RPSEA

Research Partnership to Secure Energy for America

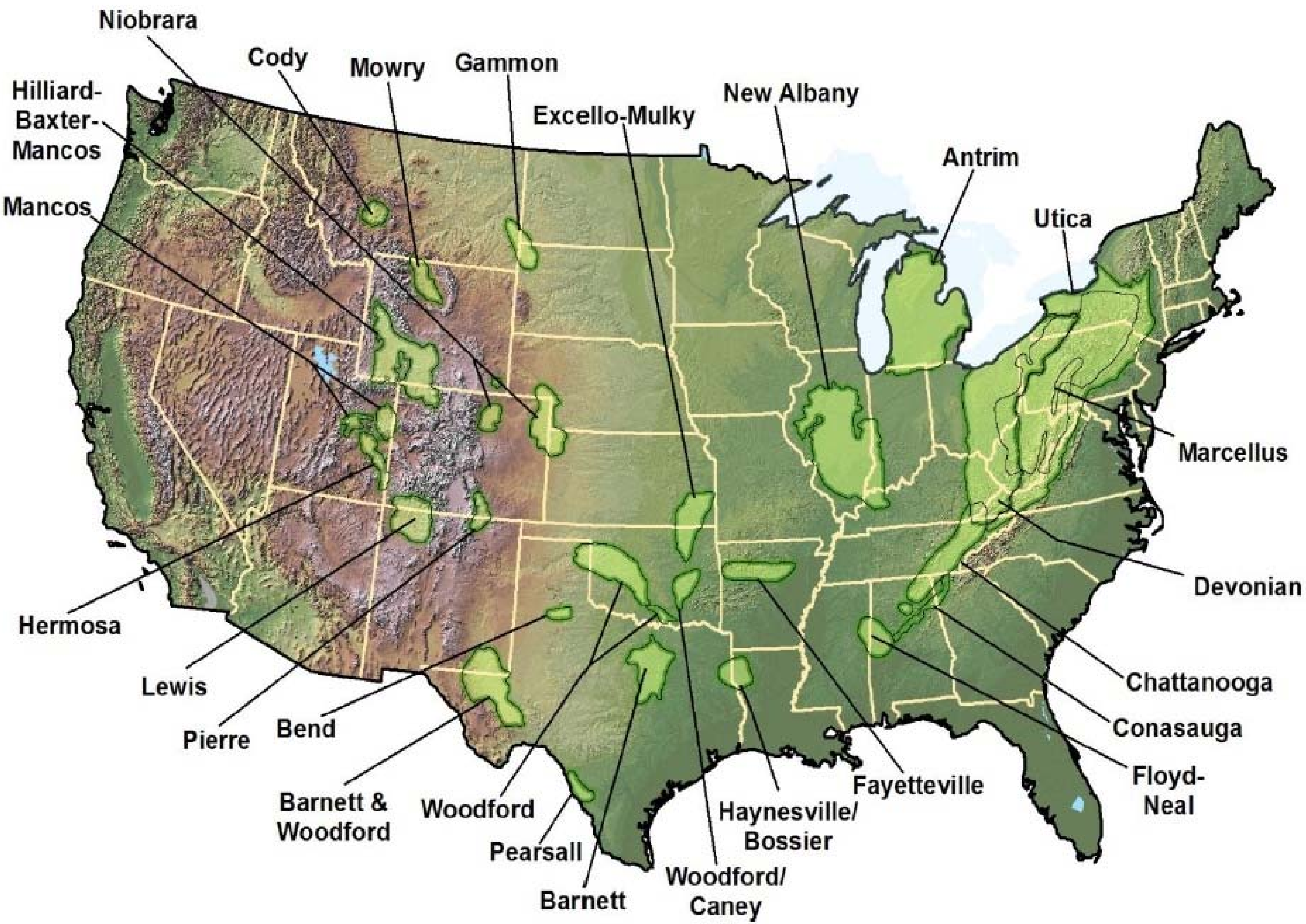
Onshore Programs Update

July 14, 2009

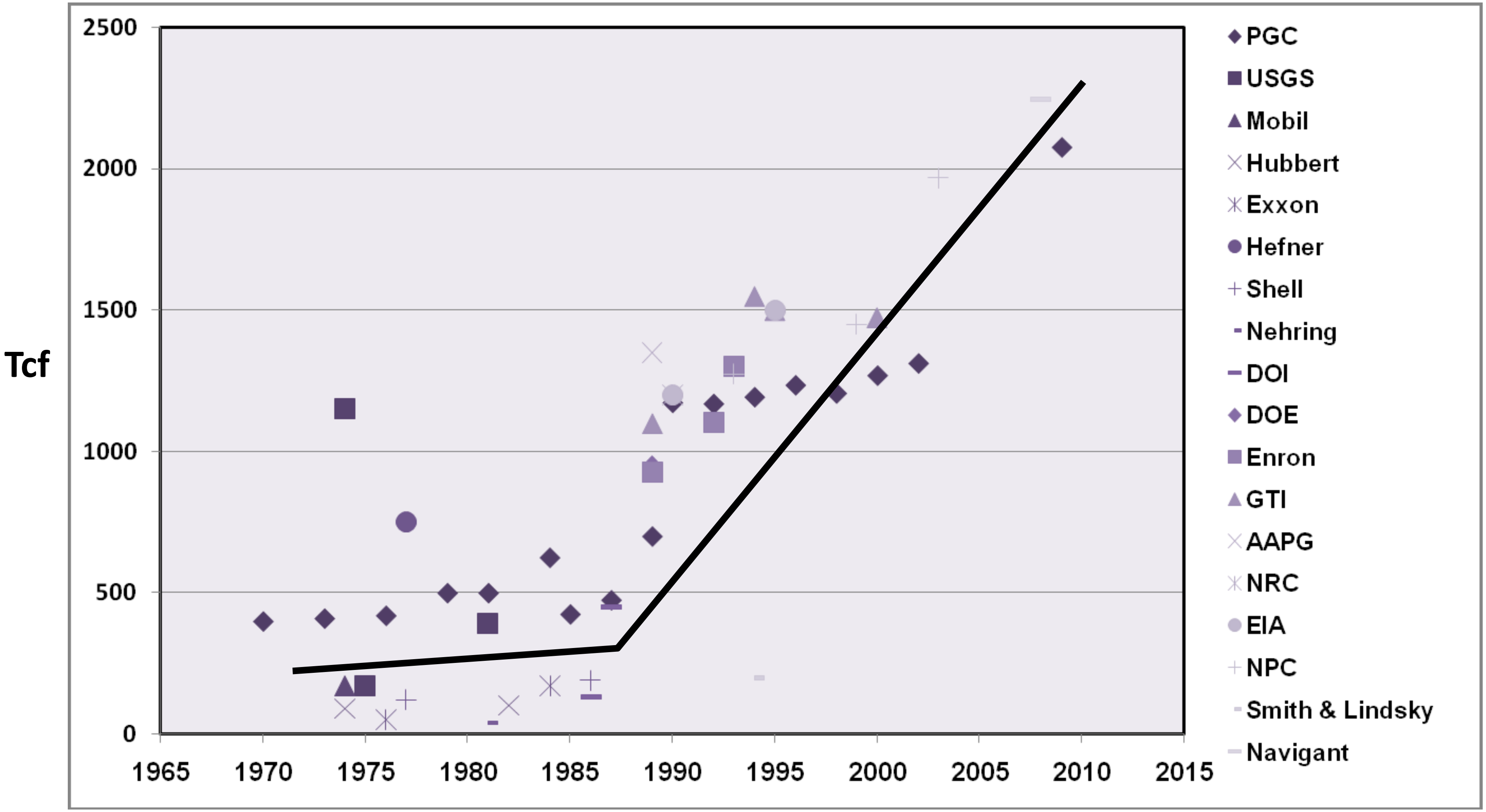
Onshore Programs

- Unconventional Resources
  - Resource Target
  - Approach
  - Status of selected projects
- Small Producer
  - Objective
  - Approach
  - Status of selected projects

U.S. Unconventional Gas Basins



U. S. Technically Recoverable Gas Resource Base - Tcf



Unconventional Gas

- Potential to Impact National, International Energy Supply
  - Abundant
  - Low carbon
  - Suitable for transportation and power generation
- Technical Challenges
  - Cost
  - Environmental impact of development
  - These challenges are closely related

Unconventional Onshore Themes

- Gas Shales
  - Rock properties/Formation Evaluation
  - Fluid flow and storage
  - Stimulation
  - Water management
- Coalbed Methane
  - Produced water management
- Tight Sands
  - Natural fractures
  - Sweet spots
  - Formation Evaluation
  - Wellbore-reservoir connectivity
  - Surface footprint

Cost Reduction in All Aspects of Operations

RPSEA Unconventional Gas Program Components & Approach

Resource Assessment

Drilling

Exploration Technologies

Stimulation & Completion

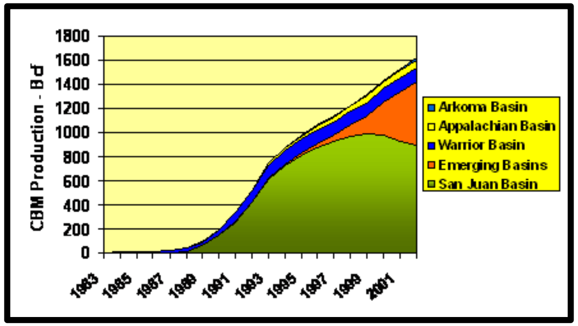
Reservoir Description & Engineering

Environmental & Water Management

Integrated Basin Analysis

Technology Dissemination

Impact By Geologic Basin and Unconventional Resource



e.g., CBM

	CBM 10%	Gas Shales 45%	Tight Sands 45%
Integrated Basin Analysis	🟧	🟩	🟨
Drilling	🟧	🟩	🟩
Stimulation and Completion	🟨	🟩	🟩
Water Management	🟧	🟨	🟨
Environmental	🟨	🟨	🟨
Reservoir Description & Management	🟧	🟩	🟨
Reservoir Engineering	🟧	🟩	🟩
Resource Assessment	🟧	🟧	🟧
Exploration Technologies	🟧	🟩	🟨

🟩 H	High Priority
🟨 M	Medium Priority
🟧 L	Low Priority

Total Cost to RPSEA

	CBM 10%	Gas Shales 45%	Tight Sands 45%	
Integrated Basin Analysis		New Albany (GTI) $3.4	Piceance (CSM) $2.9	$6.3
Drilling				$0.0
Stimulation and Completion	Microwave CBM (Penn) $.08	Cutters (Carter) $.09 Frac (UT Austin) $.69 Refrac (UT Austin) $.95 Frac Cond (TEES) $1.6	Gel Damage (TEES) $1.05 Frac Damage (Tulsa) $.22	$4.7
Water Management	Integrated Treatment Framework (CSM) $1.56	Barnett & Appalachian (GTI) $2.5	Frac Water Reuse (GE) $1.1	$5.2
Environmental	*	Environmentally Friendly Drilling (HARC)* $2.2	*	$2.2
Reservoir Description & Management		Hi Res. Imag. (LBNL) $1.1 Gas Isotope (Caltech) $1.2 Marcellus Nat. Frac./Stress (BEG) $1.0	Tight Gas Exp. System (LBNL) $1.7 Strat. Controls on Perm. (CSM) $0.1	$5.1
Reservoir Engineering		Decision Model (TEES) $.31 Coupled Analysis (LBNL) $2.9	Wamsutter (Tulsa) $.44 Forecasting (Utah) $1.1 Condensate (Stanford) $.52	$5.3
Resource Assessment		Alabama Shales (AL GS) $.5 Manning Shales (UT GS) $.43	Rockies Gas Comp. (CSM) $.67	$1.6
Exploration Technologies	Coal & Bugs (CSM) $.86	Multi-Azimuth Seismic (BEG) $1.1		$2.0
	$2.5	$20.0	$9.8	$32.3

2008 Program Priorities

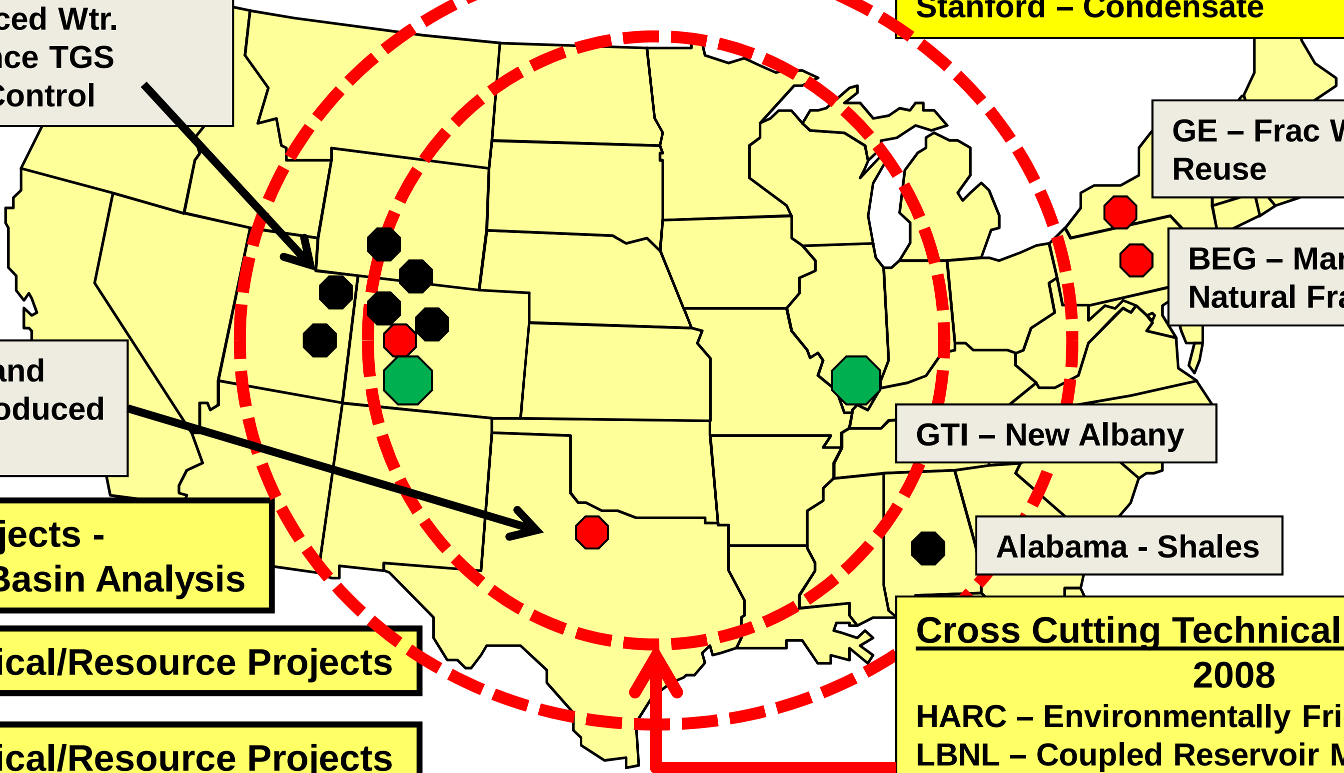
🟩 H	High Priority
🟨 M	Medium Priority
🟧 L	Low Priority

2007 Projects

2008 Projects

RPSEA Unconventional Gas Projects

Cross-Cutting Technical Projects
2007
UT – Fracturing
LBNL – Self Teaching Expert System
UT – Refracturing
TAMU – Fracture Design
TAMU – Decision Model
LBNL – High Resolution Imaging
PSU – Microwave Coals
Carter – Saws
U of Tulsa – Novel Fracturing Fluids
Stanford – Condensate



CSM - Coal Bugs
Utah GS - Paleozoic Shales
U of Tulsa – Wamsutter
CSM – Gas Composition
U of Utah – TGS
CSM – Produced Wtr.
CSM – Piceance TGS
CSM – Strat Control

GE – Frac Water Reuse

BEG – Marcellus Natural Fractures

GTI – Barnett and Appalachia Produced Water

GTI – New Albany

Alabama - Shales

🟢 Anchor Projects - Integrated Basin Analysis

⚫ 2007 Technical/Resource Projects

🔴 2008 Technical/Resource Projects

Cross Cutting Technical Projects
2008
HARC – Environmentally Friendly Drilling
LBNL – Coupled Reservoir Model
TAMU – Fracture Conductivity
BEG – Multi – Azimuth Seismic
Caltech – Gas Isotopes

$32 Million Research Portfolio

Significant Producer and Service Industry Involvement
– Crucial for Program Relevancy

- Anadarko
- Chevron
- Pioneer Natural Reources
- Williams E&P
- ConocoPhillips
- ExxonMobil
- Newfield Exploration
- NGAS
- Encana
- BP
- Bill Barrett Corp.
- Pinnacle Gas Resources
- Coleman Oil & Gas
- Ciris Energy

- Devon Energy
- Unconventional Gas Resources Canada
- Whiting Petroleum
- CNX Gas
- Trendwell
- Diversified Operating Corp
- Noble Energy
- Jones Energy
- Aurora Oil & Gas

- Schlumberger
- Halliburton
- Pinnacle Technologies
- BJ Services
- Carbo Ceramics

RPSEA

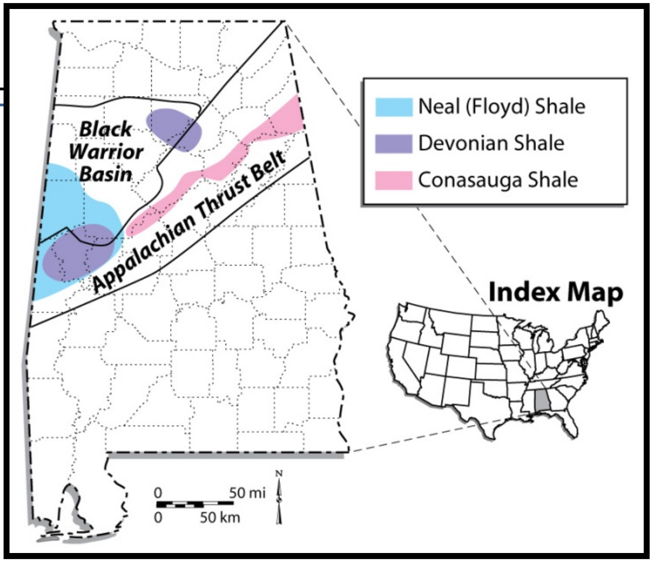
Research
Partnership to
Secure Energy
for America

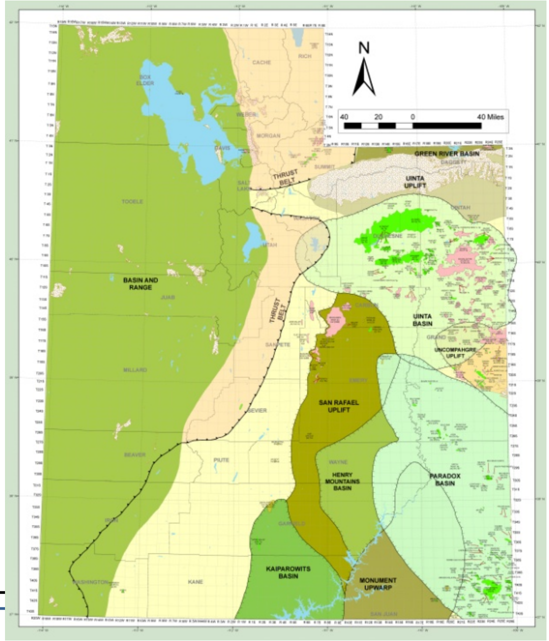
Project Highlights

Unconventional Onshore Program

Shale Resource Assessment

- **Alabama – Geological Survey of Alabama**
  - **Neal (Floyd) Shale, Conasauga Formation, Devonian Shale**
  - **Each have technical challenges/how to address?**
  - **See Spring 2009 NETL "E&P Focus"**
- **Utah – Utah Geologic Survey**
  - **Manning Canyon, Delle Phosphatic, Paradox Shale resources**
  - **Evaluate potential**
  - **Requirements for economic production**





Paleozoic Shale-Gas Resources of the Colorado Plateau and Eastern Great Basin, Utah: Multiple Frontier Exploration Opportunities – Utah Geologic Survey

Project Goal

Provide basin specific analyses of shale-gas reservoir properties to develop the best local completion practices that can be applied to the emerging Manning Canyon, Delle Phosphatic, and Paradox frontier gas shales.

Objectives

- **Identify and map the major trends for frontier gas shale**
- **Identify areas with the greatest gas potential**
- **Characterize the geologic, geochemical, petrophysical, & geomechanical rock properties**
- **Reduce exploration costs & drilling risk especially in environmentally sensitive areas**
- **Recommend the best practices to complete & stimulate frontier gas shales to reduce development costs & maximize gas recovery**

Timing and Major Milestones

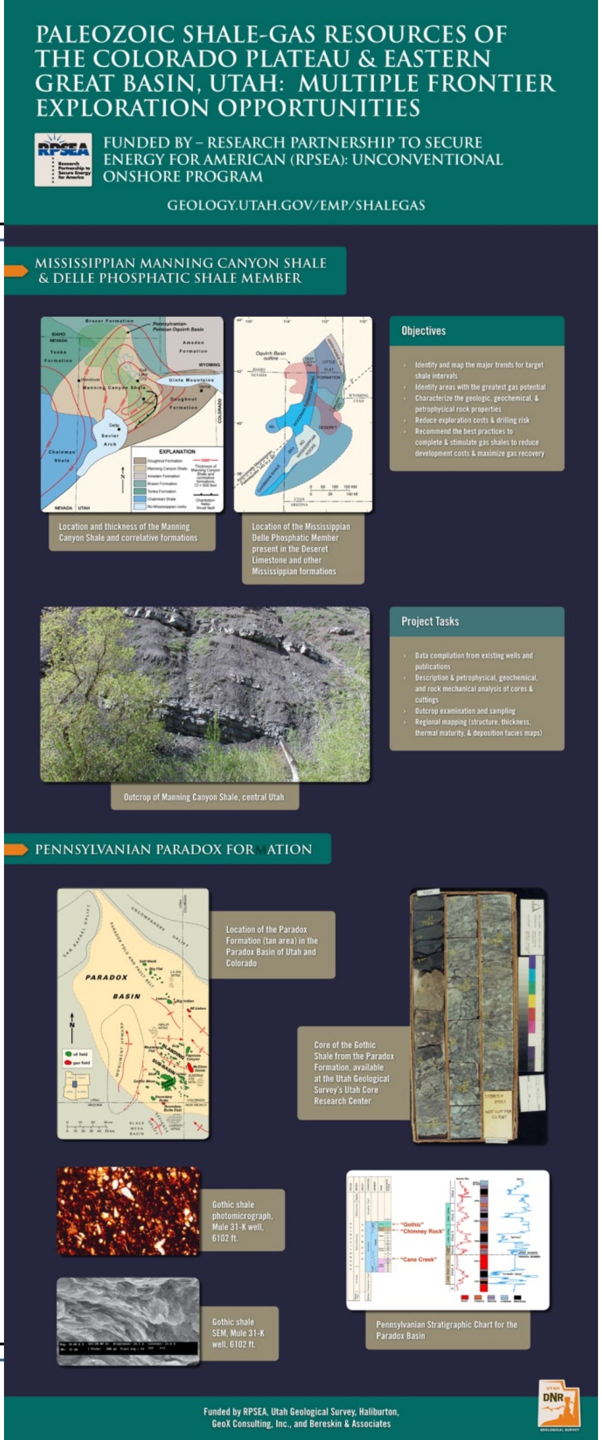
Technical Tasks	2008		2009				2010				2011	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Task 1.0. Project Management Plan	●	●	●	●	●	●	●	●	●	●	●	●
Task 2.0. Technology Status Assessment	●											
Task 3.0. Technology Transfer	●	●	●	●	●	●	●	●	●	●	●	●
Phase I												
Task 4.0: Data Compilation.	●	●	●									
Task 5.0: Core and Cuttings Examination and Sample Analysis		●	●	●	●	●	●	●				
Task 6.0: Outcrop Examination and Sample Analyses		●	●	●	●	●	●	●				
Phase II												
Task 7.0: Determination of Best Completion Practices				●	●	●	●	●	●	●	●	●
Task 8.0: Regional Correlation, Mapping, and Depositional History Determination					●	●	●	●	●	●		
Task 9.0: Final Interpretations and Recommendations							●	●	●	●	●	●

Technical Advisory Board

- **Shell E & P Company**
- **Sinclair Oil and Gas Company**
- **Encana Oil and Gas USA, Inc.**
- **Bill Barrett Corporation**
- **CrownQuest Operating, LLC**
- **ST Oil Company**

Tech Transfer

- **Two presentations at AAPG, June 2009**
  - ***Shale Gas and Shale Oil Resources of the Paradox Basin, Colorado and Utah*, by Steve Schamel**
  - ***Gas Shale Characteristics from the Pennsylvanian of Southeastern Utah, USA*, by S. Robert Bereskin and John McLennan**



PALEOZOIC SHALE-GAS RESOURCES OF THE COLORADO PLATEAU & EASTERN GREAT BASIN, UTAH: MULTIPLE FRONTIER EXPLORATION OPPORTUNITIES

FUNDED BY – RESEARCH PARTNERSHIP TO SECURE ENERGY FOR AMERICAN (RPSEA): UNCONVENTIONAL ONSHORE PROGRAM

GEOLOGY.UTAH.GOV/EMP/SHALEGAS

MISSISSIPPIAN MANNING CANYON SHALE & DELLE PHOSPHATIC SHALE MEMBER

Location and thickness of the Manning Canyon Shale and correlative formations

Location of the Mississippian Delle Phosphatic Member present in the Deseret Limestone and other Mississippian formations

Objectives

- Identify and map the major trends for target shale intervals
- Identify areas with the greatest gas potential
- Characterize the geologic, geochemical, & petrophysical rock properties
- Reduce exploration costs & drilling risk
- Recommend the best practices to complete & stimulate gas shales to reduce development costs & maximize gas recovery

Outcrop of Manning Canyon Shale, central Utah

Project Tasks

- Data compilation from existing wells and publications
- Description & petrophysical, geochemical, and rock mechanical analysis of cores & cuttings
- Outcrop examination and sampling
- Regional mapping (structure, thickness, thermal maturity, & deposition facies maps)

PENNSYLVANIAN PARADOX FORMATION

Location of the Paradox Formation (tan area) in the Paradox Basin of Utah and Colorado

Core of the Gothic Shale from the Paradox Formation, available at the Utah Geological Survey's Utah Core Research Center

Gothic shale photomicrograph, Mule 31-K well, 6102 ft.

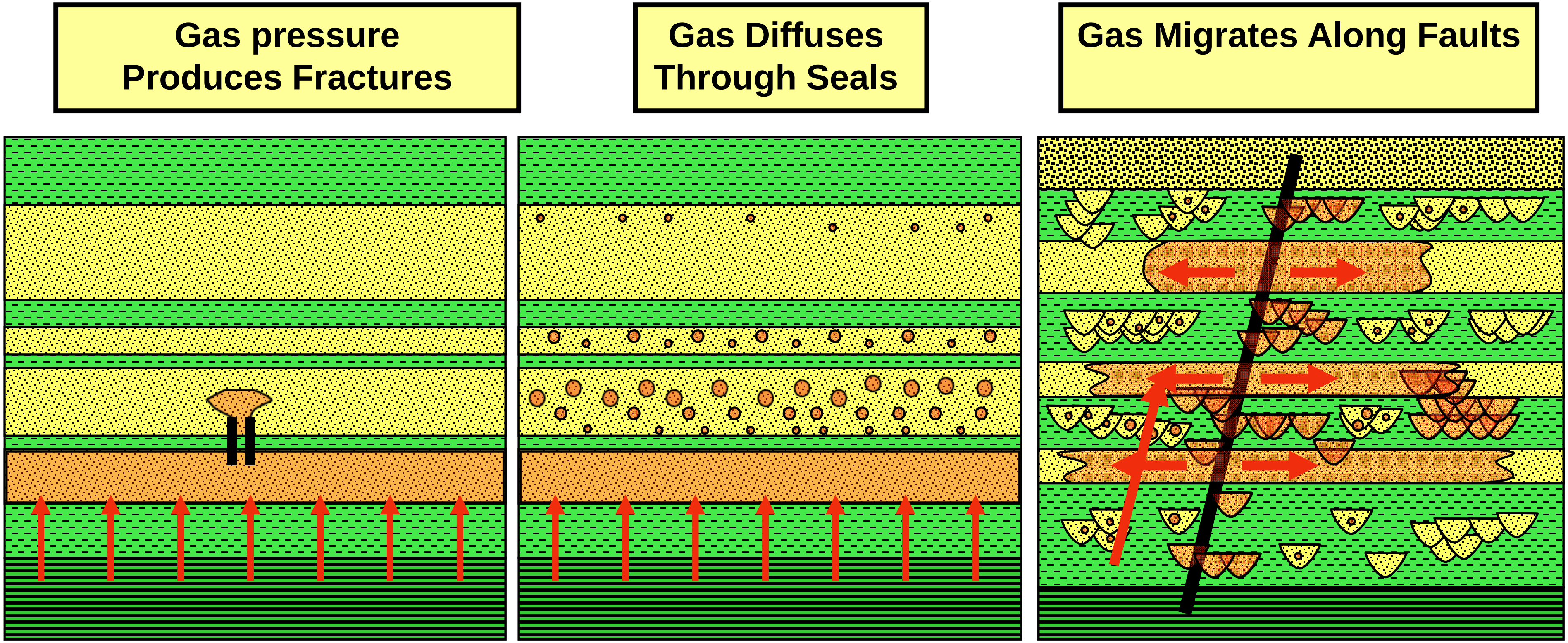
Gothic shale SEM, Mule 31-K well, 6102 ft.

Pennsylvanian Stratigraphic Chart for the Paradox Basin

Funded by RPSEA, Utah Geological Survey, Haliburton, GeoX Consulting, Inc., and Bereskin & Associates

How Does Gas Migrate into and Fill Unconventional Reservoirs?

Different Mechanisms Should Leave Different Signatures in the Gas Composition; Assisting with Exploration Strategy



Gas pressure Produces Fractures

Gas Diffuses Through Seals

Gas Migrates Along Faults

Gas Migration into Unconventional Reservoirs
Colorado School of Mines

Progress to date:

Technology status document submitted.

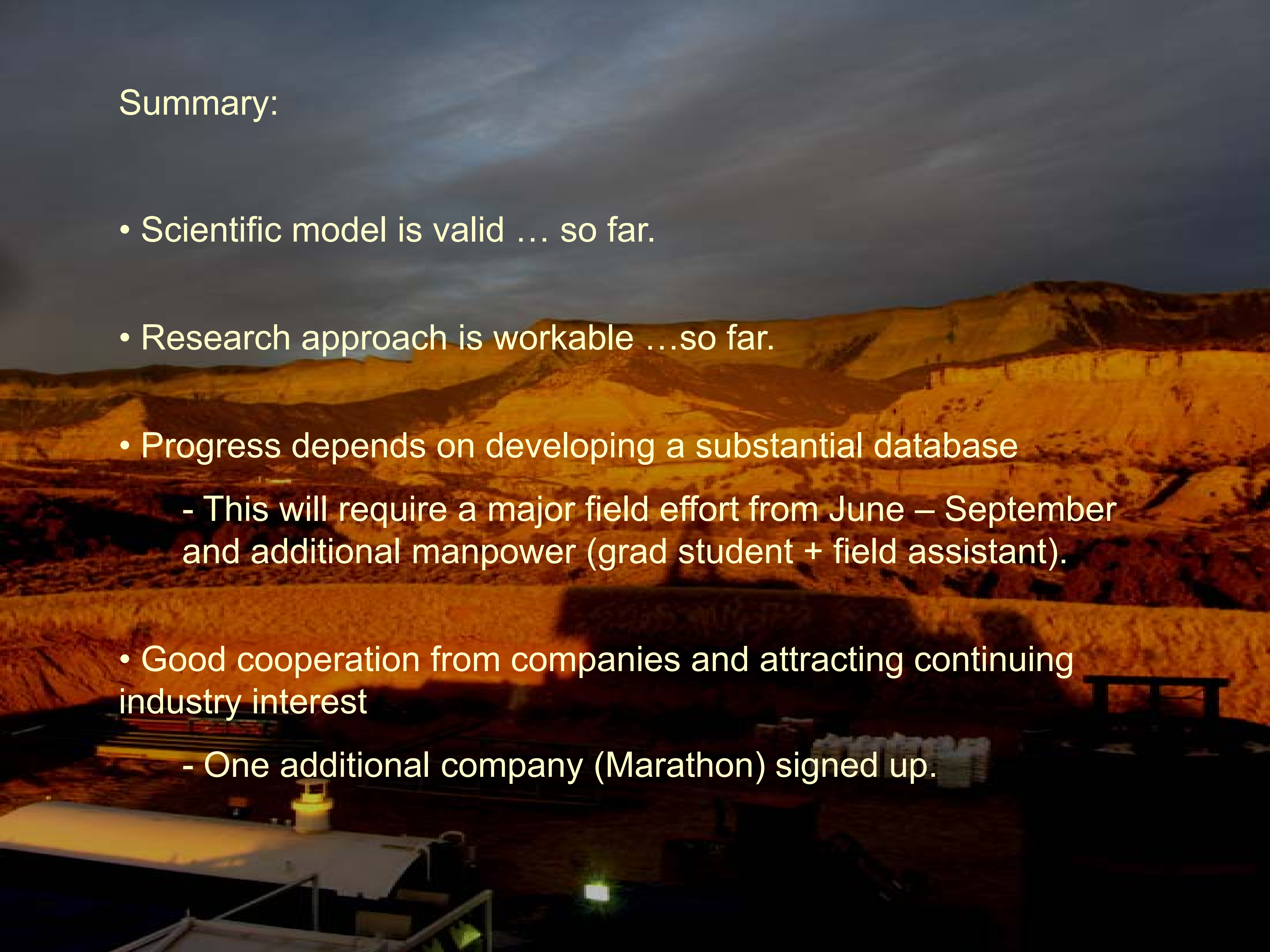
Project website is online, with resources for the general public.

Analysis of gas samples – underway.

- Initial set of bulk gas and compound-specific isotopic analyses – complete.

Migration modeling – underway

- Training in MPath is complete.
- Ph.D. student now developing a preliminary migration model for Jonah Field.

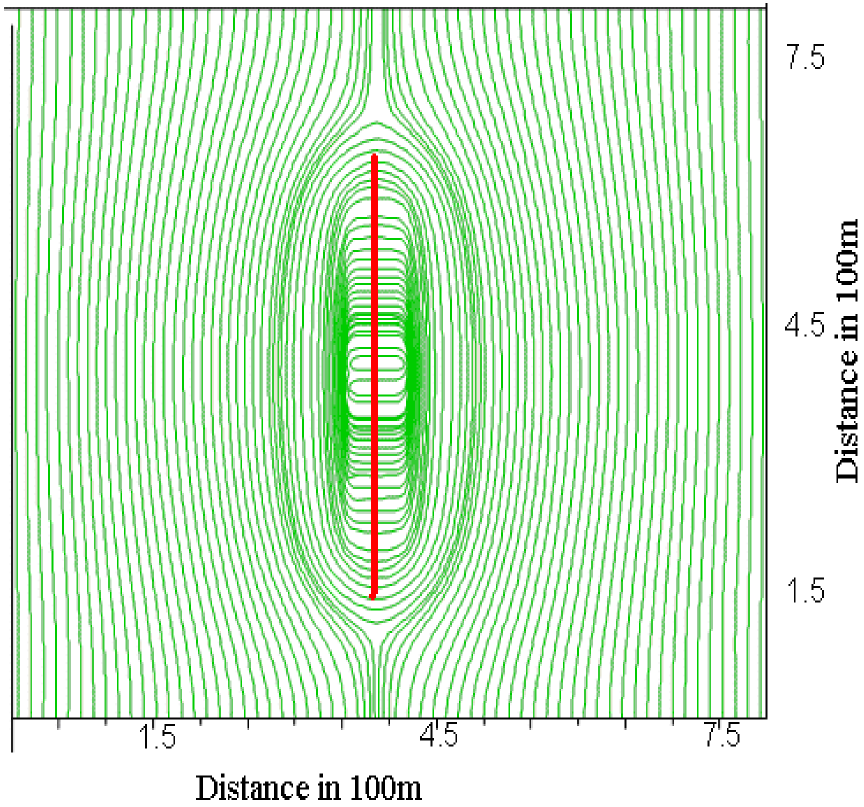


Summary:

- Scientific model is valid … so far.
- Research approach is workable …so far.
- Progress depends on developing a substantial database
    - This will require a major field effort from June – September and additional manpower (grad student + field assistant).
- Good cooperation from companies and attracting continuing industry interest
    - One additional company (Marathon) signed up.

Identification of Refracturing Opportunities

- Methodology for candidate well selection based on poro-elastic models and analysis of field data.
- Recommendations for the time window most suitable for re-fracturing
- Re-fracture treatment design for horizontal and deviated wellbores

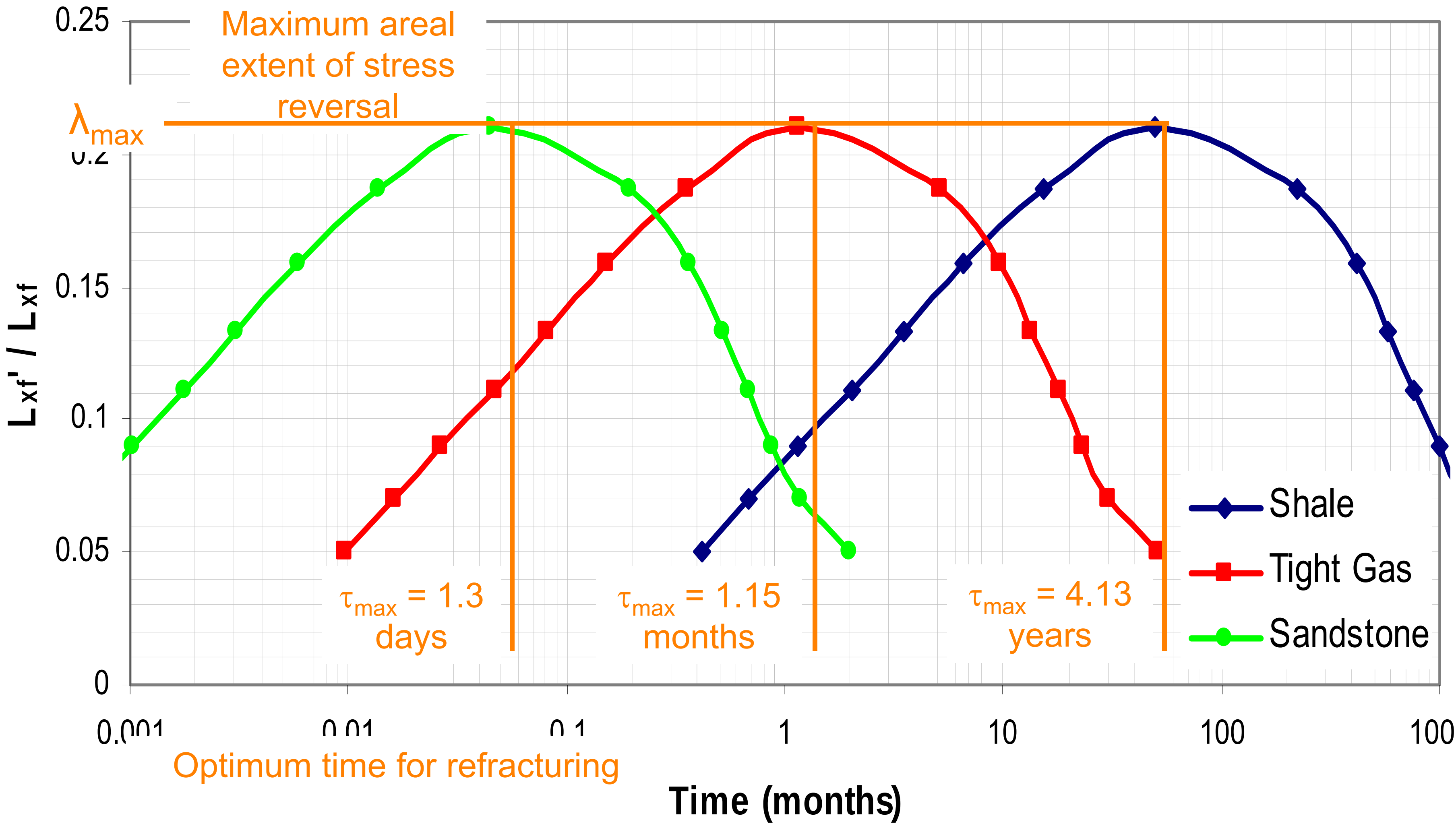


Stress Profile Created by Horizontal Producing Well

Objectives

- Use principal component analysis to determine the increase in production rate after a refracture treatment.
- Use stress reorientation models to study the role played by stress reorientation vs other factors such as GOR and depletion.
- Use these findings to recommend timing for refracs
- Create a statistical, predictive model for
  - ✓ Production enhancement
  - ✓ Candidate well selection

Selecting Timing and Candidate Wells for Re-fracturing



Summary of Progress to Date

- Stress reorientation due to poroelastic effects has been calculated for vertical, fractured and horizontal wells.
- Key parameters and conditions that control this stress reorientation have been identified.
- The optimum timing of refrac treatments has been computed for the first time.
- A data set of refrac treatments from the Wattenburg field has been reviewed and is being analyzed for statistical trends.
- Review of refrac treatment designs in progress.

Unconventional Resources Program

- All Projects Reviewed with PAC, April 2009
  - Critical review by PAC
  - Review by PI Group
  - Communication among PIs
  - Identify opportunities for cooperation
  - Provide direction for draft Annual Plan

The Technology Challenges of Small Producers

Focus Area – Advancing Technology for Mature Fields

- Target – Existing/Mature Oil & Gas Accumulations
  - Maximize the value of small producers' existing asset base
  - Leverage existing infrastructure
  - Return to production of older assets
  - Minimal additional surface impact
  - Minimize and reduce the existing environmental impact
- Lower cost and maximize production

7 Small Producer Projects Funded in 2007

- Cost Effective Treatment of Produced Water Using Co-Produced Energy Sources for Small Producers
- Enhancing Oil Recovery from Mature Reservoirs Using Laterals and High-volume Progressive Cavity Pumps
- Reducing Impacts of New Pit Rules on Small Producers
- Field Site Testing of Low Impact Oil Field Access Roads: Reducing the Footprint in Desert Ecosystems
- Near Miscible CO_2 Application to Improved Oil Recovery for Small Producers
- Preformed Particle Gel for Conformance Control
- Seismic Stimulation to Enhance Oil Recovery

Field Site Testing of Low Impact Oil Field Access Roads: Reducing the Footprint in Desert Ecosystems

Project Leader: Texas A&M University
Additional Project Participants: Rio Vista Bluff Ranch and Halliburton

The Problem:

Intensive development within existing fields requires more infrastructure and road-building. This can increase costs, regulatory requirements, and environmental impacts.

Project Goals:

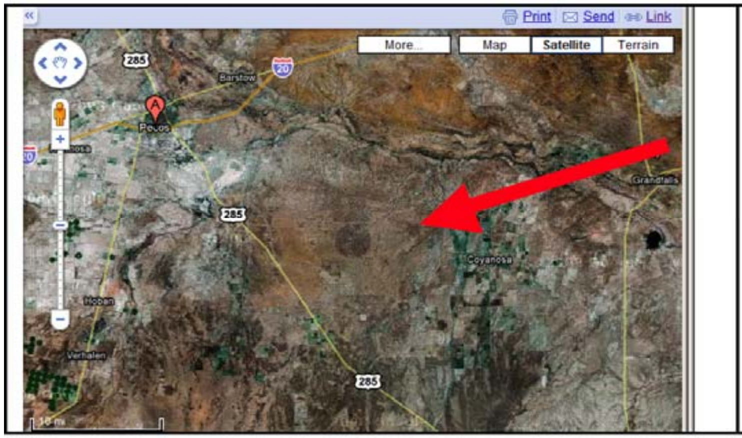
- **Create an industry desert test center where new technology can be evaluated under controlled conditions in a field environment**
- **Build a test track simulating a minimal impact O&G lease road**
- **Analyze the performance of various products used in test sections and perform an economic analysis to measure applicability of the alternate systems**

Field Site Testing of Low Impact Oil Field Access Roads: Reducing the Footprint in Desert Ecosystems

Web site has been established at http://sites.google.com/a/pe.tamu.edu/low-impact-access/Home/low-impact-access-roads-demonstration

A test road location has been selected, and a detailed schedule has been prepared.

Road sections will be laid out alongside but offset from the existing gravel track because we want to see how the test sections will work on unprepared soil and ultimately how easily they can be remediated.



The Pecos Research and Testing Center is located Southeast of Pecos Texas, approximately 1.5 hour drive from the Midland/Odessa airport.

Cost Effective Treatment of Produced Water Using Co-Produced Energy Sources for Small Producers

Approach:

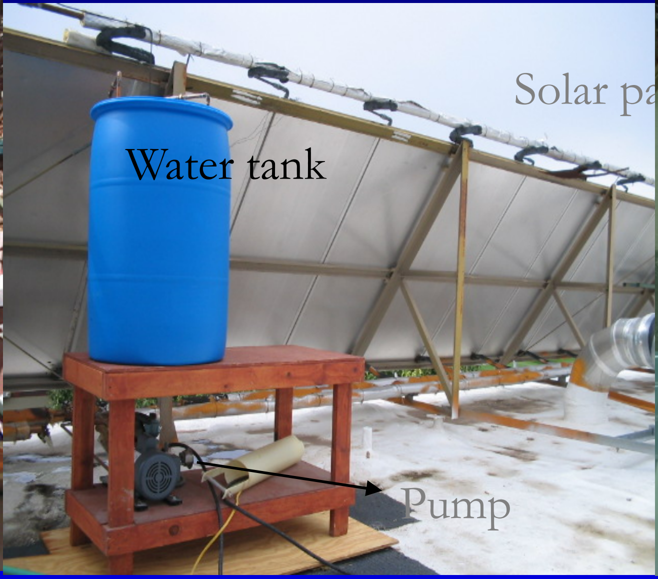
1. Process has been optimized for enhanced water recovery and energy efficiency

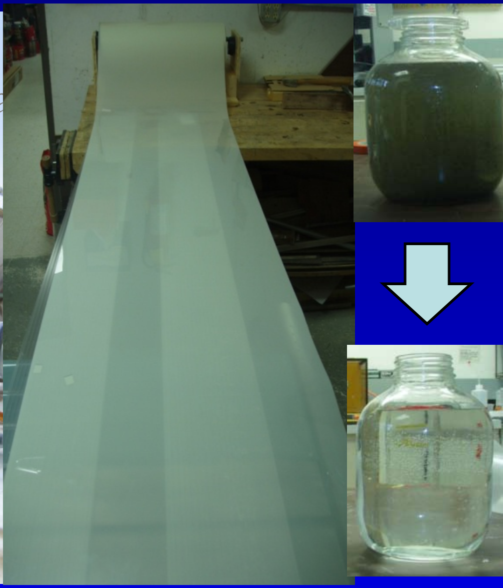
2. Researchers have designed the optimized process for demonstration

3. Produced water direct heating by solar energy has been designed

4. On-going work includes equipment procurement and on site preparation for demonstration

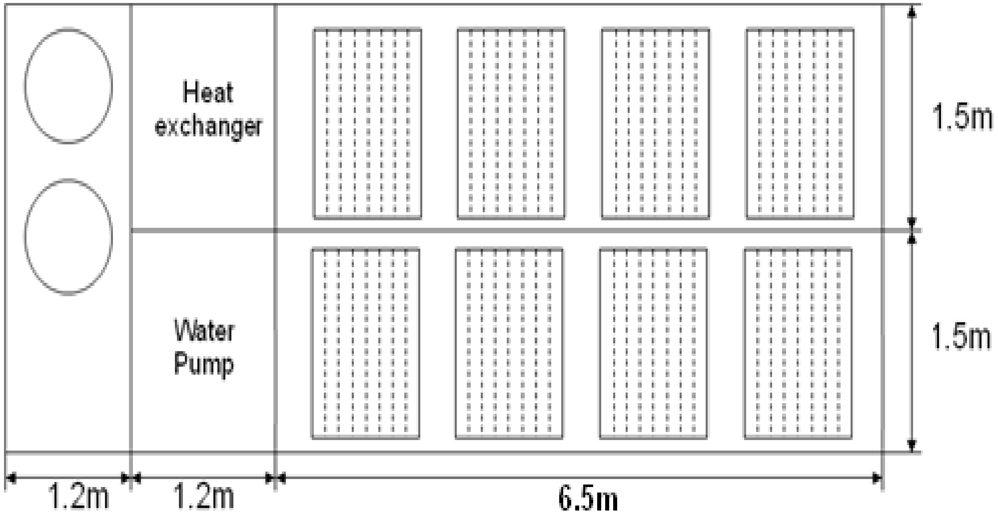
Laboratory Test and Process Optimization

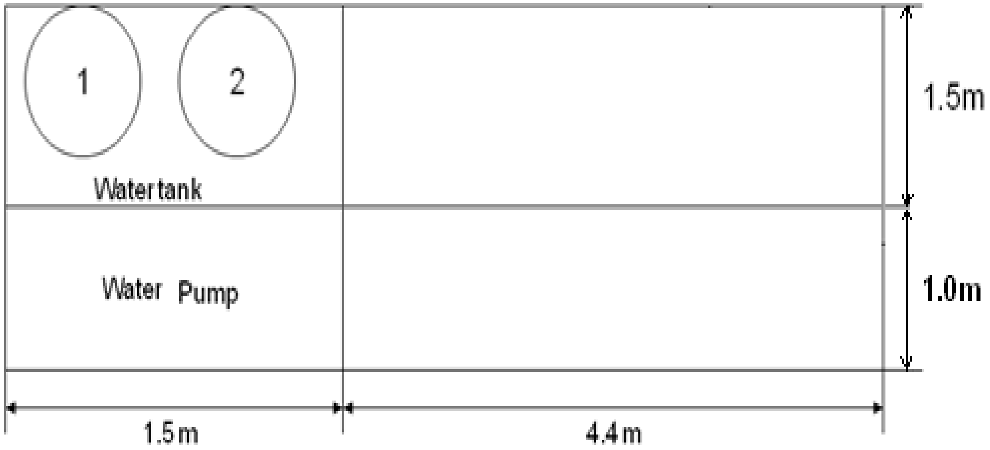




Composition	Feed water	Purified water	Removal efficiency, %
Total dissolved solid (TDS), mg/L	19756.0	76.35	99.6
Total suspended particulates, mg/L (0.22µm < dia.< 100µm)	99.6	Undetectable	100%
Total organic carbon (TOC), mg/L	470.2	17.83	96.2%

Site Preparation and Demonstration Preparation





Planned Site for Water Treatment

2008 Small Producer Project Selections

Reservoir Characterization

Lead Organization	Title	Partners	Main region	Total Cost	Cost Share	Duration
University of Texas of the Permian Basin	Commercial Exploitation and the Origin of Residual Oil Zones: Developing a Case History in the Permian Basin of New Mexico and West Texas	Chevron, Legado Resources, Yates Petroleum	Permian Basin	$962,251	34	2 years
Western Michigan University	Evaluation and Modeling of Stratigraphic Control on the Distribution of Hydrothermal Dolomite Reservoir away from Major Fault Planes	Polaris Energy Company	Michigan	$1,138,864	65	2 years
UT Austin - Bureau of Economic Geology	Development Strategies for Maximizing East Texas Oil Field Production	Danmark Energy, John Linder Operating	Texas	$1,969,890	50	3 years

2008 Small Producer Project Selections

Oil and Gas Recovery

Lead Organization	Title	Partners	Main region	Total Cost	Cost Share	Duration
New Mexico Institute of Mining and Technology	Mini-Waterflood: A New Cost Effective Approach to Extend the Economic Life of Small, Mature Oil Reservoirs	Armstrong Energy	Southwest	$1,107,659	71	2 years
Layline Petroleum 1, LLC	Field Demonstration Of Alkaline Surfactant Polymer Floods In Mature Oil Reservoirs Brookshire Dome, Texas	Tiorco, University of Texas at Austin	Mid-Continent	$1,226,396	51	2 years

2008 Small Producer Project Selections

Utilizing Waste to Increase Efficiency

Lead Organization	Title	Partners	Main region	Total Cost	Cost Share	Duration
Gulf Coast Green Energy	Electrical Power Generation from Produced Water: Field Demonstration of Ways to Reduce Operating Costs of Small Producers	Denbury Resources, ElectraTherm Inc, Dry Coolers Inc.	Gulf coast	$431,344	50	3 years