

Chevron's Plans for Rubblization of GROS for Chemical Conversion



**Mark D. Looney, Greg Minnery, Robert Polzer, Keita Yoshioka
Chevron U.S.A.**

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Outline

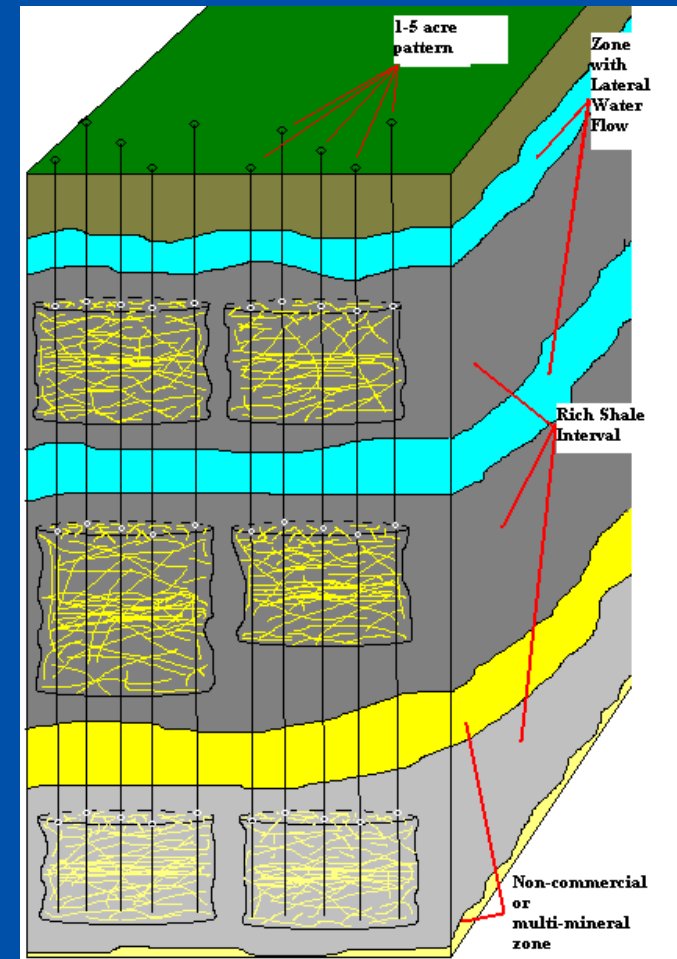
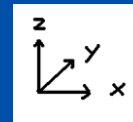


- Background
- Tech development plan
- Containment methods
- Potential methods and approaches
- Overview of intermediate testing
- Summary

What is Rubblization? Why do we need it?



- For our purposes, rubblization is breaking a zone of reservoir into discrete chunks of rock. In other words, generating fractures in the x,y, and z planes
- Adjacent aquifers and fractures can limit the amount of surface area generated by conventional fracturing. Rubblization can provide the high surface area needed for our conversion chemicals within a compact zone.



Rubblization Tech Development Plan



- Build simulation tools – complete
- Testing in lab/boulders to verify models - in progress – ETA July, 2012
- Refine models
- Design larger scale testing
- Conduct larger scale tests – ETA Dec 2012
- Refine models
- Choose rubblization method for lease – ETA May 2013
- Design implementation at RD&D lease
- Conduct rubblization on lease – ETA fall 2013
- **Verify containment**
- Conduct conversion phase – ETA early 2015

Potential Methods for Verifying Containment



- Micro-seismic and tiltmeter analysis during stimulation
- Injection/pressure pulse testing
 - Monitor pressure in adjacent wells in multiple zones
- Tracer testing
 - Before and during testing
 - Possibly some new techniques
- Groundwater monitoring wells
 - Before and during testing
- We anticipate a combination of methods will be used

Potential Rubblization Methods



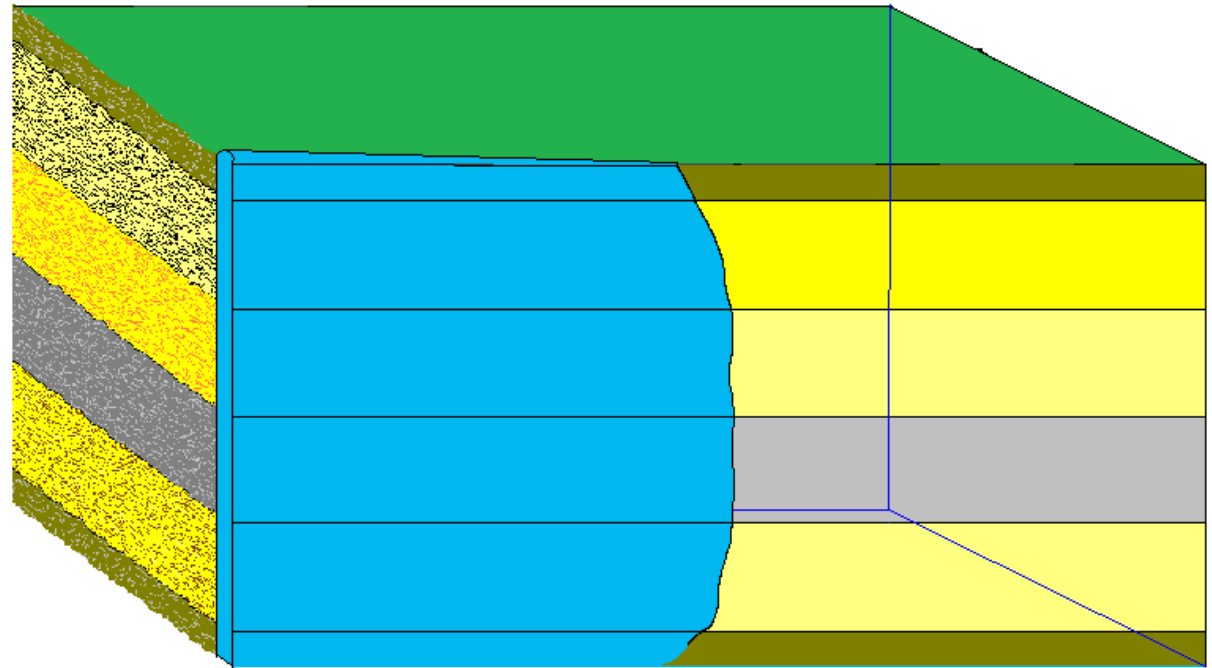
- Thermal
 - Rock shrinks when cooled. Extreme cooling will cause it to go into tension (vs. its normal state of being in compression)
 - The rock is weak in tension
 - The coefficient of thermal expansion varies with layers, resulting in varying amounts of shrinkage, and shear stresses which aid rubblization
 - A large amount of cooling is needed
 - Some control over where the cooling is done
- Explosive
 - Timed explosives to generate “constructive interference”
 - Drilling intensive
 - Control over height and direction. Ability to “generate shapes”

Thermal Rubblization Process

Initiating a fracture



- **Initiate a “conventional” fracture, using water or liquefied gases (liquid CO₂ or N₂)**
- **Need to create surface area in basically impermeable reservoir**

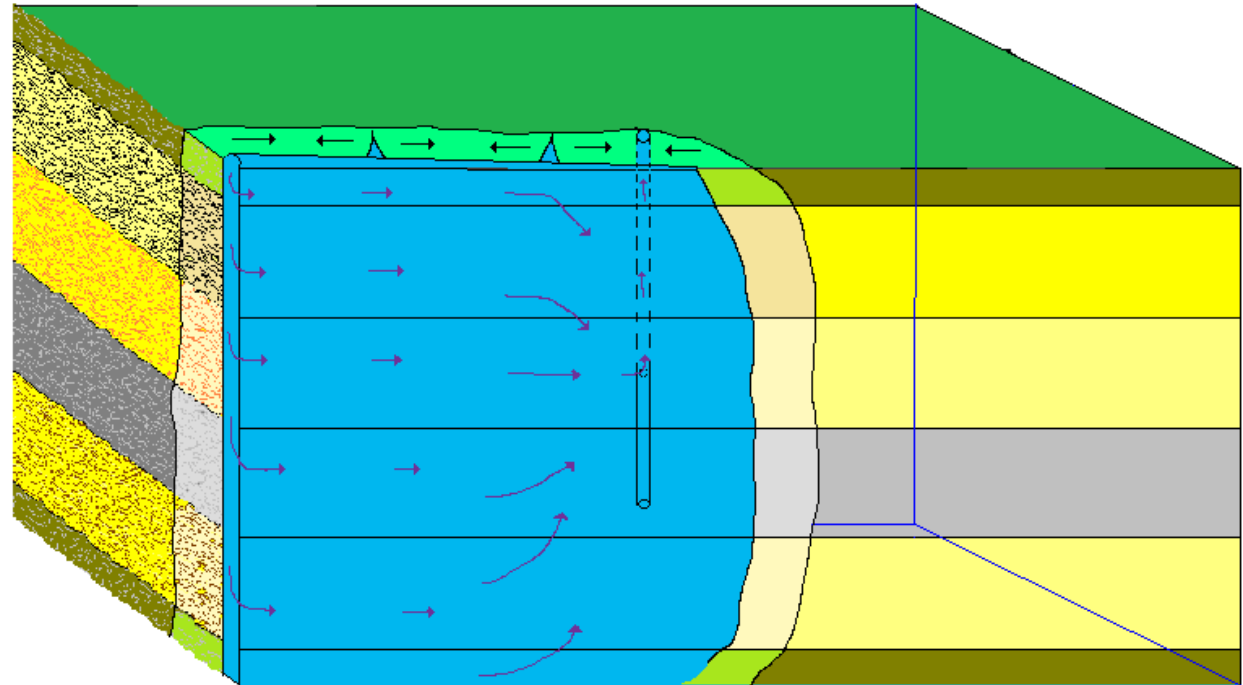


Thermal Rubblization Process

Intersecting Fracture and Circulating Cold Fluids



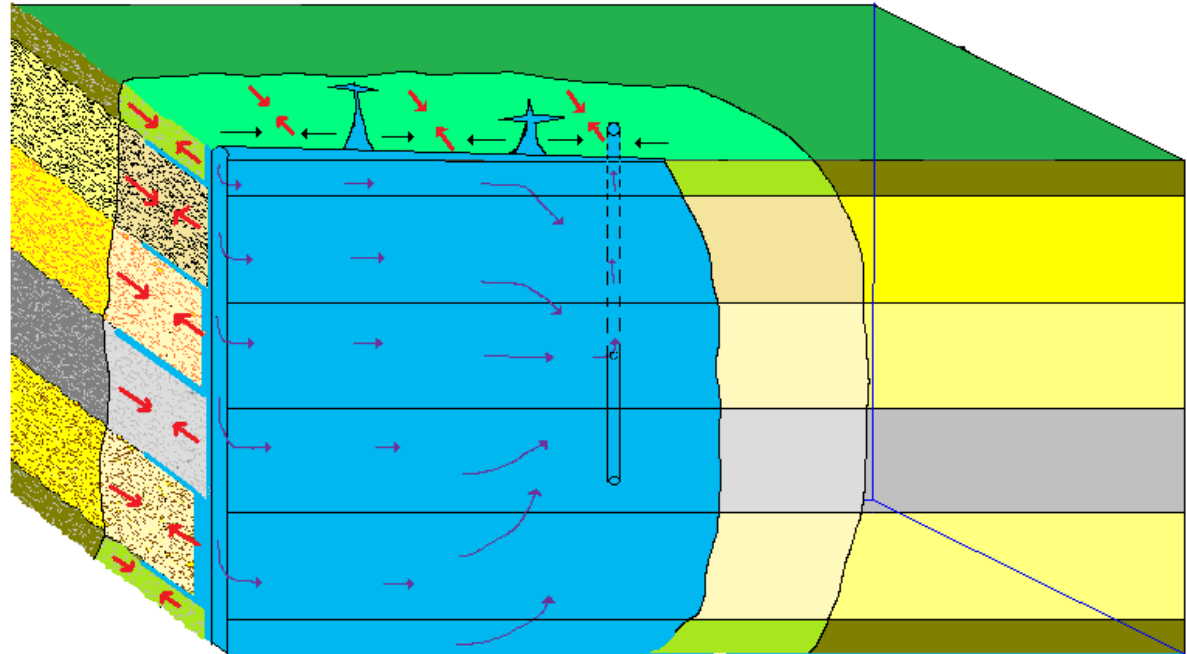
- **Drilling a deviated hole to intersect fracture and initiate circulation of cold fluids**
- **As the rock cools, it shrinks, creating secondary fractures perpendicular to the initial fracture**



Thermal Rubblization Process Creating Tertiary Fractures



- **Circulation continues**
- **As the rock cools, zones shrink by different amounts, creating shear stress and possible horizontal shear failure across reservoir layers**
- **Branches on secondary fractures may also form, eventually generating a connected network of fractures**

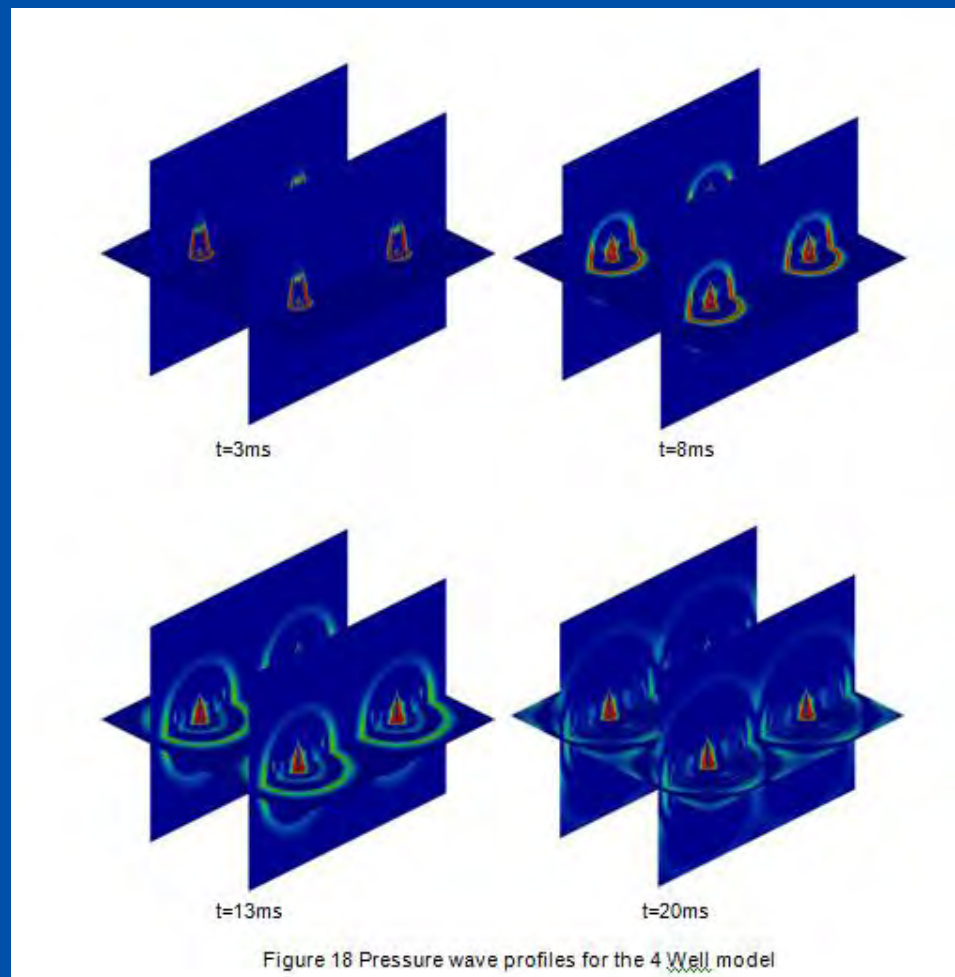


Explosive Rubblization

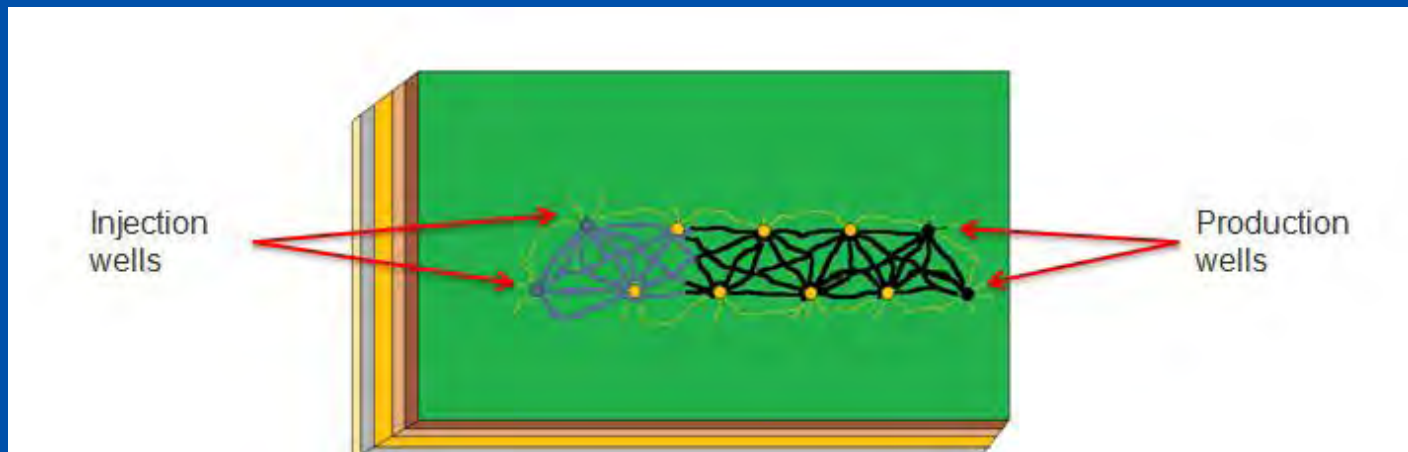
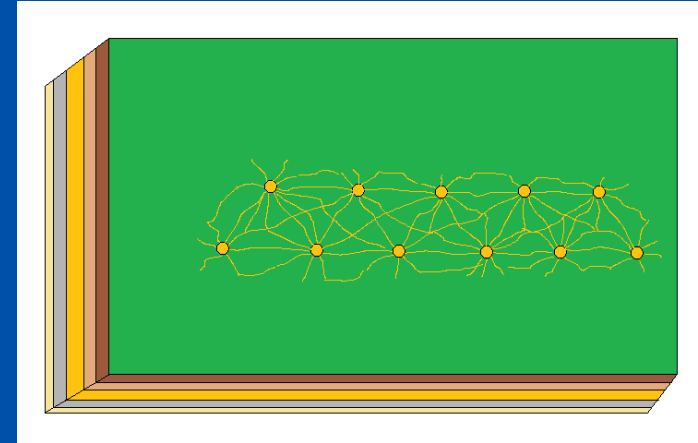
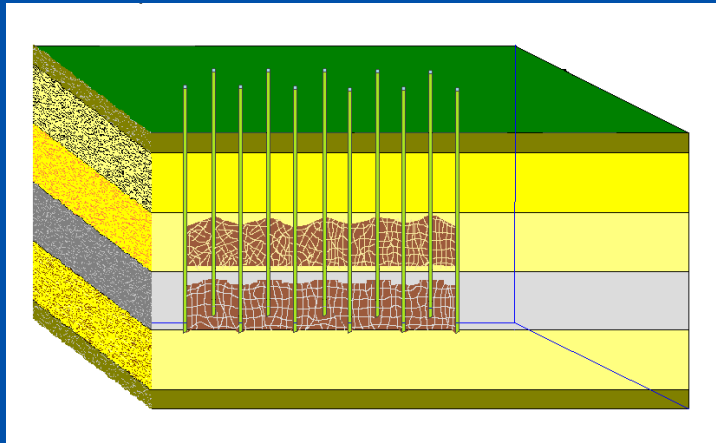


Program Focus:

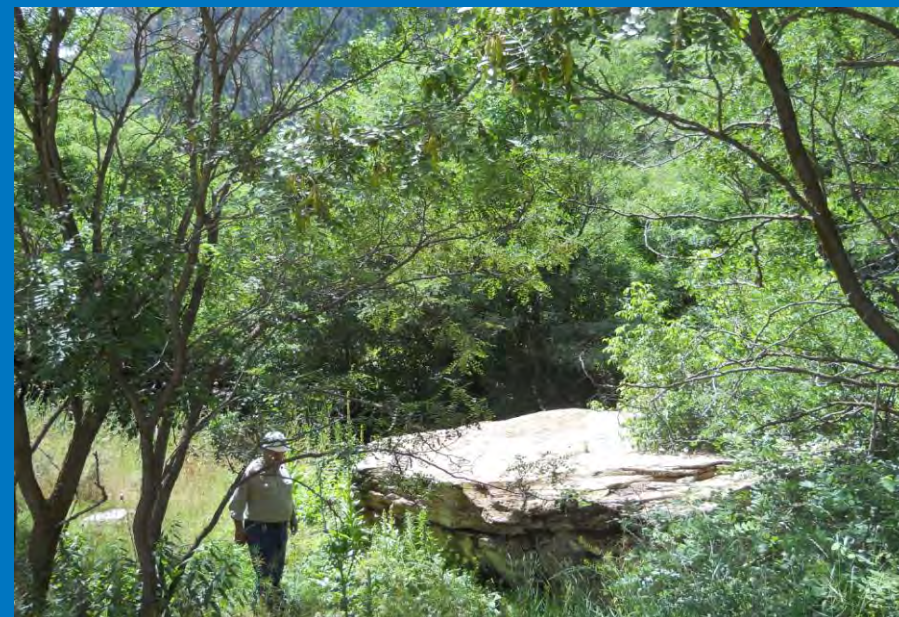
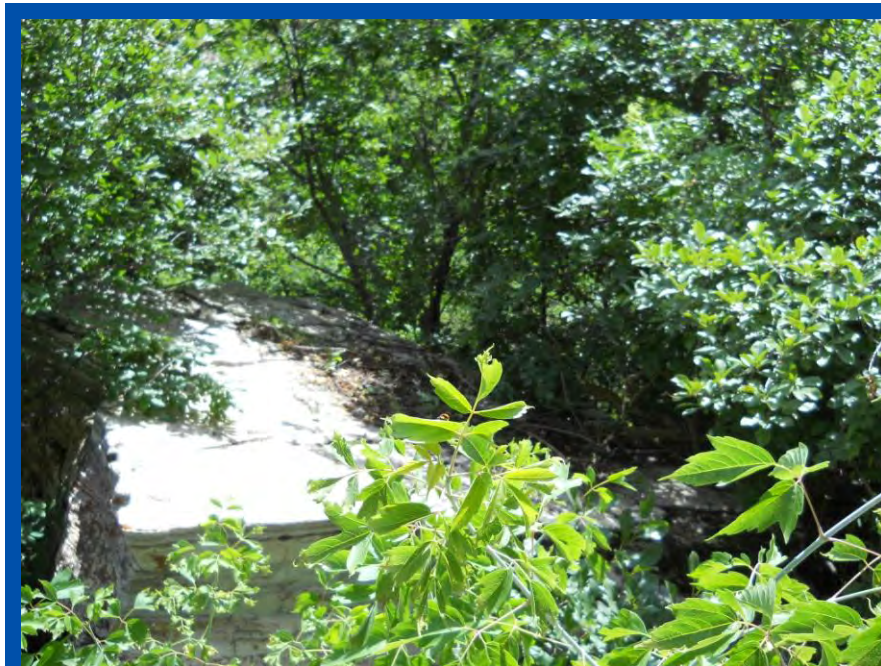
- Timed shot patterns that will generate constructive interference in the reservoir and extend the rubblization zone deeper and more efficiently



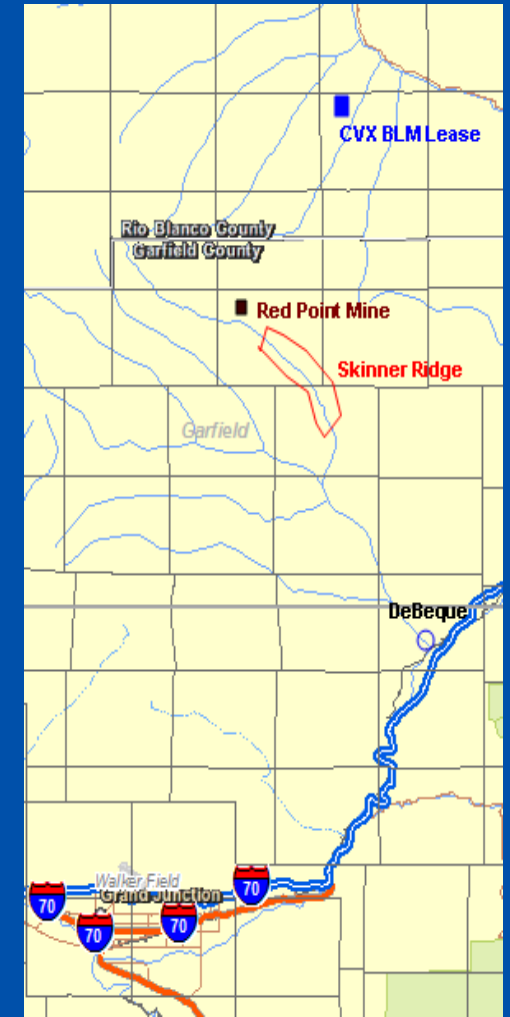
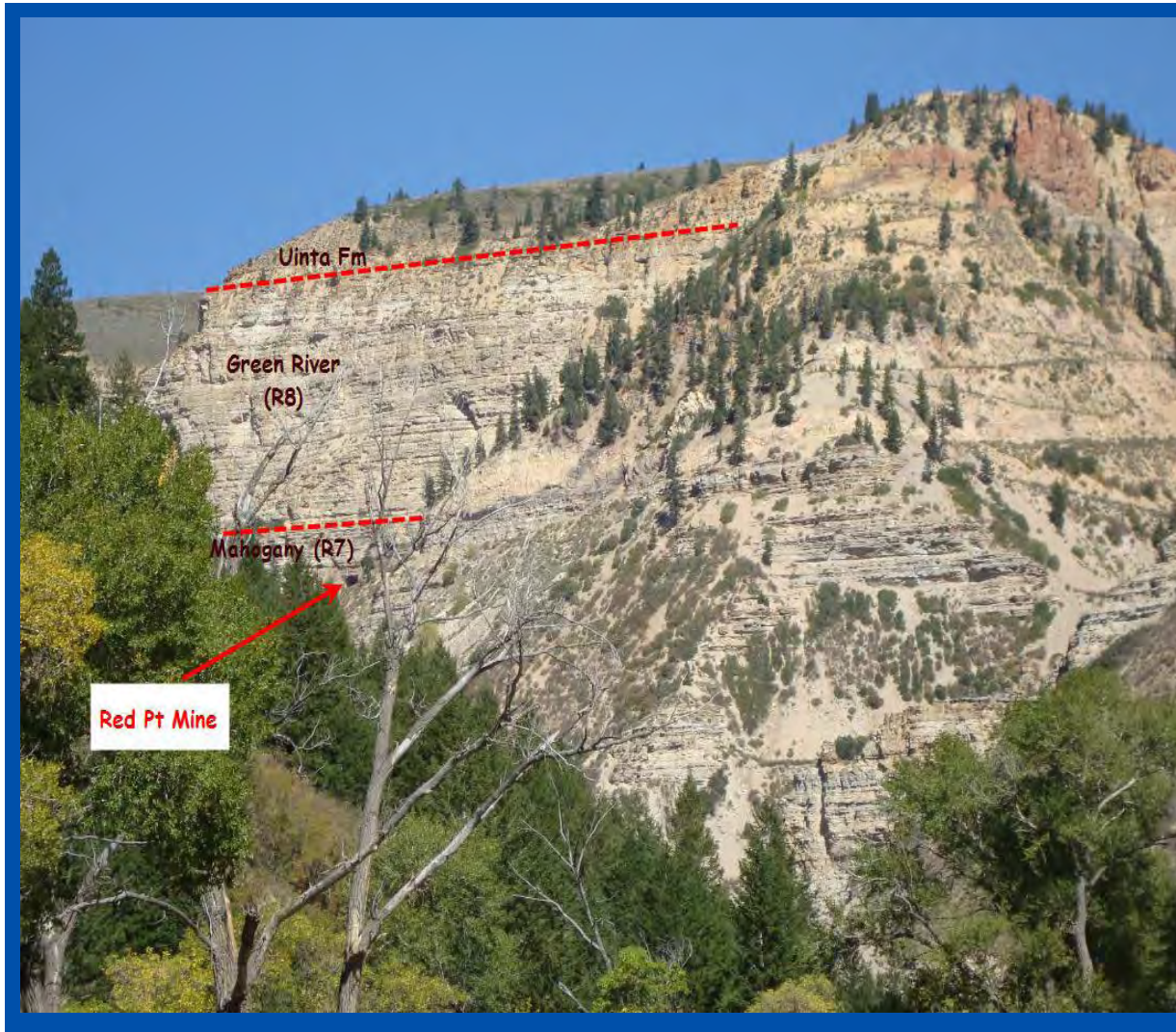
Explosive Rubblization – Potential Approach



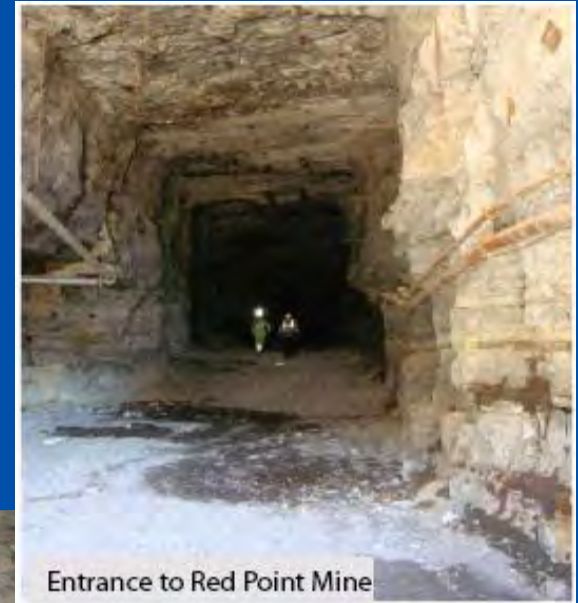
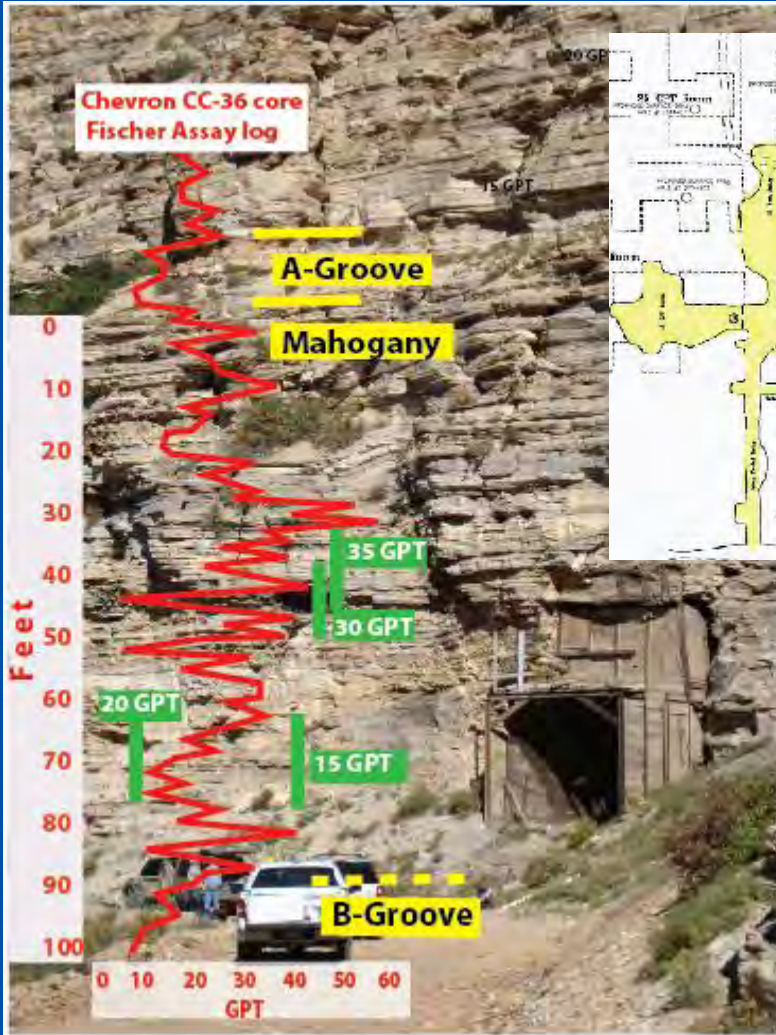
Boulder testing



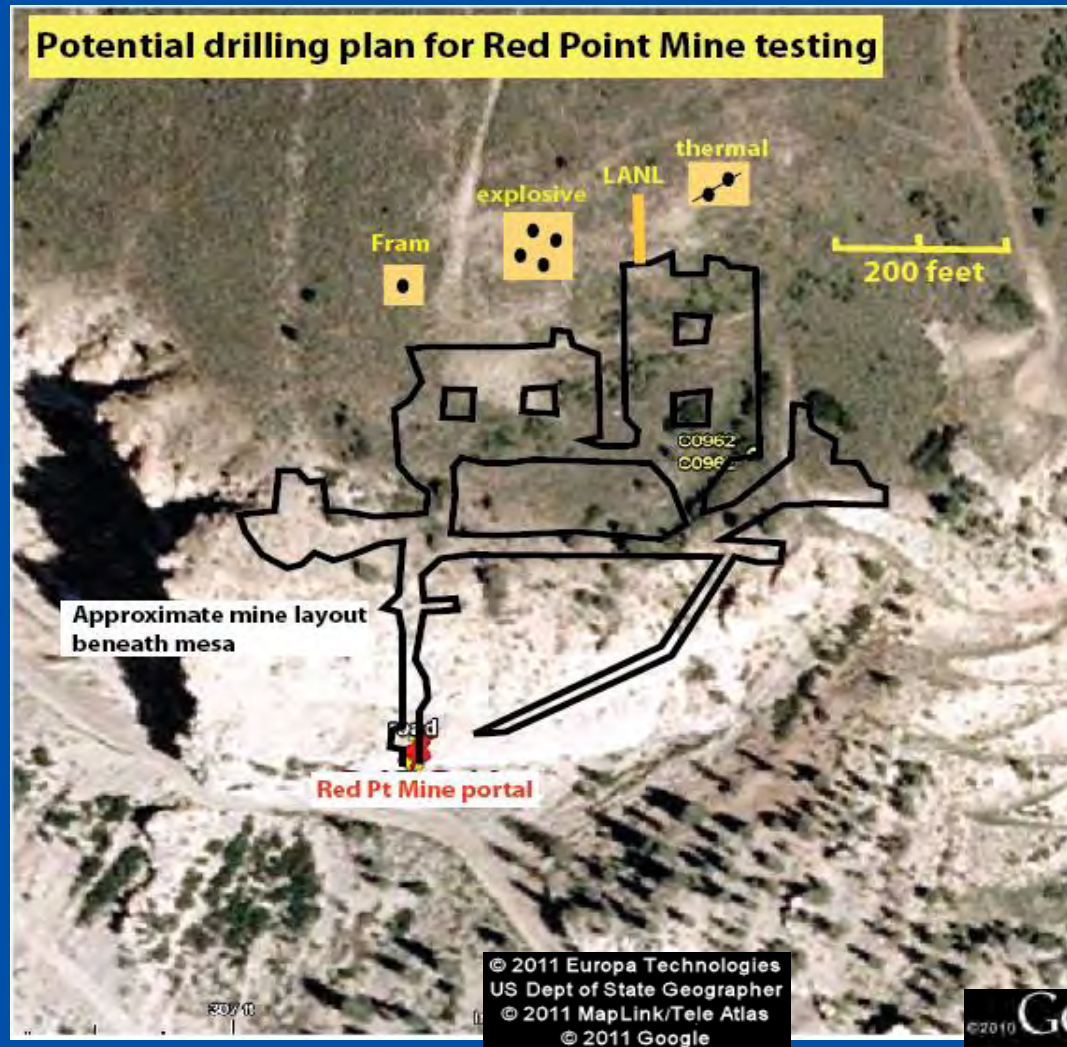
Chevron-ConocoPhillips Red Point Mine



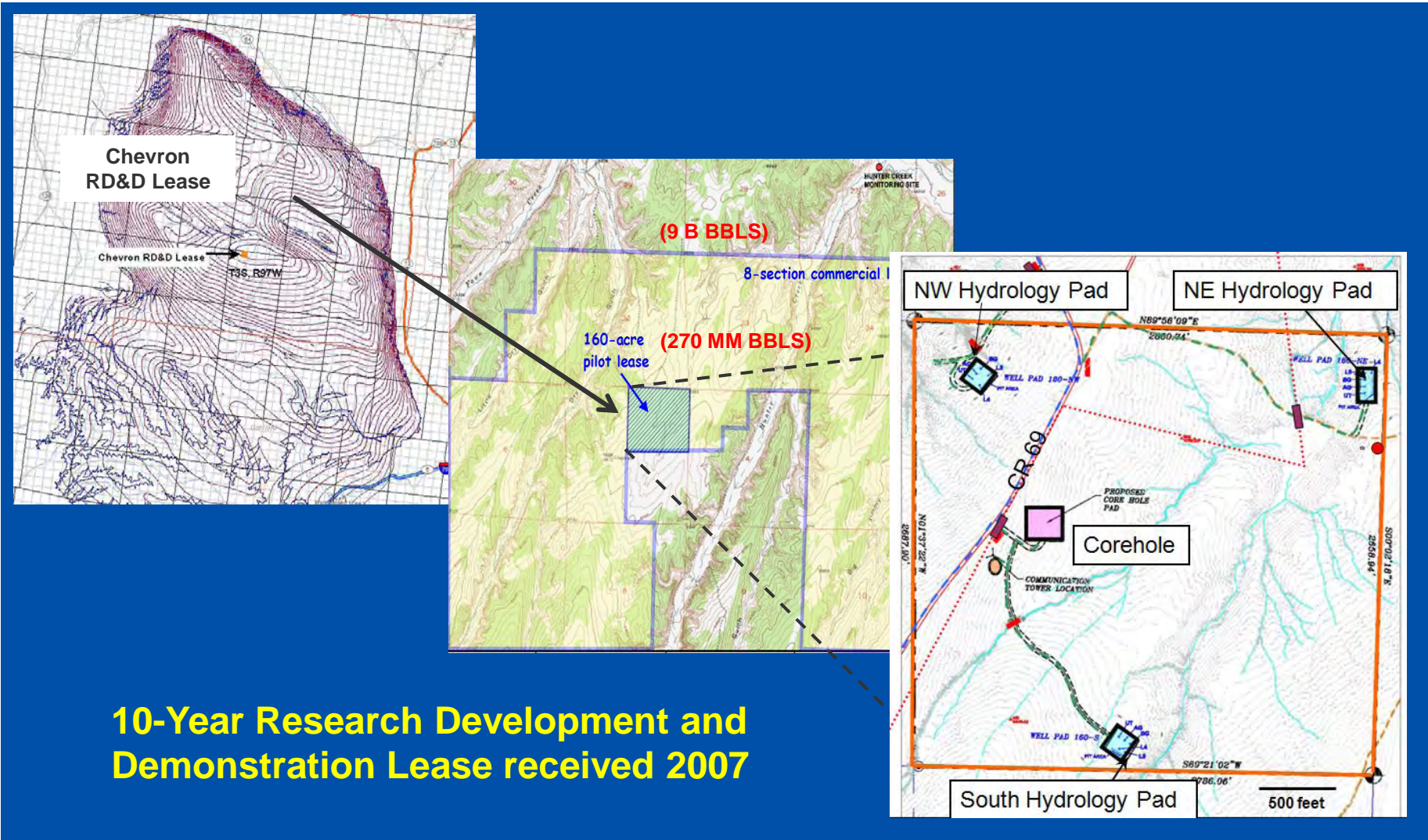
Chevron-ConocoPhillips Red Point Mine



Fracture testing in Red Point Mine



Chevron's Oil Shale RD&D Lease



10-Year Research Development and Demonstration Lease received 2007

Summary



- New stimulation methods are required for oil shale
- These new methods required new simulation tools, and the means to calibrate the tools
- We have made steady progress but are proceeding carefully, with several intermediate steps
- Containment is very important to us, and we will not test the conversion technology until containment is verified.

Questions?

