

# Advantages of In-situ Gas Extraction

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MOUNTAIN WEST ENERGY

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# MWE's Oil Shale Strategy

“Those who do not learn from the past are doomed to repeat it.”

[George Santayana]

“I’ve missed almost 9,000 shots. I’ve lost almost 300 games. I’ve failed over and over again in my life. And that is why I succeed.”

[Michael Jordan]

We are fortunate to learn from the failures and build on the successes of the those that have blazed the path.



# Oil Shale Issues

- The quantity of oil shale is well documented.
- Oil from oil shale is technically feasible.
- Critical issues today are economic and environmental.
- Commercial viability requires the following:
  1. Low capital and operating costs.
  2. Fast return on investment (ROI).
  3. Low environmental impact.



# Why in-situ?

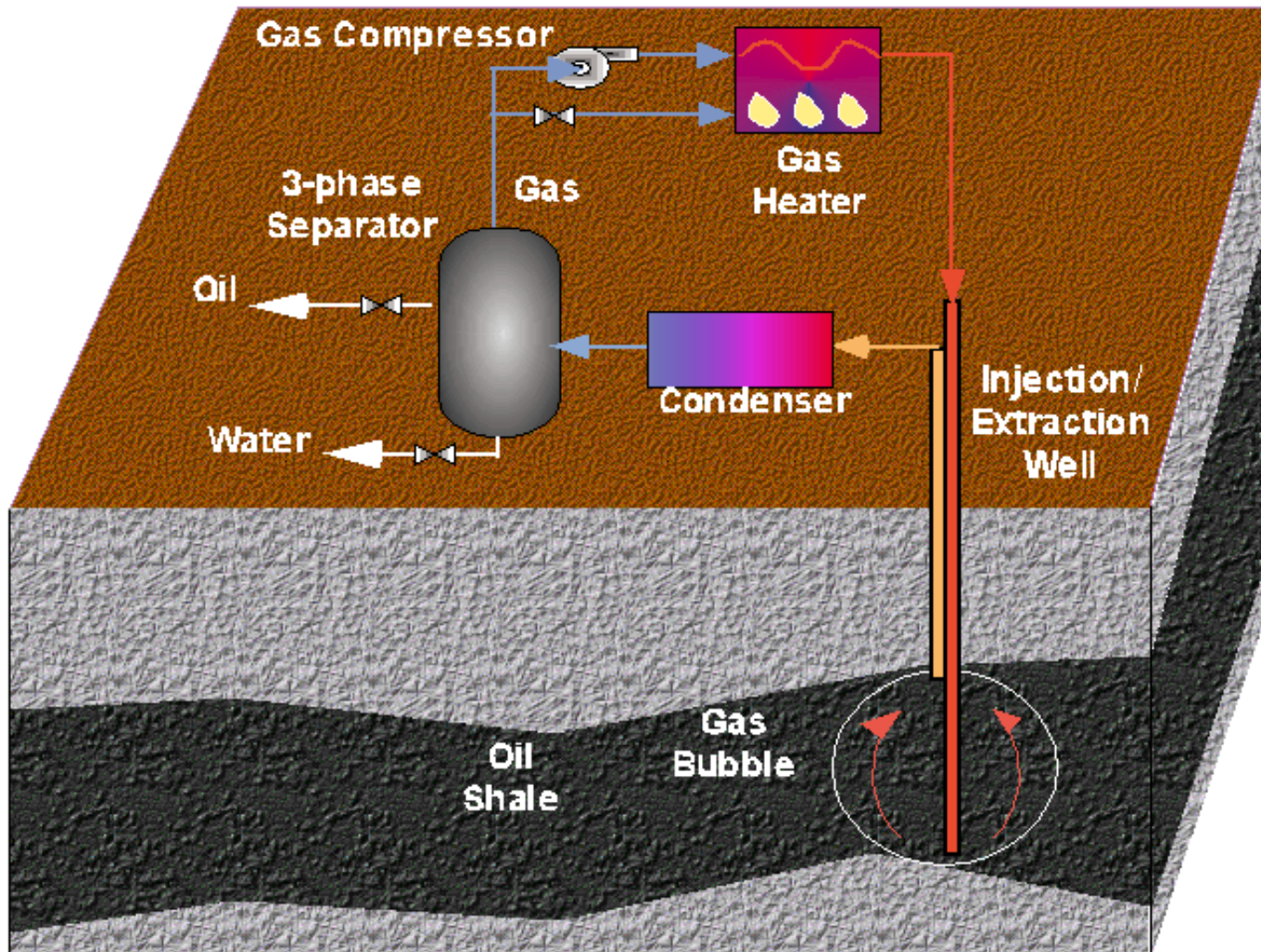
- Lowest cost
- Lowest environmental impact
- Safest

In-situ methods produced 289,000 bbls/day of oil from Canadian oil sands in 2005.

The in-situ conversion process (ICP™) showed us the possibilities for oil shale.



# MWE In-situ Gas Extraction

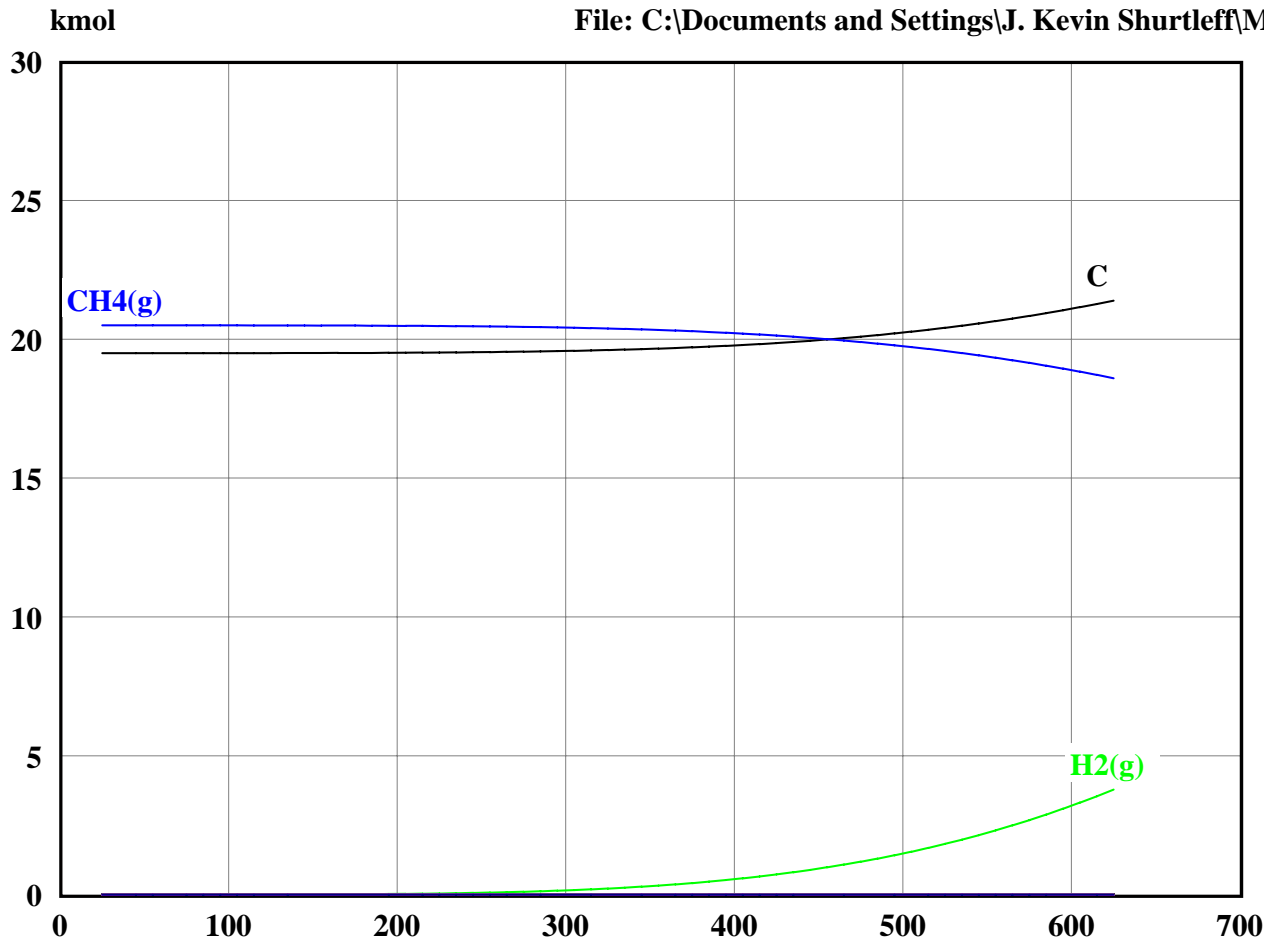


- Closed loop, re-circulating gas.
- Faster heating by convection.
- Oil vapor (not liquid).
- Inverted flow (extraction point above injection point).
- Single well.



# Pyrolysis Thermodynamics

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Thermodynamic equilibrium calculations using HSC (Outokumpu Research).

Pyrolysis of a large paraffin molecule (C<sub>40</sub>H<sub>82</sub>) at 1300 psia.

Pyrolysis is kinetically limited.

Temperature  
C



# Pyrolysis Kinetics

M.D. Lewan and T.E. Ruble,  
Organic Geochemistry, 33,  
(2002), 1457-1475

Slow, low temperature, high  
pressure, natural process  
produces the highest quality oil.

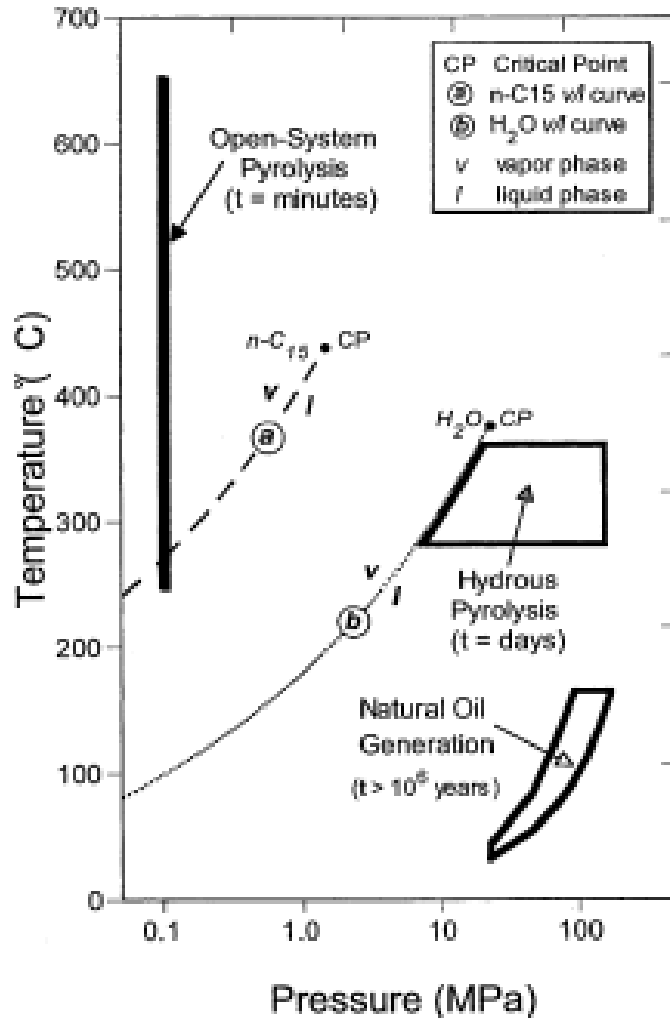


Fig. 19. Temperature-pressure plot showing conditions employed by open-system pyrolysis, hydrous pyrolysis, and natural oil generation relative to the vapor-liquid (v/l) phase curves and critical points (CP) for *n*-pentadecane (a) and water (b).



# Pyrolysis Energy Requirements

- 1 acre of oil shale (235 ft diameter x 100 ft thick)  
= 291,500 tons (long)
- = 168,013 GJ to heat to 350 C with 10% heat loss  
(not including heat of cracking/reaction).
- = 1.95 GW over a day, 2.66 MW over two years,  
1.07 MW over five years.
- = Natural gas cost of ~ \$955,471 (\$6 per mmBtu) or  
electricity cost of ~ \$2,800,209 (\$0.06 per kWhr)
- = Potential to produce ~152,700 bbls of oil (22  
gal/ton).



# Single Well Process

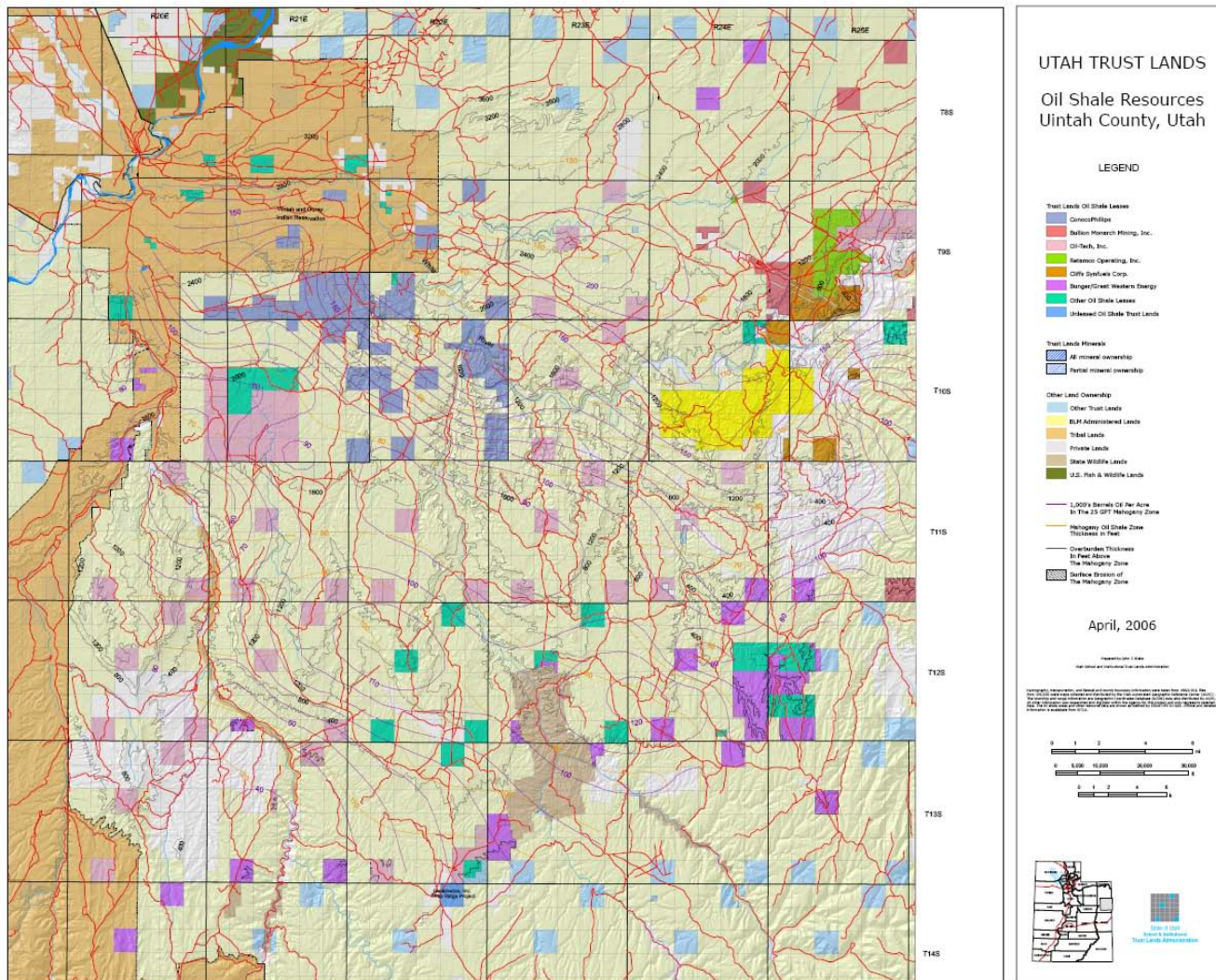
- Low surface impact (chemistry underground).
- Each well covers ~  $\frac{3}{4}$  acre
- Oil extracted over 2 years (fast recovery).
- 60,000+ barrels per well at 50% extraction efficiency.
- Total direct costs for a single well project ~ \$800,000.



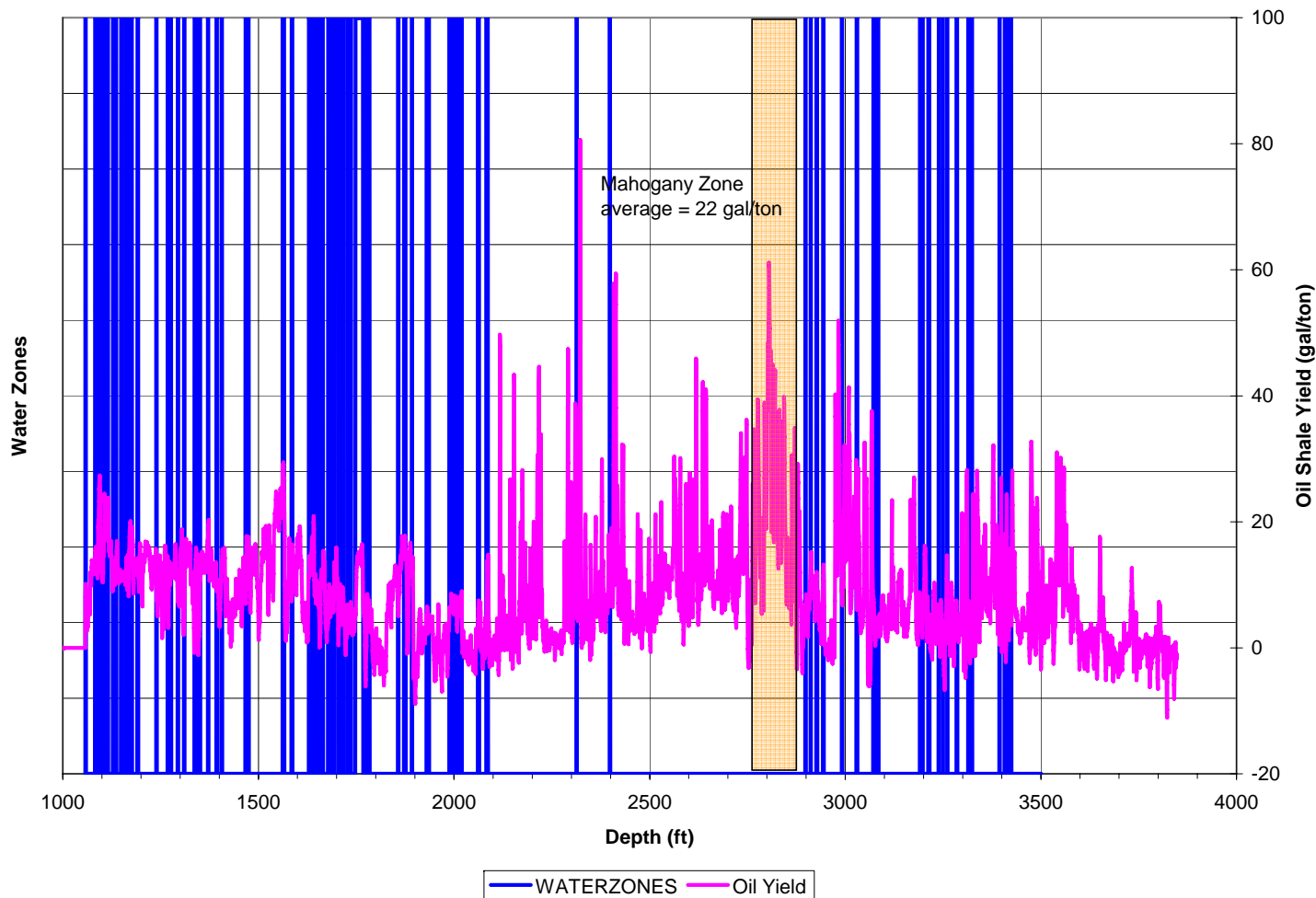
(Illustrative well)



# Why Utah?



# Preventing Groundwater Contamination



Density and sonic log analysis according to John Dyni, et al, USGS Open File Report 91-285.

(Brian Black)



# Environmental Impact

- IGE requires 14 wells to cover a 10 acre plot.

Almost 300 wells, spaced 8 ft, are required to surround a 10 acre plot.

- Natural gas heaters for IGE will produce 9,341 metric tons of carbon dioxide (90% conversion efficiency).

Electric heaters will produce 37,217 metric tons of carbon dioxide from a coal fired power plant (40% conversion efficiency).

- IGE enables heat capture from previously depleted zones, to reduce energy costs and emissions.
- IGE could use solar thermal heating to reduce energy costs and eliminate most emissions.



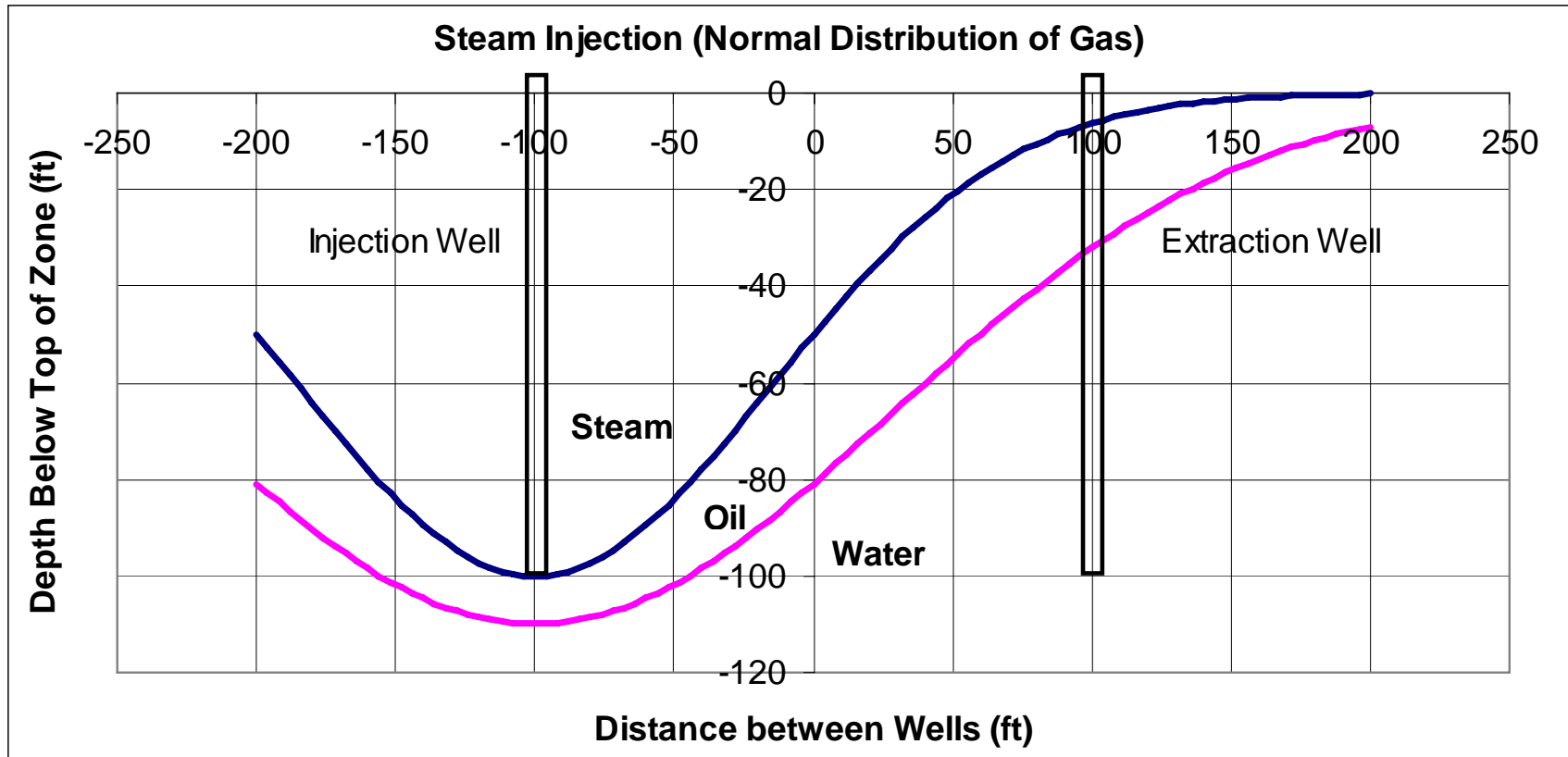
# Why Natural Gas?

- Natural gas is readily available near oil shale deposits in the Uintah Basin of Utah.
- Natural gas produced during pyrolysis can be re-circulated without separation.
- Natural gas produced by pyrolysis can be directly burned to generate heat for the process.

Carbon dioxide would work, but requires additional equipment for separating natural gas from the re-circulating gas.



# Why not steam?

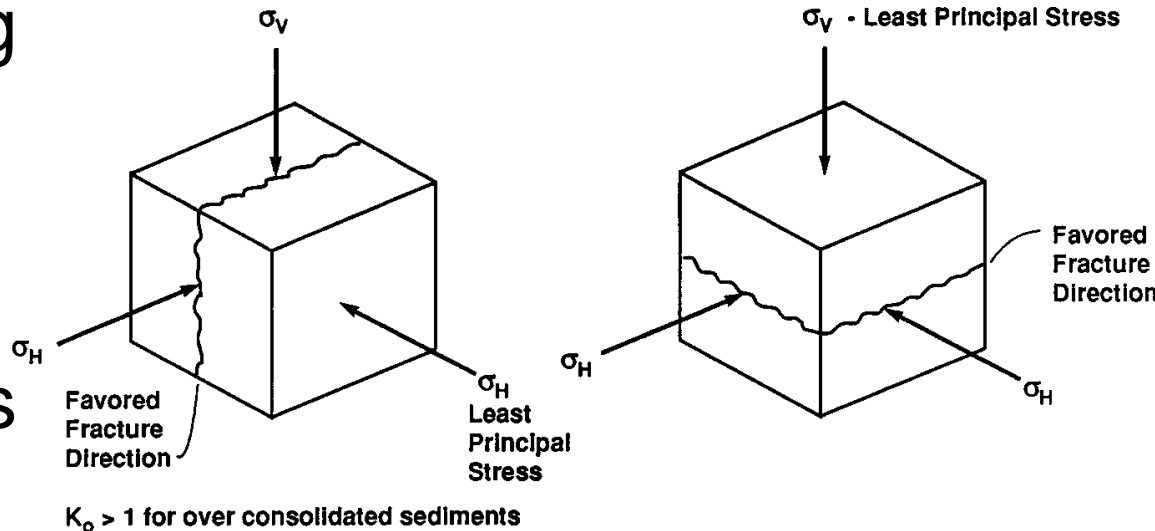


Steam is a better heat carrier (heat of vaporization), but condenses to liquid in the formation. Does the oil float?



# Fracturing for Gas Flow

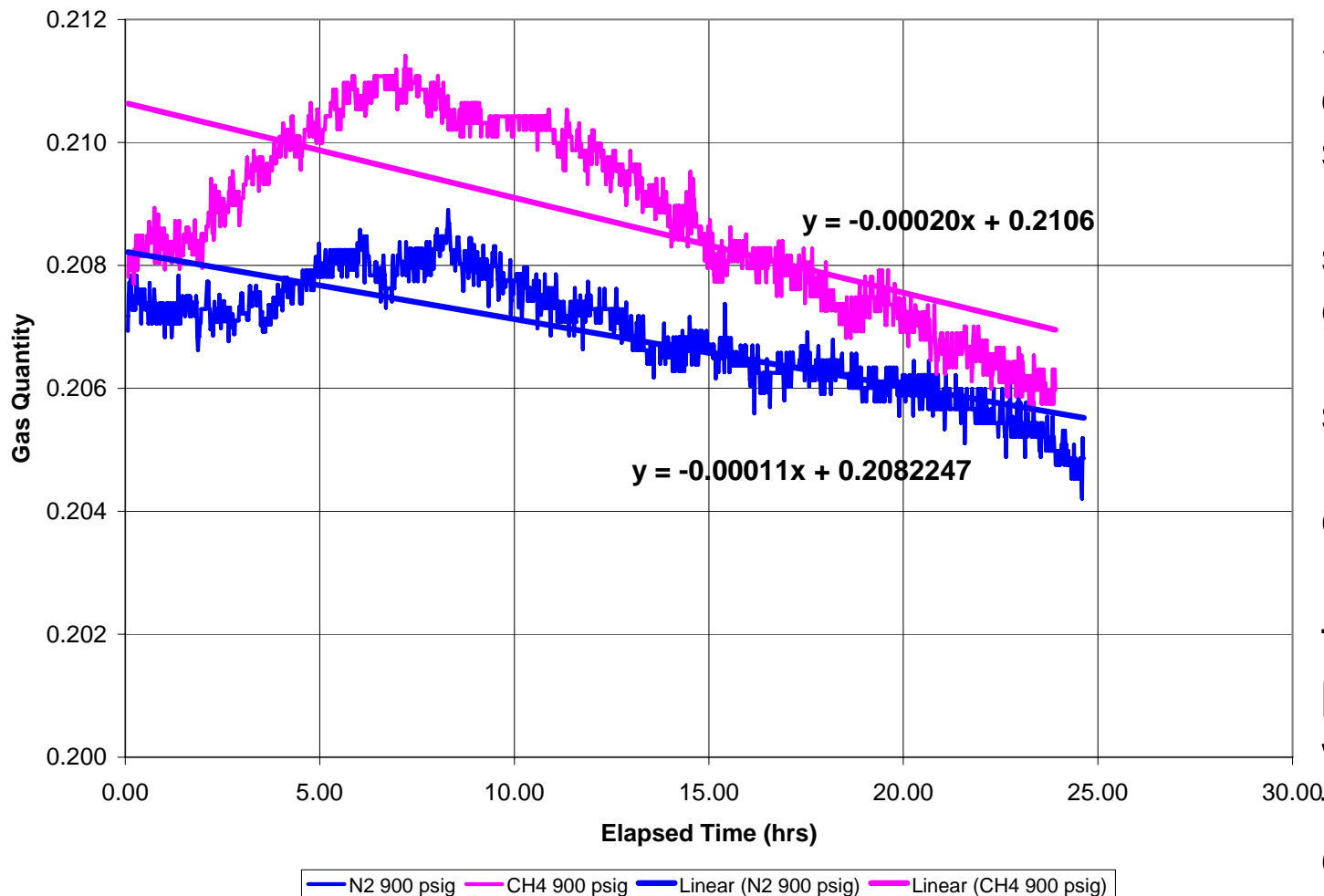
- Thermal fracturing
- Hydraulic stimulation
- Gas Gun™
- High pressure gas fracturing
- Methane solubility
  - No fracturing required?



Fracturing occurs perpendicular the least principal stress. In shallow oil shale formations, this may result in horizontal fractures.



# Methane Solubility in Oil Shale



Slope differences suggests methane solubility is ~2x greater than nitrogen solubility ( non-isothermal conditions).

Test system has been enhanced with constant temperature controller.



# Laboratory Scale System



- Functioning system.
- Parameters
  - 1.8 kg of Utah oil shale
  - 99% recirculating methane
  - Gas temp. = 350 - 400 C
- Results
  - 0.11 kg of oil (6 wt%)
  - API gravity 18-21
  - Sulfur content 0.5-1.0 wt%
  - Wax content 3.9 wt%
  - Hydrogen/Carbon ratio 1.6  
(Conventional oil = 1.9)
- Experimentation is on-going



# RMOTC Project

Naval Petroleum Reserve #3,  
Teapot Dome, Shannon  
Formation

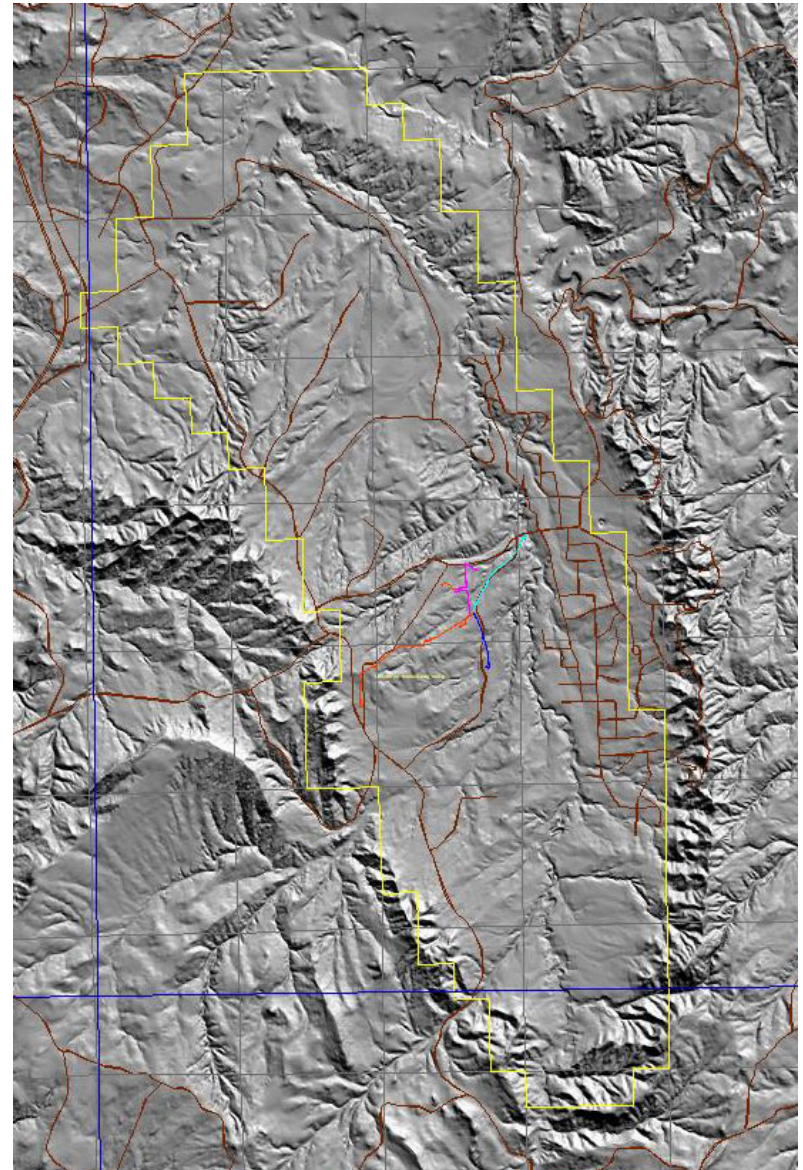
Phase 1 – gas flow testing

Phase 2 – heating and oil  
extraction

Starting Fall 2007



U.S. Department of  
**ENERGY**  
Fossil Energy Program



# MWE's Competitive Advantages

- Lowest capital and operating costs.
- Scalable by replication.
- Faster return on investment.
- Marketable oil without upgrading.
- Low environmental impact.
- Five patents in process.



(Low cost truck mounted rig)



# Acknowledgements

- Brian Black - RMOTC
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# Questions

