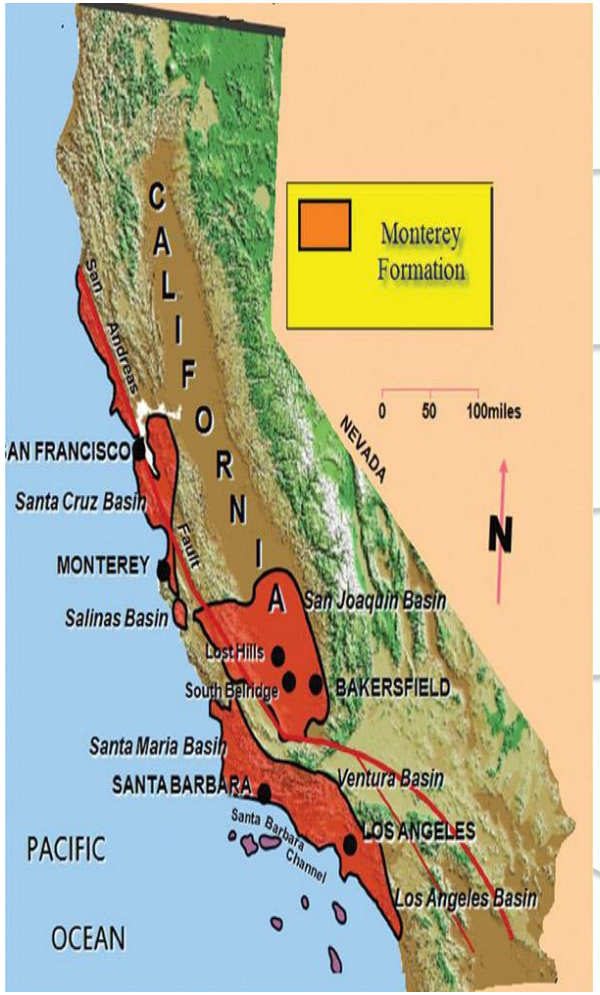
USC Viterbi School of Engineering

ISC University of Southern California

Summary



Overview of Monterey Shale

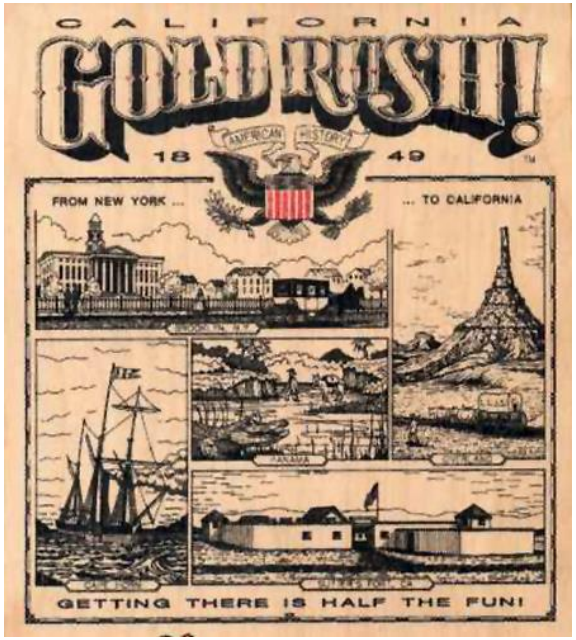
Development Challenges

Environmental Considerations

Economic Impact

Conclusions

California Monterey Shale, Another Gold Rush?



In the late 1840s, Californians shouted, **"There's gold in them thar' hills!"**

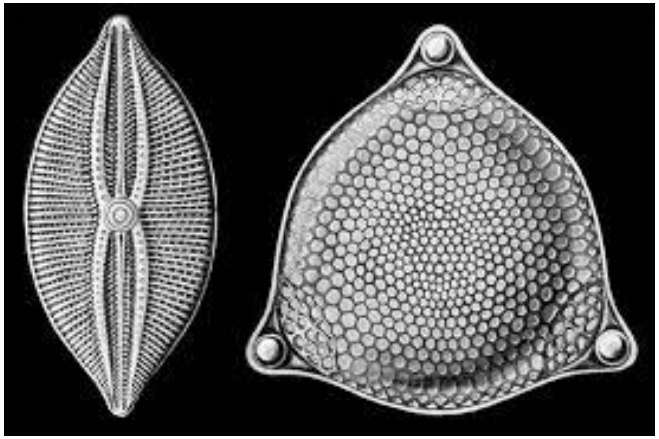
Today many other shale success stories the rallying cry is, **"There's oil in that thar' Monterey Shale!"**

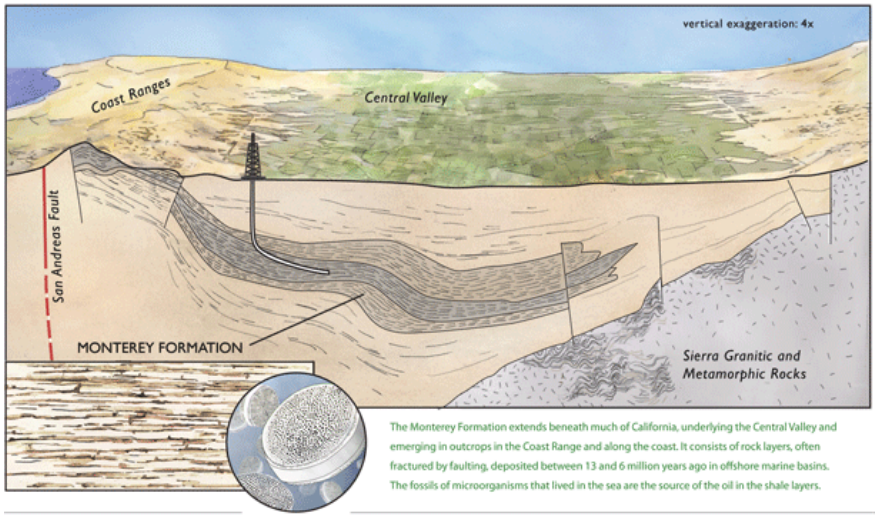
The Monterey Formation

Onshore- Tight with less micro fractures

- OPAL A: Diatomite type: Waterflood/ Thermal
- Opal CT: Potential Development as Shale Oil

Offshore- Cherty/Fractured





Source: underwoodillustration.com

Monterey Formation History

- First discovered at the Orcutt Oil Field in the Santa Maria Basin of Santa Barbara County in 1901.
- Subsequent discoveries: Cat Canyon Oil Field and Lompoc Oil Field: All natural fractures in the Monterey.
- The Monterey Formation is one of the reservoirs in the Elk Hills Oil Field of Kern County.
- State Water Offshore Monterey production: South Ellwood Oil Field : Santa Barbara Channel
- Federal Water Offshore: Point Arguello, Point Pedernales, Hondo…

California Monterey Shale

- (EIA) estimates the Monterey/Santos play holds 15.4 bbo of shale resources
- the Bakken and Eagle Ford combined have about 7 bbo
- Monterey shale is the primary source rock for the conventional oil reservoirs found in the Santa Maria and San Joaquin basins

Monterey Oil Shale Seen as Next Wave of U.S. E&P Efforts

www.rigzone.com/news/article.asp?a_id=109845

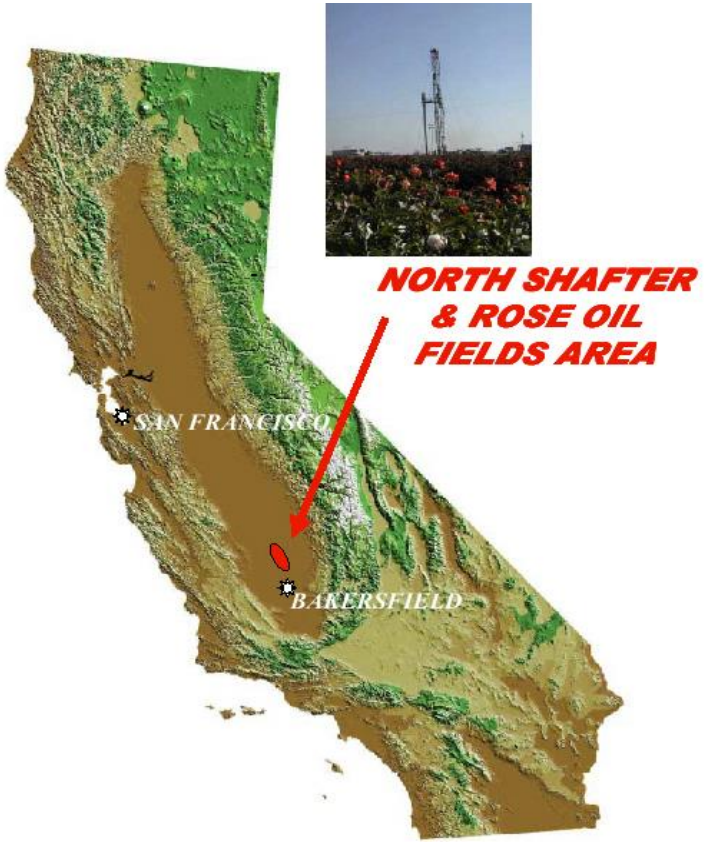
California Monterey Shale

- The Monterey Formation is considered the source of 84% of the oil in known fields of the San Joaquin Basin,
- A total of 12.2 billion barrels of oil (source rock)
- 112 million barrels of oil in known fields is produced (reservoir rock)

California play full of complexities Monterey Shale Continues to Tempt and Tease

www.aapg.org/explorer/2013/02feb/monterey_shale0213.cfm

North Shafter/Rose: A Monterey Shale Oil Field Example



Location map of North Shafter and Rose Oil fields area.

- Miocene McLure Shale of the Monterey formation discovered in 1983
- The first horizontal well was drilled in North Shafter / Rose Field in 1998.
- Close to 60 horizontal wells have been drilled since then.
- The area of Rose and North Shafter fields in 1995 was undeveloped.

Development history of North Shafter / Rose oil field

1982 - discovery "by accident."
5 vertical wells were drilled by Amoco: 75 BOD best IP – 2 producers + 3 dry holes on Tenneco F/O.

1991- horizontal-well attempt by Texas Crude; well was drilled mostly out of zone and not stimulated – no production.

1995 - EOG becomes landlord of acreage - Texaco and Texas Crude begin vertical well program. All vertical wells stimulated; fracture design varied from well to well.

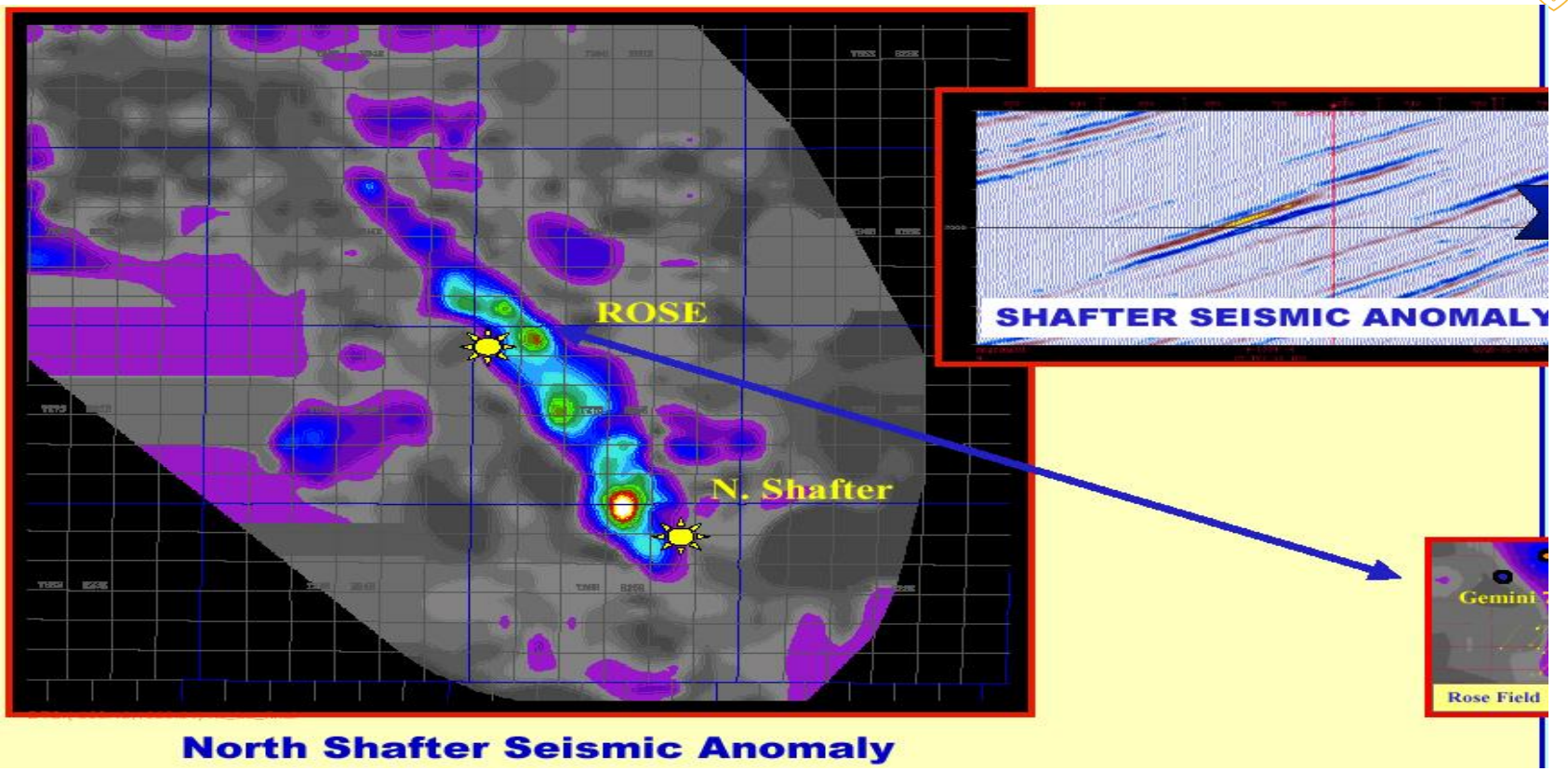
1997 -Texaco drills first horizontal (I.P. 1070 BOD); EOG becomes Texaco's partner in development. Utilized limited entry fracs in uncemented liner. Frac size maximum 1,000,000# sand – Frac size varies.

2000 - EOG reenters an abandoned well and successfully stimulates bypassed pay in McLure Shale, opening up the Rose Field.

North Shafter / Rose area

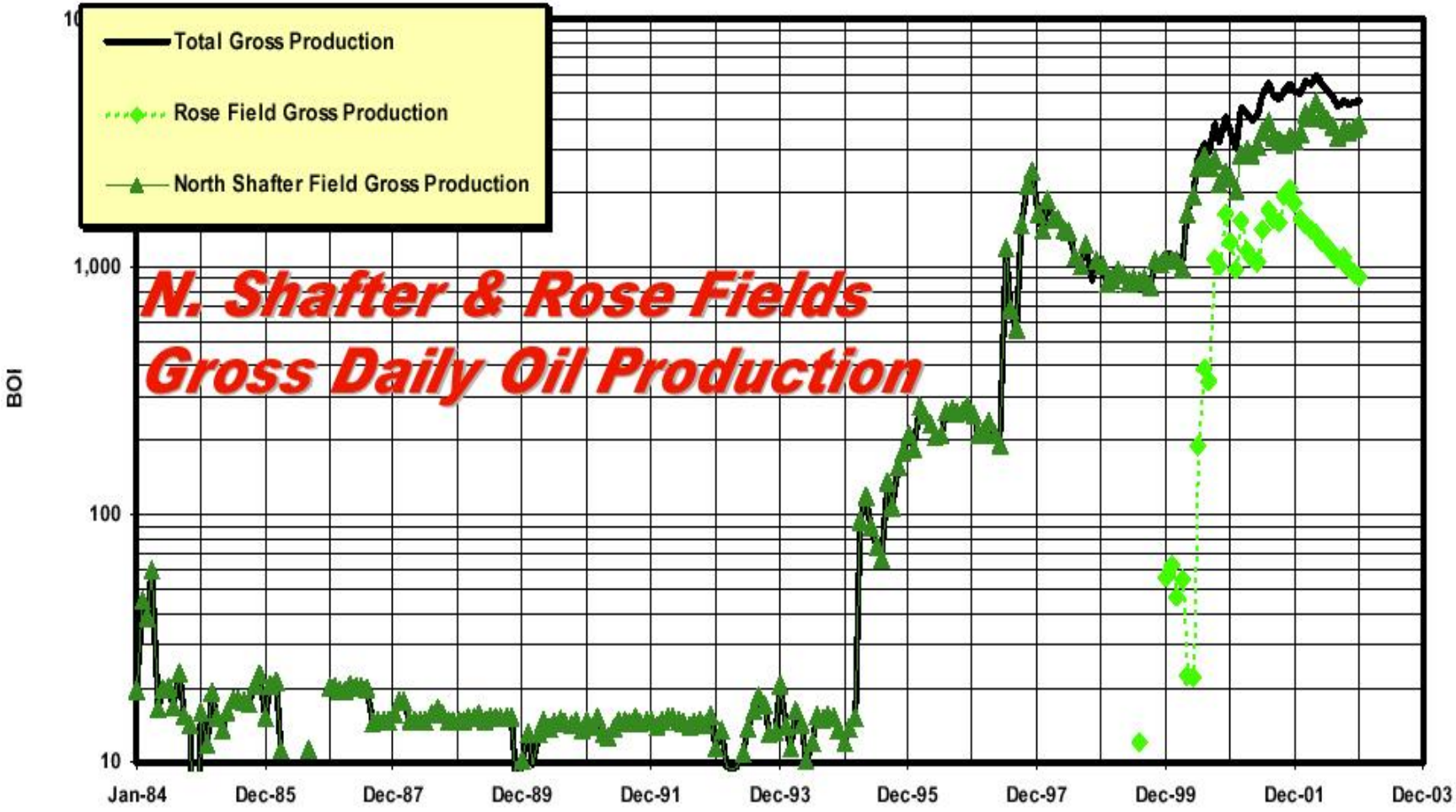
- Composed primarily of diagenetically altered biogenic silica.
- Relatively high porosity but very low permeability that must be naturally or artificially fractured to produce oil at economic rates.
- It is producing at 40% of its original reservoir energy.
- Production has been declining, and the wells are in danger of being abandoned
- Using variety reservoir characterization techniques
  - Determine the production characteristics
  - Evaluate fracture characterization, modeling and simulation.

Rose and North Shafter oil fields



Map of North Shafter seismic anomaly, Rose and North Shafter oil fields, inset with character of the anomaly.

Production history of North Shafter and Rose fields, along production plot for two typical wells.



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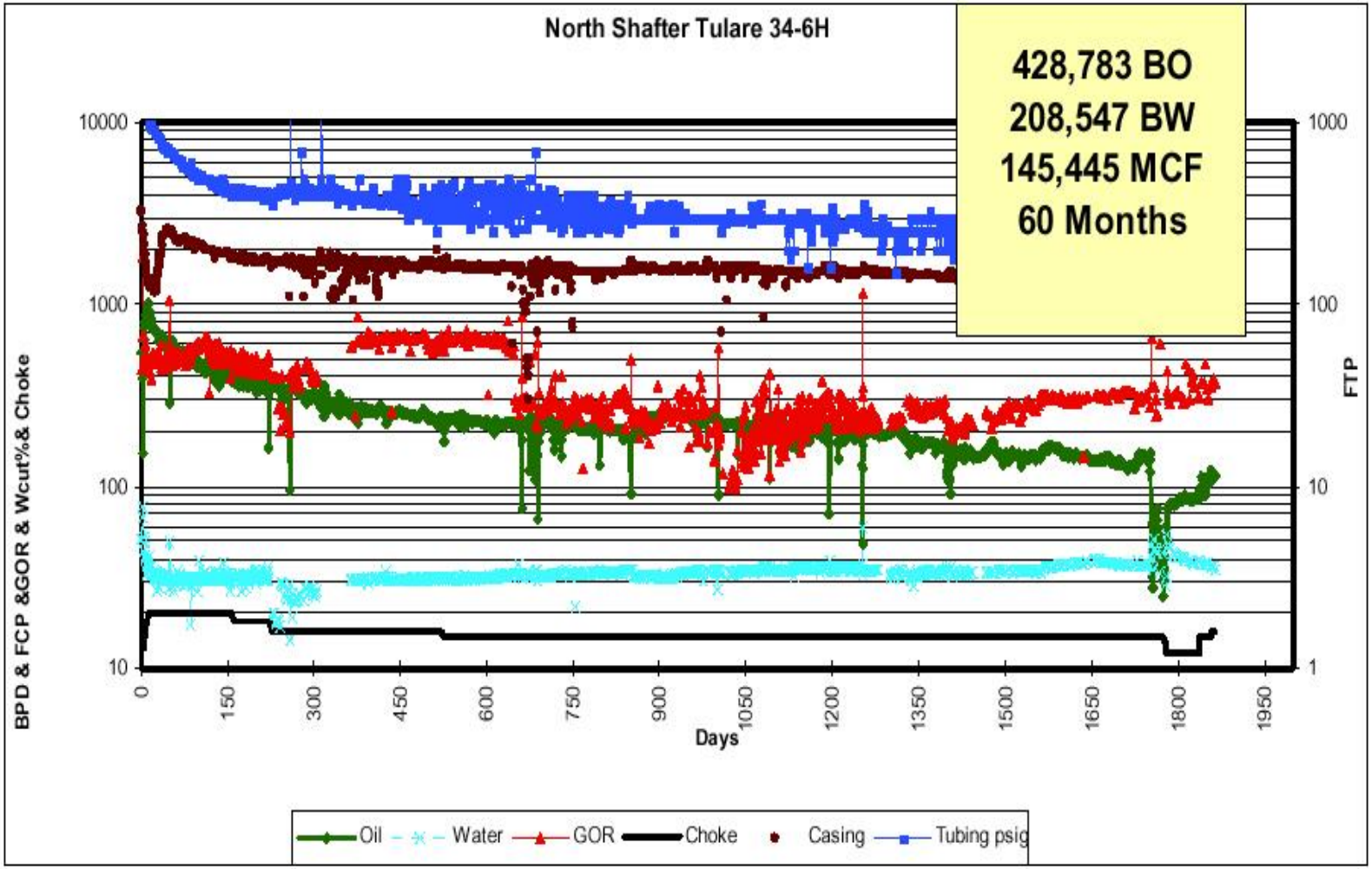
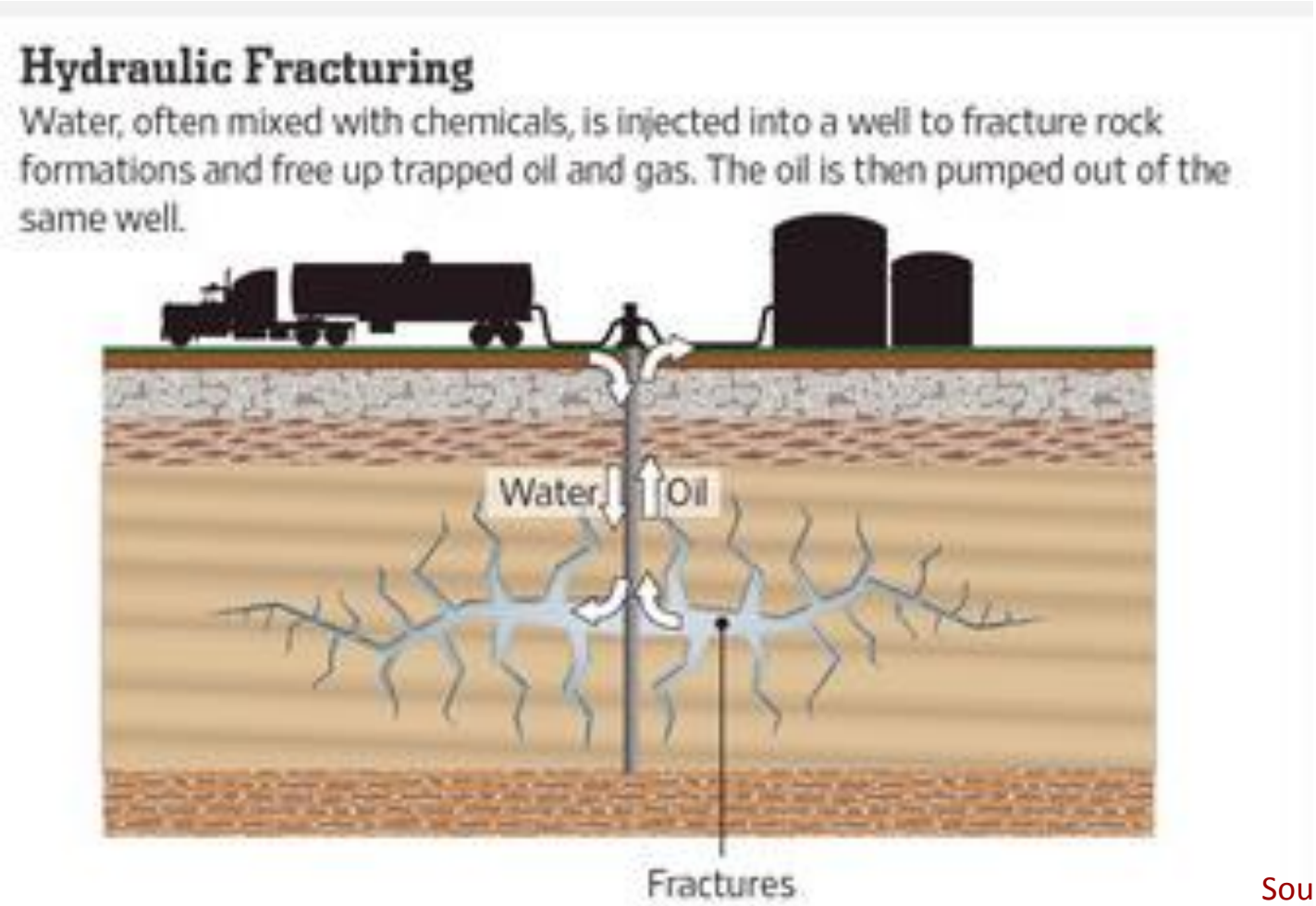
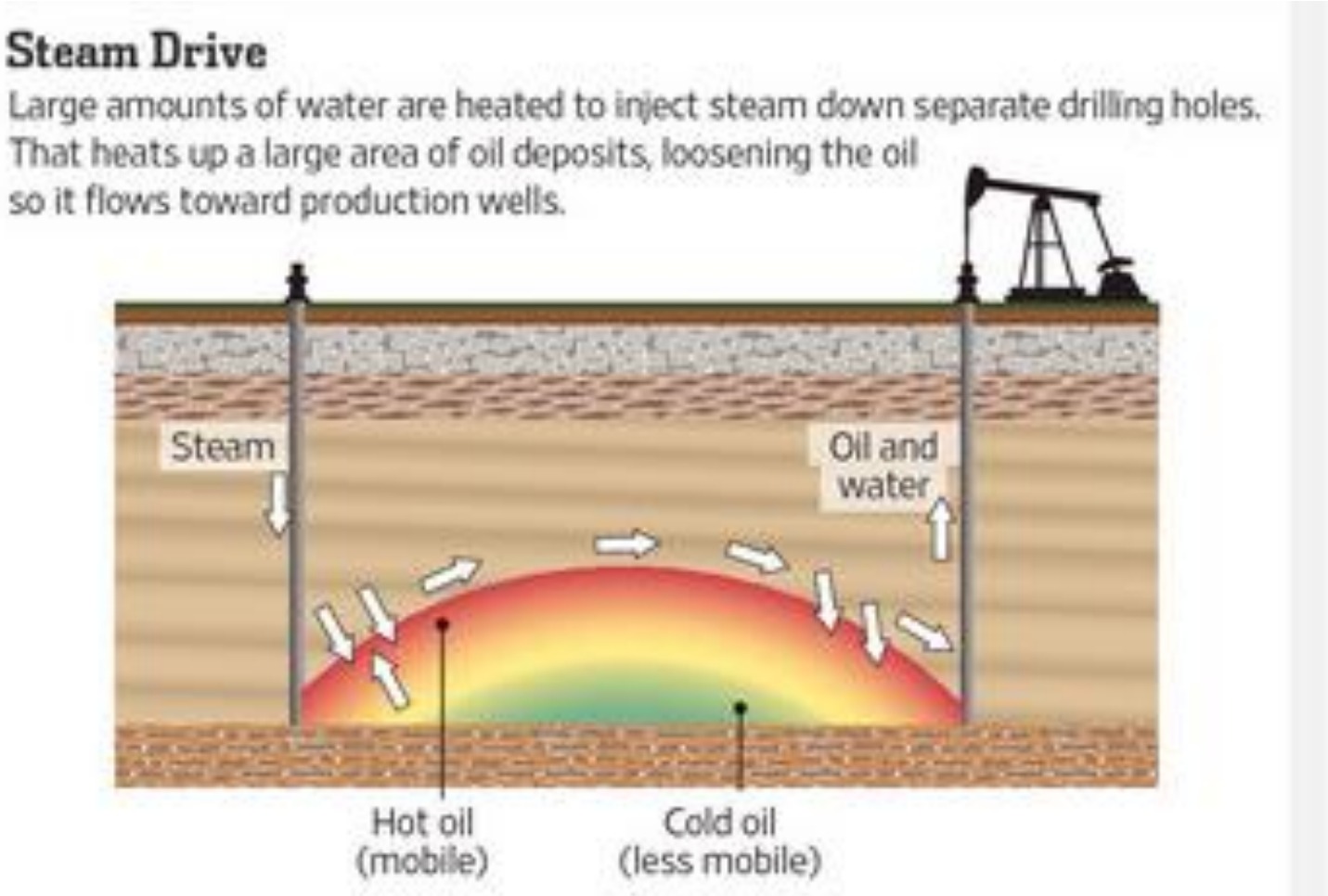


Addressing Monterrey Shale Development Challenges



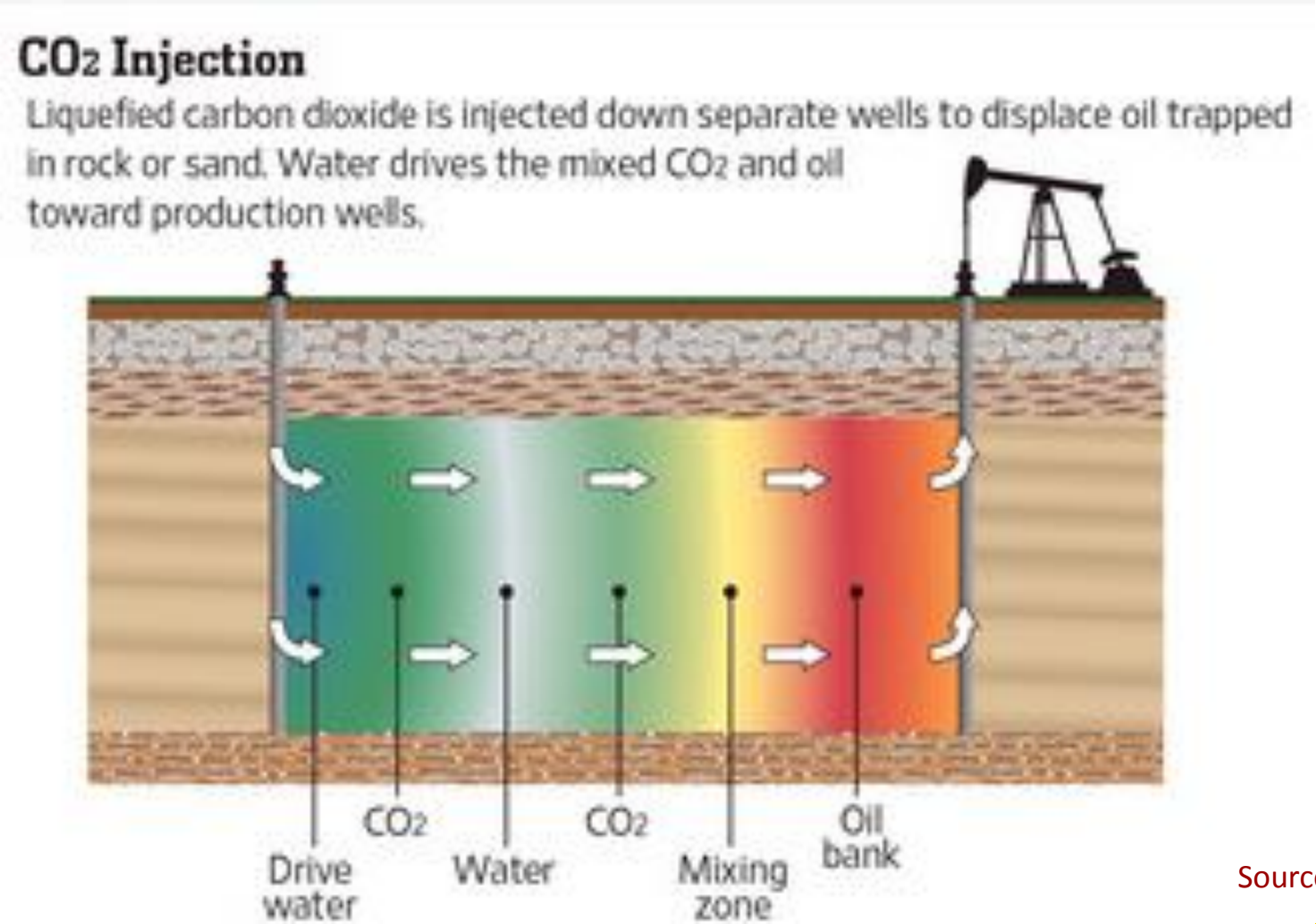
Source: DOE

Addressing Monterrey Shale Development Challenges



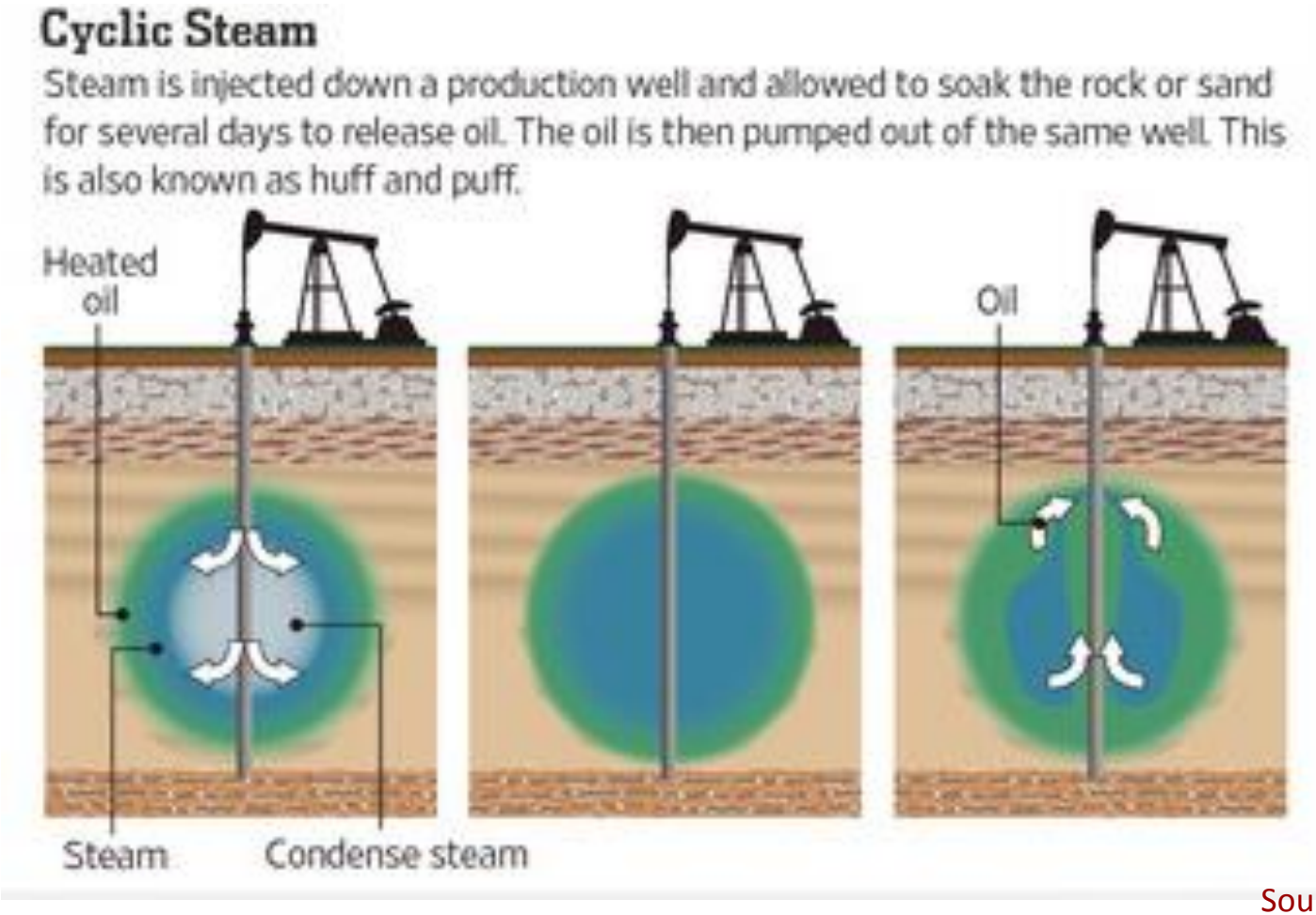
Source: Total S. A.

Addressing Monterrey Shale Development Challenges



Source: NETL

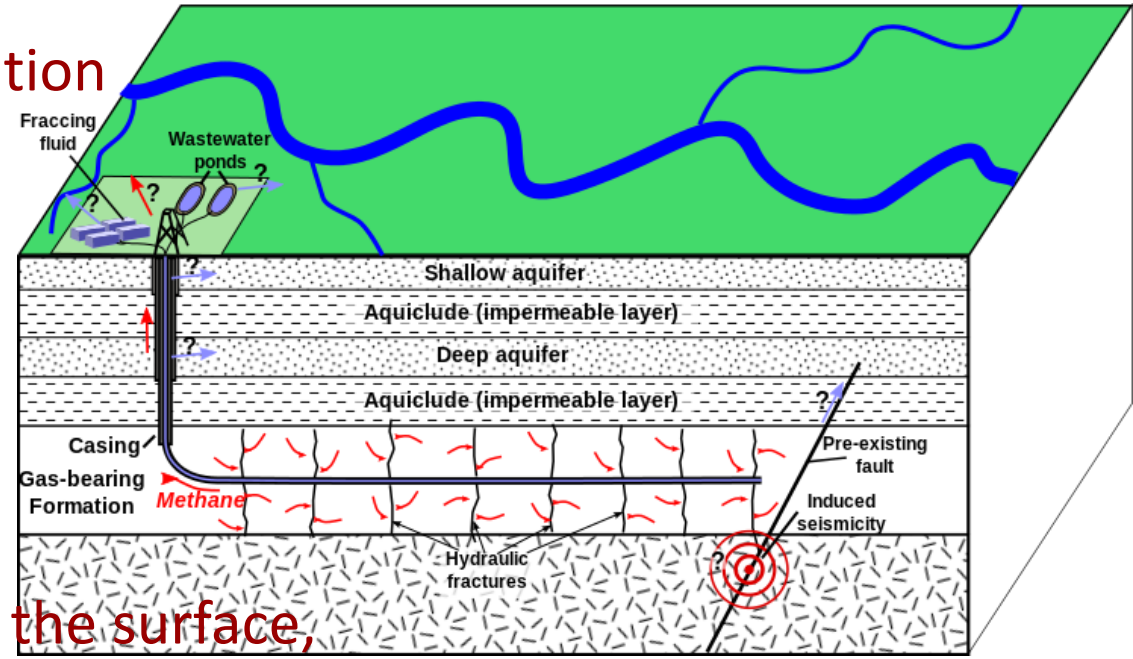
Addressing Monterrey Shale Development Challenges



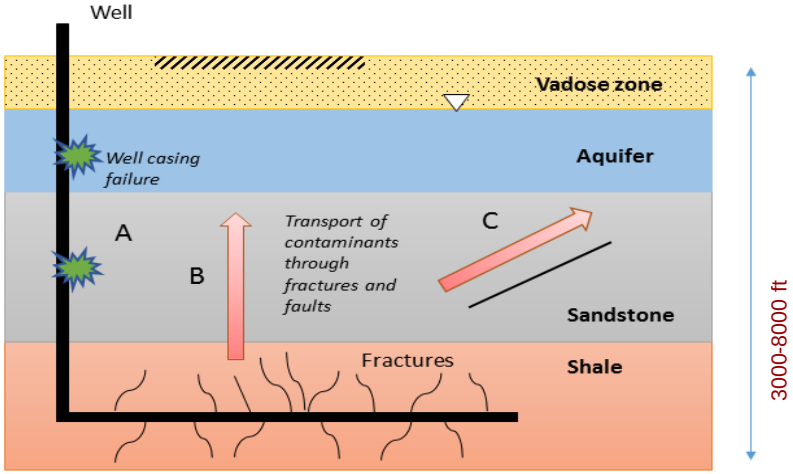
Source: Schlumberger

Potential Environmental Impacts / Risk Factors

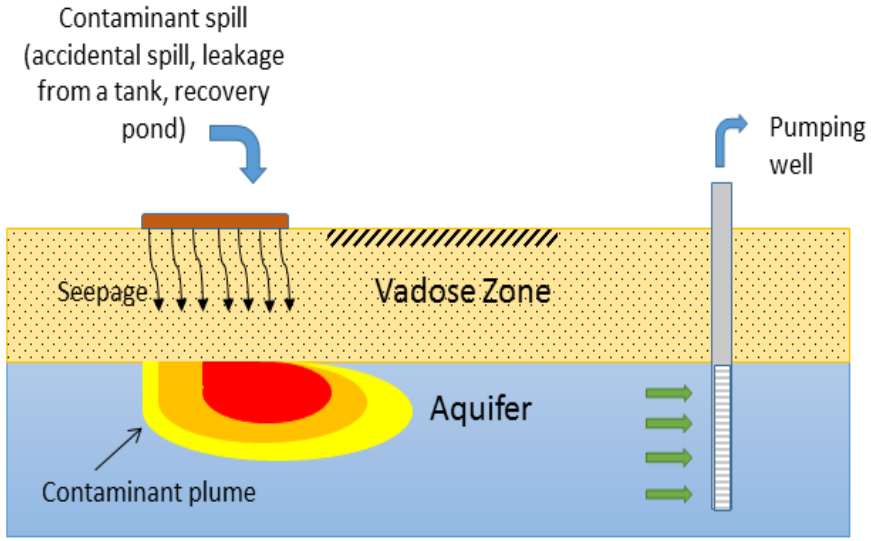
- Ground Water Contamination
- Depletion of fresh water
- Risks to air quality,
- Induced Seismicity
- Emission of gases
- Impact on infrastructure
- Migration of chemicals to the surface,
- Surface contamination from spills and flow-back



Examples of Groundwater Contamination



Multiple contaminant pathways stemming from the subsurface. The HF fluid and other contaminants can travel toward groundwater aquifer through failed well casing (A), fractures (B), and faults (C).



surface to aquifer contamination pathway

Rupture in the well! Contamination of the aquifer.

Spill in the ground surface! Contamination of the vadose zone and the aquifer.

Monterey Shale Study

GEN

Global Energy Network

University of Southern California

The Monterey Shale & California's Economic Future

March 2013

http://gen.usc.edu/assets/001/84954.pdf

USC Viterbi School of Engineering

GEN ISC University of Southern California

Objectives of the Economic Impact Studies

- Estimate the ***macroeconomic impacts*** of *unconventional oil* drilling in California's Monterey Shale
  - Develop a state of the art economic impact method
  - Apply it to reasonable development scenarios

- Contribute to the ***informed dialogue*** on this emerging issue
  - *Caveat*: Exploratory study and preliminary results => warrant further study
  - We've addressed *only one dimension*; need to examine: environmental, seismicity and land use issues
  - We are stimulating broad range of research

Energy Background

- Oil production in CA fell by 47% from 1985 to 2010
- While CA has been a leader in conservation, still projected to need twice as much energy in 2050
- Where will energy come from? Foreign or Domestic?
- Shale rock is boosting production of oil/gas in other states
- These trends promote U.S. energy security & the economy
- CA's Monterey Shale has 15.5 billion barrels of oil (2/3 of U.S. shale-oil reserves)
- Monterey Shale could be a foundation for the renewed California economy

Modeling Approach: ARMA Analog

1. Develop an ARMA trend model for CA GDP per capita; use for CA *baseline* forecasts (includes price/quantity effects)
2. Study how GDP per capita responded to enhanced oil drilling in the oil-boom states
3. Select the experience of the most conservative boom (North Dakota *for the years we had all data*, 2000-10)
4. Apply to two California enhanced drilling scenarios
5. Use steps 2 to 4 to estimate *alternative* GDP per capita forecasts for CA
6. Use historic relationships of California GDP per capita to: personal income, employment, and tax collections

Overview of Incremental California Economic Impacts

	Year	Change	% Change
Per Capita GDP ($) Economic activity within the state, divided by the state's population	2015	1,600	2.6
	2020	10,300	14.3
	2025	11,000	13.4
	2030	8,300	8.9
Employment (jobs) Total number of people employed in the state	2015	512,000	2.1
	2020	2,815,800	10.0
	2025	2,652,800	8.2
	2030	1,770,900	4.9
Personal Income ($ millions) Total of all income earned by all people within the state	2015	40,600	2.1
	2020	223,200	10.0
	2025	210,300	8.2
	2030	140,400	4.9
Tax Collections ($ millions) Tax revenue by state, local, & county government	2015	4,500	2.1
	2020	24,600	9.9
	2025	23,200	8.2
	2030	15,500	4.9

Key Economic Impact Results

	Change (Year 2020)	% Change (Year 2020)	Annual Avg % (2020-30)
Per Capita GDP ($)	10,300	14.3%	12.0%
Employment (jobs)	2,815,800	10.0%	7.5%
Tax Collections ($ millions)	24,600	9.9%	7.5%

Economic Implications

- Significant gain to CA economy over 15 years & beyond
- Gains not just in the oil industry but ripple through every sector of the state's economy
  - supply-chain effects in industry
  - stimulus form increased consumer income & spending
- Could result in major in-migration into state
- CA can capture most of these gains if:
  - attract support industries to the state
  - provide educations & training for new jobs

Monterey Shale Development, Pros and Cons

Benefits:

- Create more jobs: 512K to 2.8 million new jobs
- Stimulate economy. GDP up by 2.6-14.3%
- Increase personal income. Up by 2.1-10.0%.
- Boost State revenue. Tax growth $4.5-24.6B

Caveats:

- Exploratory study and preliminary results,
- Warrants further multi-dimensional studies
- Need to examine: environmental issues,
- Need to address technology challenges

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Conclusions

- We expect *large and positive economic impacts* of Monterey Shale-Oil development, but that is *only one aspect* of the issue of shale-oil development in the state.
- Every forecast has to include the *other aspects of Monterey shale development:*
  - *Environmental impact, Regulation*
  - *Technological Challenges*
  - *Development cost and time line*
- At this stage we are not prepared to make policy recommendations.
- We intend our study to contribute to the *informed dialogue* on this important issue in California.

Acknowledgements

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For More Information see:

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