NATIONAL ENERGY TECHNOLOGY LABORATORY

Low Impact Drilling: *A Current and Future Technology Focus Area*

Roy Long, E&P Technology Manager

September 4, 2008

National Energy Technology Laboratory
Who We Are

- **Only DOE national lab dedicated to fossil energy R&D**
  - Fossil fuels provide 85% of U.S. energy supply
- **One lab, five locations, one management structure**
- **1,200 Federal and support-contractor employees**
- **Research spans fundamental science to technology demonstrations**

Alaska

Oklahoma

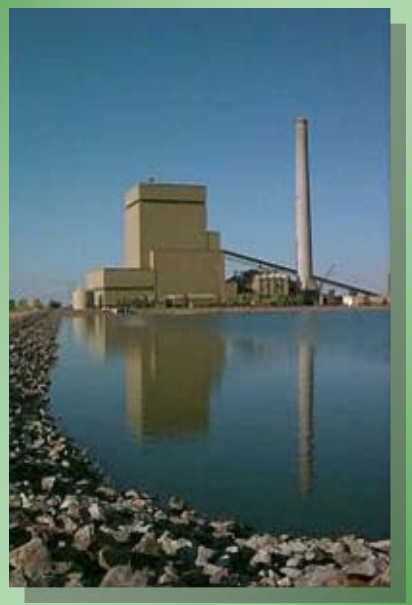
Oregon

Pennsylvania

West Virginia

NETL Mission Areas

- Strategic Center
- for Coal



Strategic Center for Natural Gas and Oil

Project Management Center

Accomplishing Our Mission

- **Conduct onsite research**
- **Implement and manage extramural RD&D**
  - Title IX, Subtitle (j) of Energy Policy Act of 2005
    - RPSEA Consortium
      - Ultradeepwater
      - Unconventional
      - Small Producer
- **Support energy policy development**

Vast Domestic Resource Available

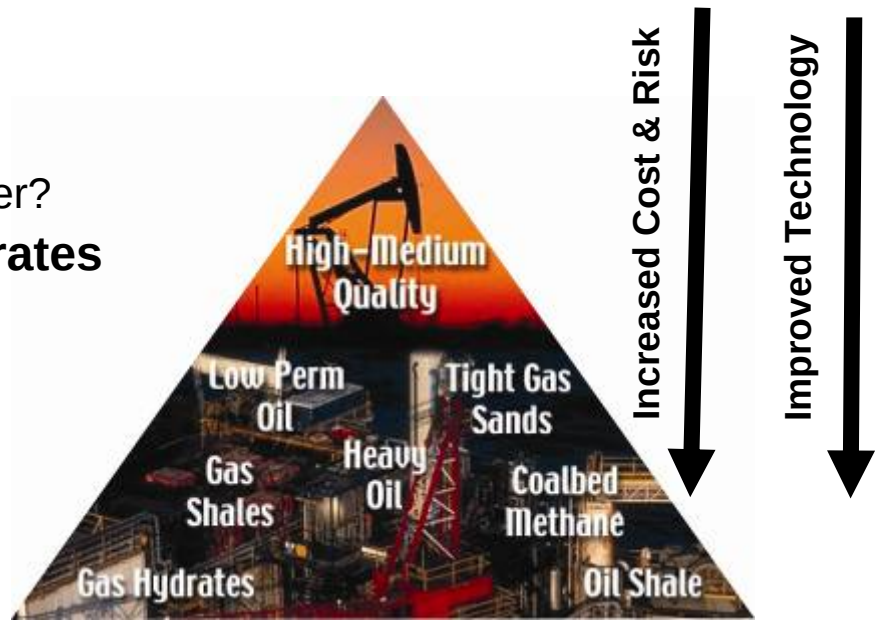
More Difficult & Costly to Produce

GAS

- **100's Tcf in-place: Ultra-Deep Gas**
  - Recoverable, but not economic
- **1000's Tcf in-place: Unconventional**
  - 2% recoverable now; how much higher?
- **100,000's Tcf in-place: Methane Hydrates**
  - Recoverability not established

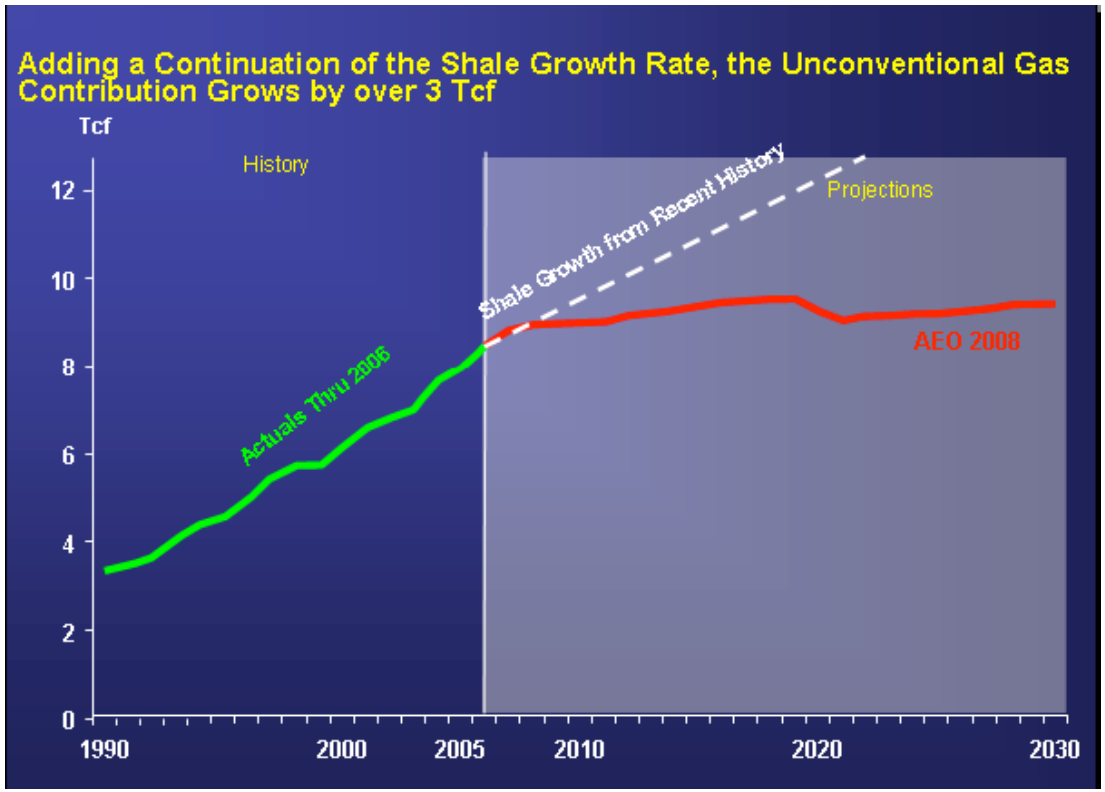
OIL

- **100's Billion bbl in-place: Remaining after current recovery methods**
  - Awaiting advanced technologies
- **10's Billion bbl in-place: Oil Sands**
  - Awaiting technology development
- **1000's Billion boe in-place: Oil Shale**
  - Economic and environmental hurdles



Unconventional Gas Supply Potential

- **Navigant Consulting / Clean Skies Foundation forecasting 3 Tcf more gas from gas shales in 2020**



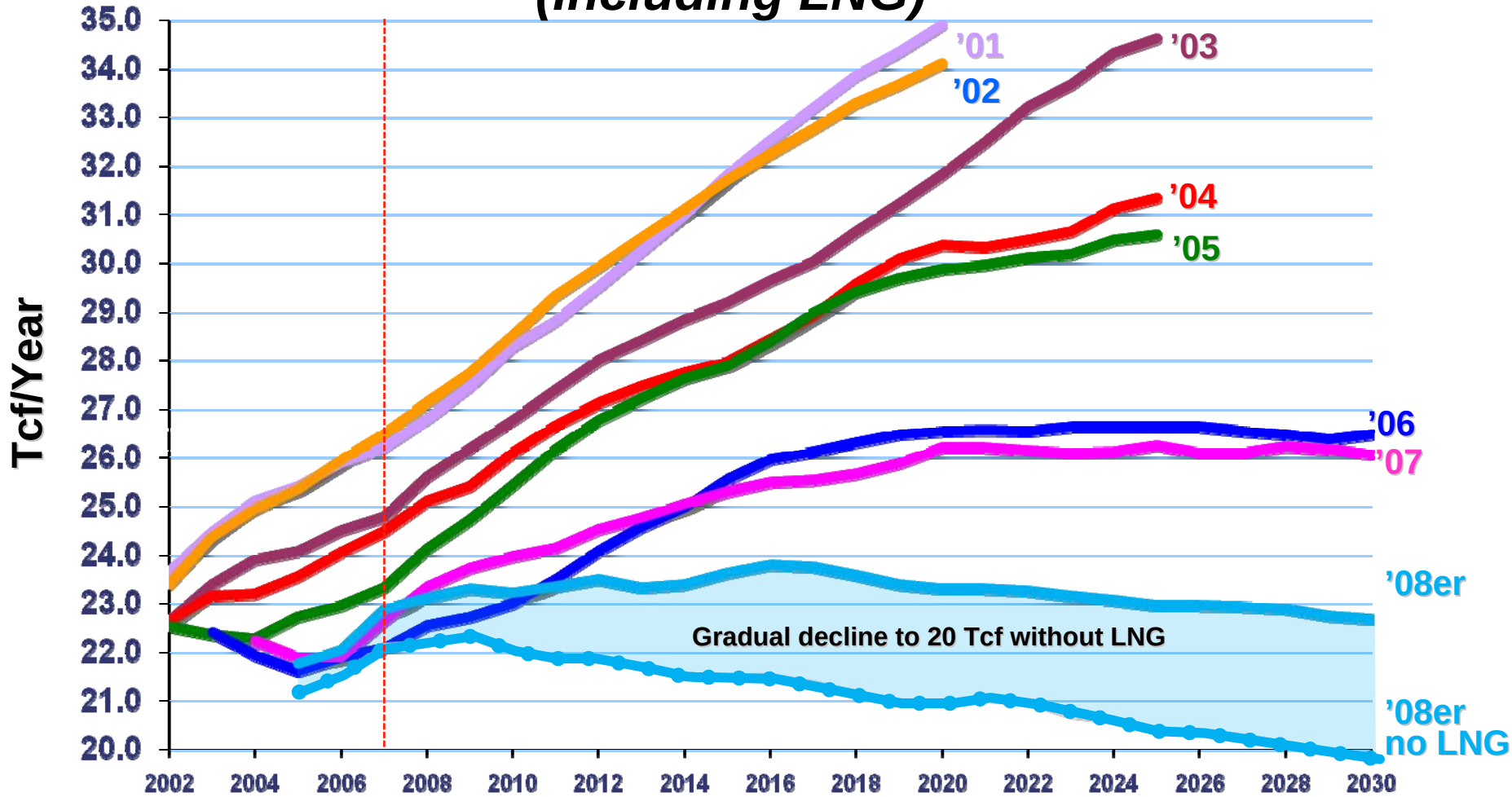
North American Natural Gas Supply Assessment, July 4, 2008

Summary:

- 2,246 TCF Technically Recoverable Resource
- 118 years supply at 2007 demand levels

Total Natural Gas Supply to U.S.

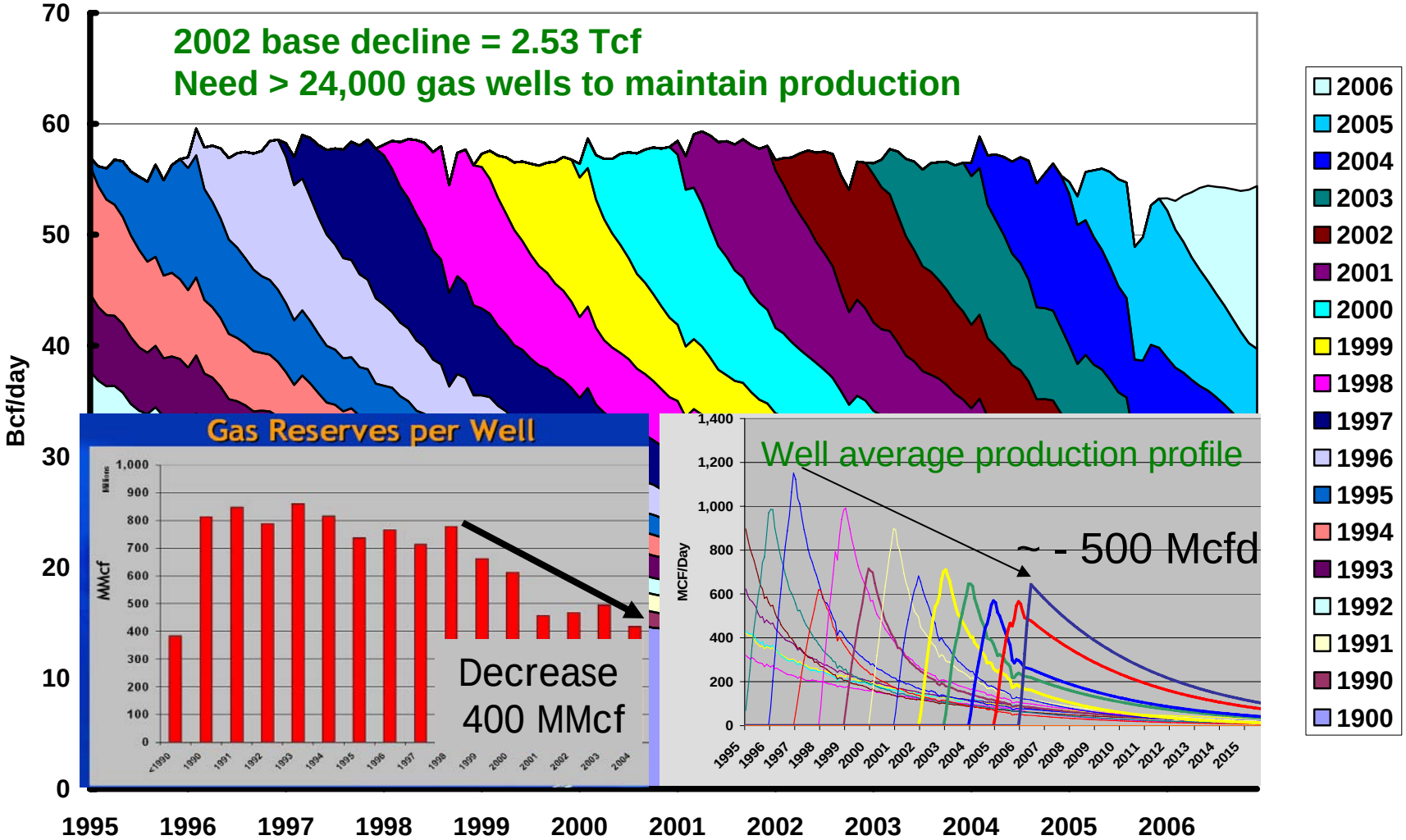
(Including LNG)



Increased Use of Natural Gas in Electricity Will Require LNG; North American Natural Gas Supply for U.S. Trending Down

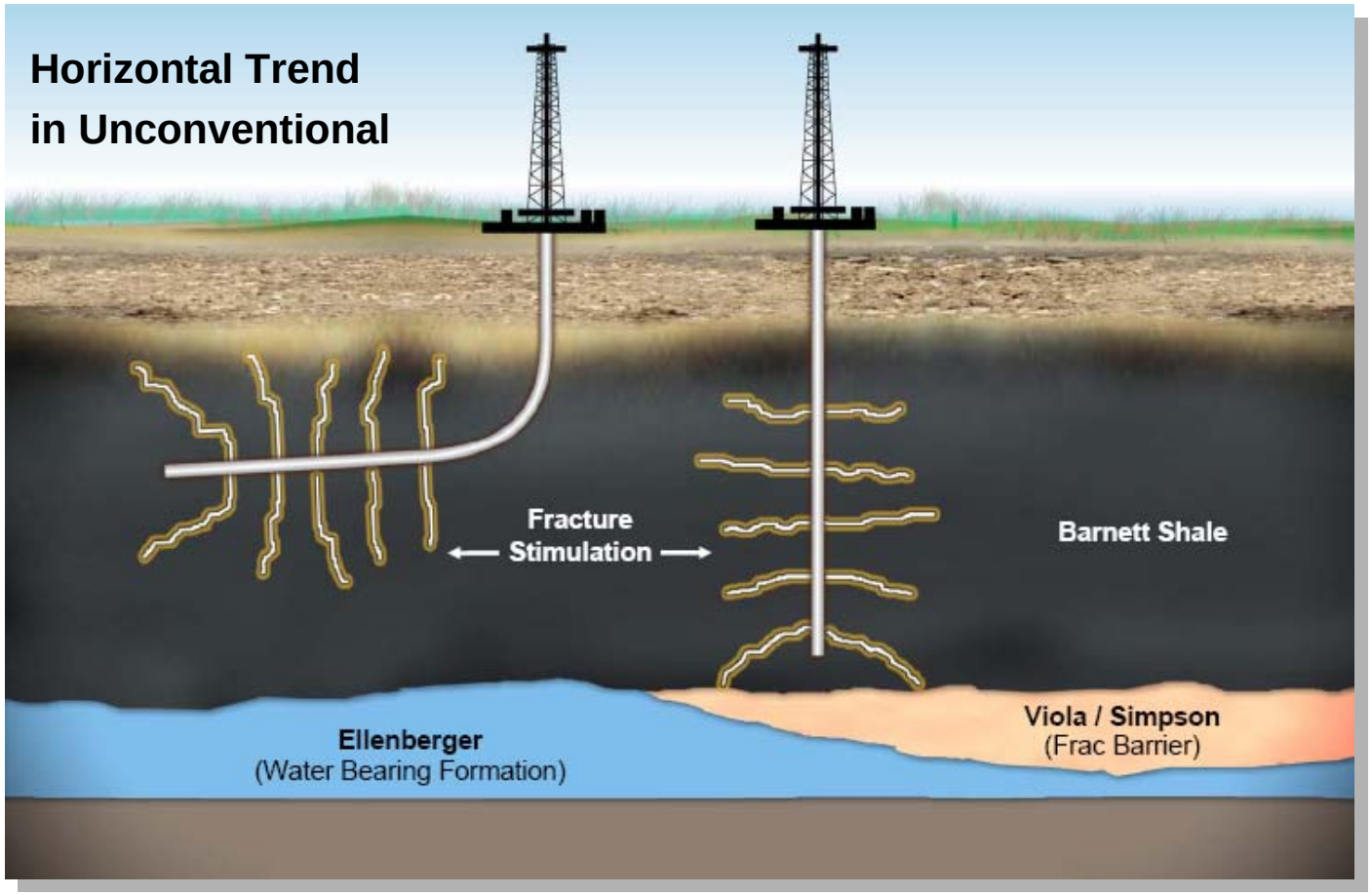
Annual Energy Outlook 2001, 2002, 2003, 2004, 2005, 2006, 2007, and 2008 revision, reference cases

IHS/CERA Vintage Gas Production Profile for U.S. Lower 48 States: 1995 - 2006



Updated 02/25/2008

Keys to Gas Supply in the Unconventional Era:
Technology, Environment, and Operational Efficiency



Courtesy Devon

ARI Unconventional Gas Development Summary

Unconventional Gas Well Productivity (Kuuskraa, 2007).

	Tight Gas Sands			Coalbed Methane			Gas Shales		
Period	Wells	Reserves Added, Tcf	Well Productivity Bcf/well	Wells	Reserves Added Tcf	Well Productivity Bcf/well	Wells	Reserves Added Tcf	Well Productivity Bcf/well
1996-2000	14,000	31.5	2.25	7,320	11.6	1.58	4,110	5.2	1.25
2001-2002	10,570	19.5	1.84	10,450	5.7	0.55	3,640	2.8	0.76
2003-2005	31,080	30.1	0.99	14,830	6.6	0.47	14,990	6.7	0.93

Continued Development of Unconventional Gas Depends On:

- **Improved Technologies**
  - Allow previously unrecognized resources to become economic
- **Improved cost and operating efficiencies**
  - Make the less-favorable reservoirs producible
- **Increased Environmental Emphasis**
  - Greater pressure on reducing footprint and overall impact

Note: Continued "high" gas price assumed above

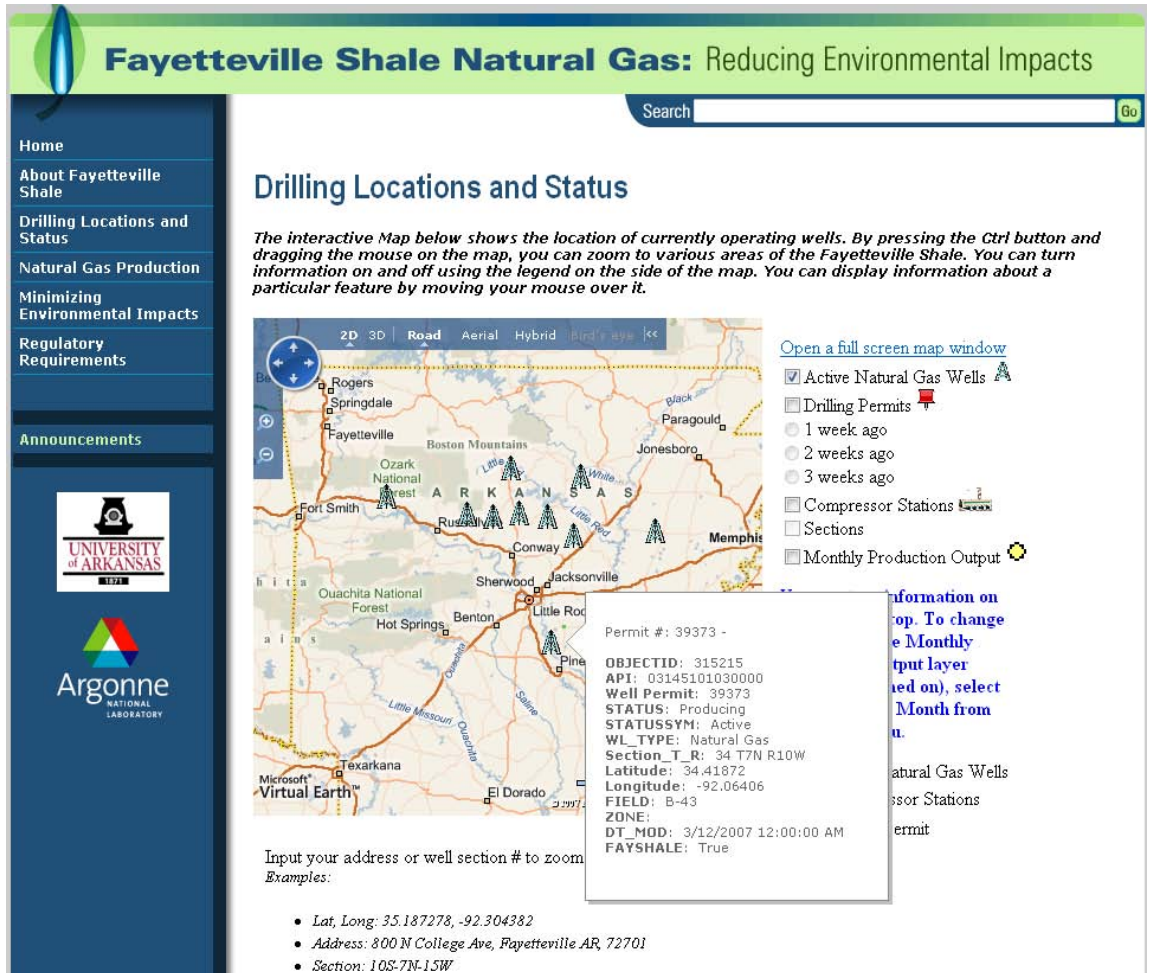
UNCONVENTIONAL GAS SUPPLY

TECHNOLOGIES FOR POTENTIALLY:

1) Increasing operational efficiency
2) Decreasing drilling impact

University of Arkansas: Fayetteville Shale

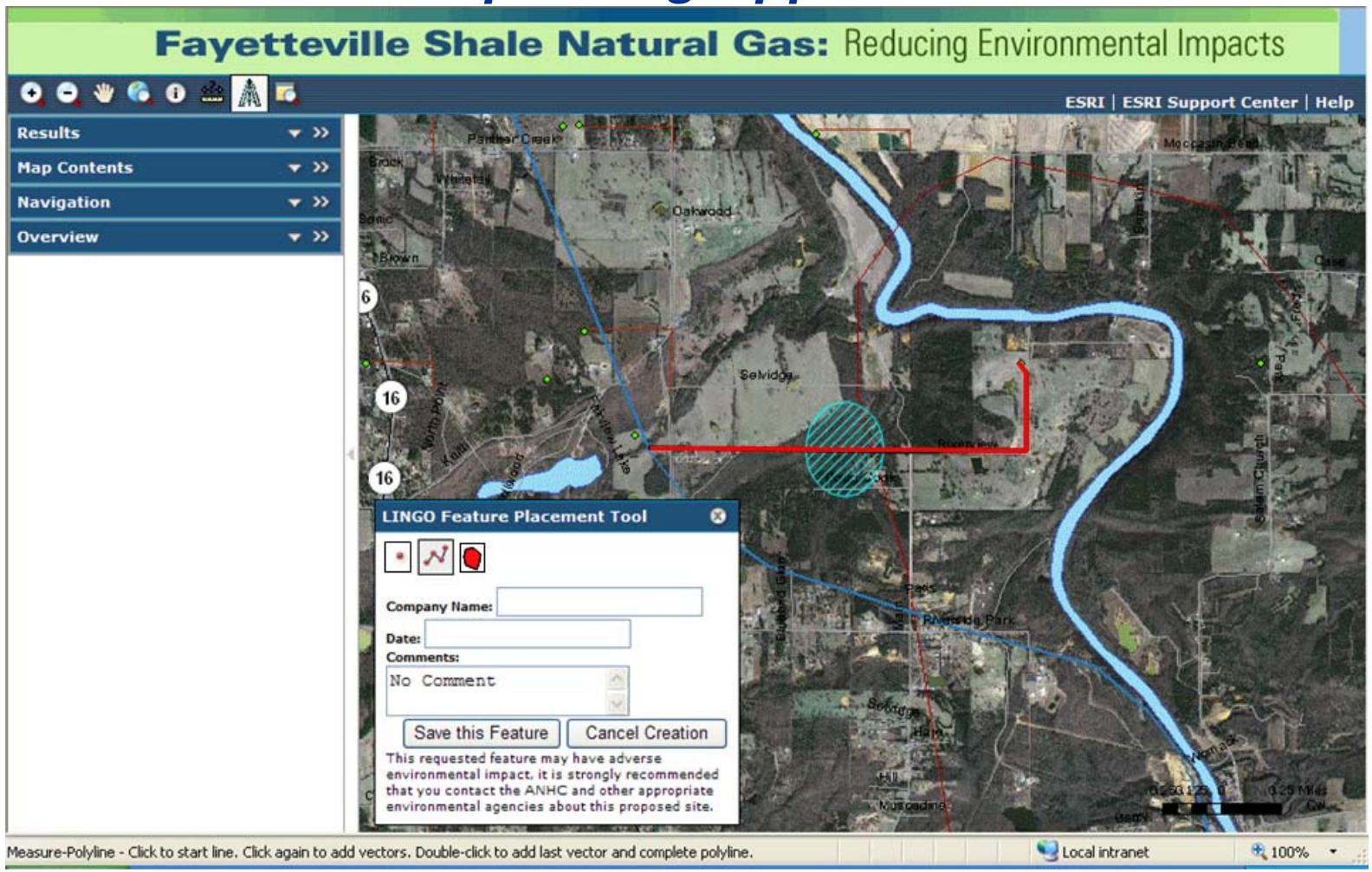
Probabilistic Risk-Based Decision Support for Oil and Gas Exploration and Production Facilities in Sensitive Ecosystems



http://lingo.cast.uark.edu/LINGOPUBLIC/

Operator's Page:

Detailed Assistance for Drill Site Planning and Expediting Approvals

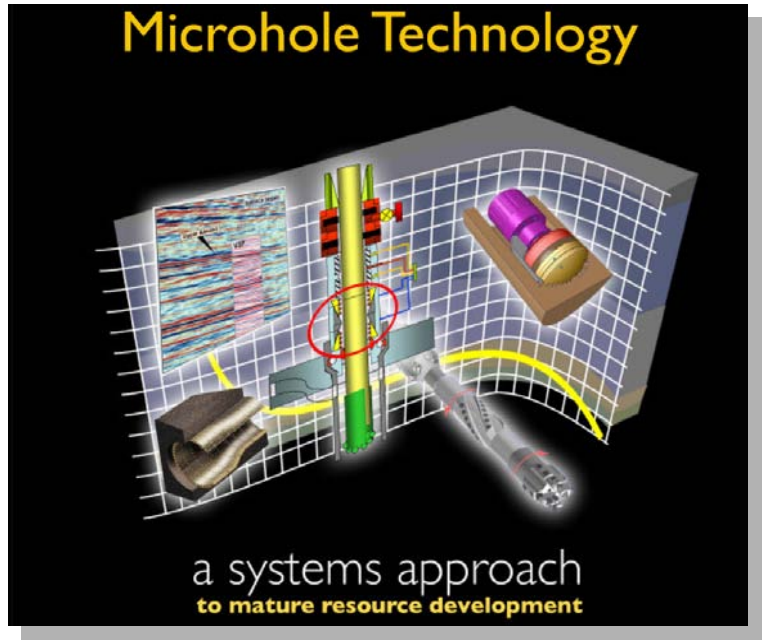


Dr. Greg Thoma (gthoma@uark.edu or 479-575-4951)

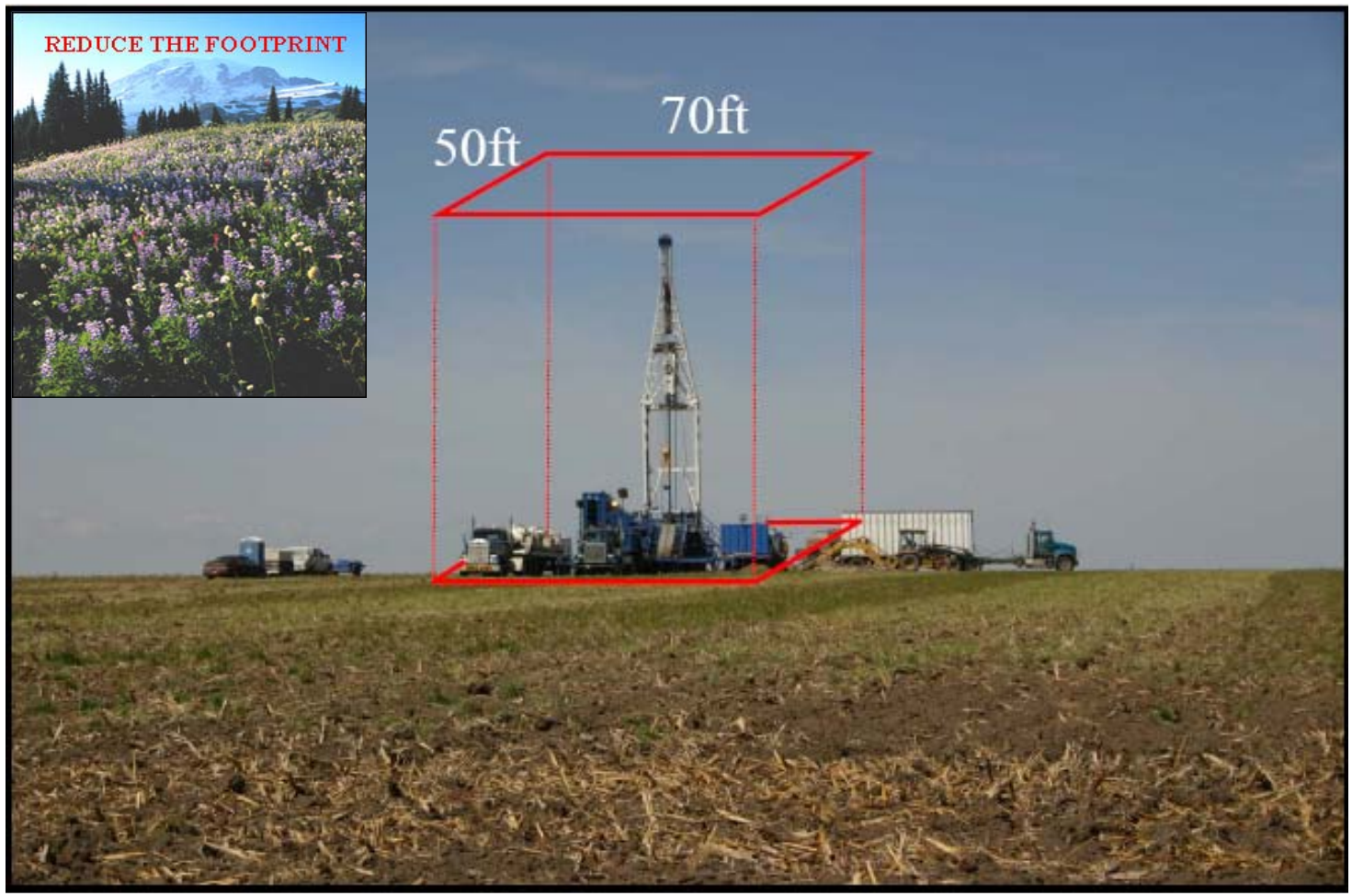
NETL Microhole Technologies Initiative

Mature Field Focus w/Unconventional Gas Applications

- **Access: Tap new reserves in marginal fields with minimal environmental impact**
  - **Expand coiled tubing drilling** in new and existing wells
    - **Demonstrations**
    - **R&D – new tool development**
- **Imaging: Sweet spots & monitor production in complex reservoirs via new "24/7" (passive) 4-D seismic imaging capabilities**
  - Combine CTD purpose built instrument holes with **"downward looking VSP"**
  - Demonstrate unprecedented high imaging resolution using state-of-art **geophones and microsiesmic instrumentation** installed without a rig



Access: "Hybrid" Coiled Tubing Drilling Reduces Drilling Cost and Environmental Footprint



CTD Demo for Marginal Oil and Gas Resources

High Efficiency Technologies for Unconventional Gas

Objectives

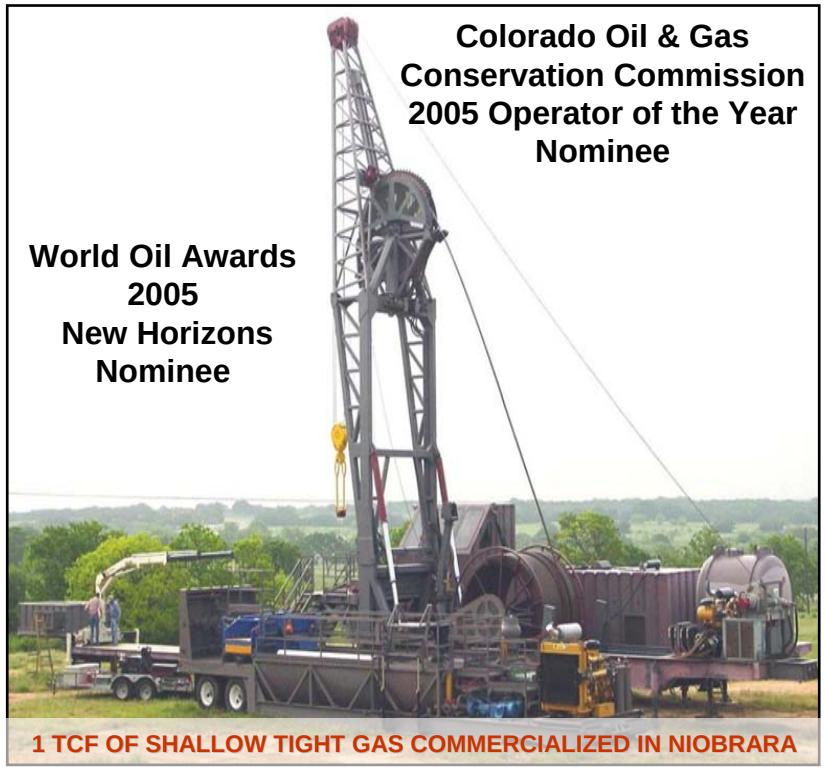
- Demonstrate first U.S. built / based high efficiency hybrid CT rig

Accomplishments

- Drilled 25 wells in the Niobrara
  - 300,000 feet of hole in 7 months
  - Drilled and completed 3,000' wells in 19 hours

Benefits

- Made 1 Tcf of shallow bypassed tight gas in Niobrara economic
- Reduced the cost of drilling wells by 25-38%
- Reduced environmental impact



Note: Program included a host of other enabling downhole technologies for coiled tubing drilling

Photo courtesy Tom Gipson, ADT, LLC, Yuma, Colorado

Rapid Growth of Coiled Tubing Drilling

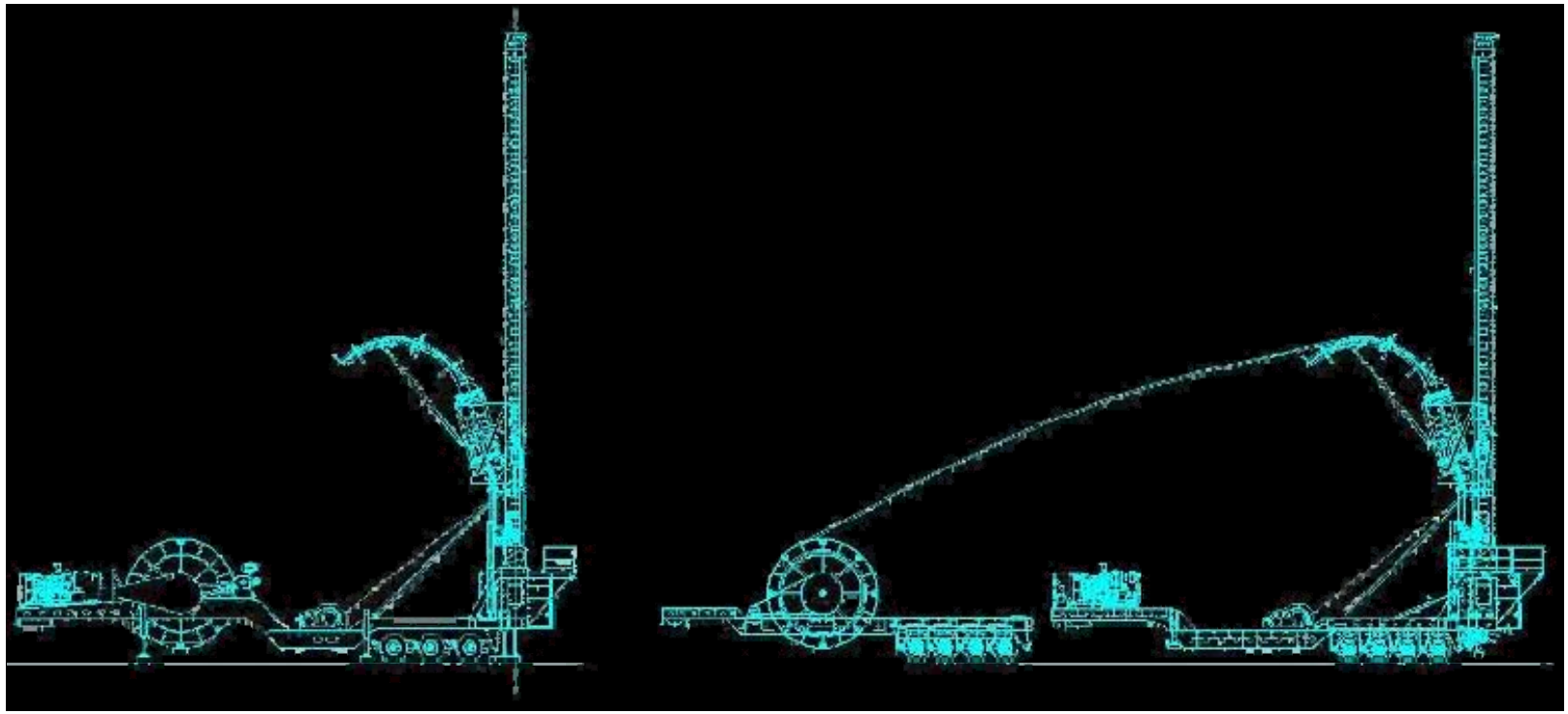
The New Wave of High Efficiency Technologies

- **Denver Post (Jan 2007) –**
  Business Section Front Page
  Article Attributes CT Drilling Boom
  in Colorado to DOE
  "The technology got a thumbs up after NETL (in conjunction with ADT and Rosewood Resources) drilled 25 small bore wells with CT rigs in the Niobrara formation in eastern Colorado and western Kansas"
- **Oil and Gas Investor:** ***"Microholes and Coiled Tubing" (March 2007)***
  - Microhole Field Demo success in Niobrara detailed
- **Nickles New Technology Magazine:** ***"Coiled Tubing Busting Out All Over – Smallbore Drilling Hardware Could Extend the Reach of CT Drilling" (March 2007)***
  - Feature on Counter-Rotating Tandem Drilling System

Anadarko Petroleum began using a coiled tube rig in November in the Wattenberg oil and gas field in eastern Colorado. The newer rigs are smaller and more portable than standard rigs. (Special)

Hybrid Coiled Tubing Drilling Rigs Now Have 10/14,000' coil/rotary capability

Shallower Hybrid CT Rigs Using 3-1/2” Coil
XTC 200ST, 200DT, 200DT^{Plus}



XTC 200ST

Coil 6,500 feet
Hook load 120,000 lbs

Pipe 8,200 feet
Hook load 200,000 lbs

XTC 200DT

Coil 8,200 feet
Hook load 120,000 lbs

Pipe 8,200 feet
Hook load 200,000 lbs

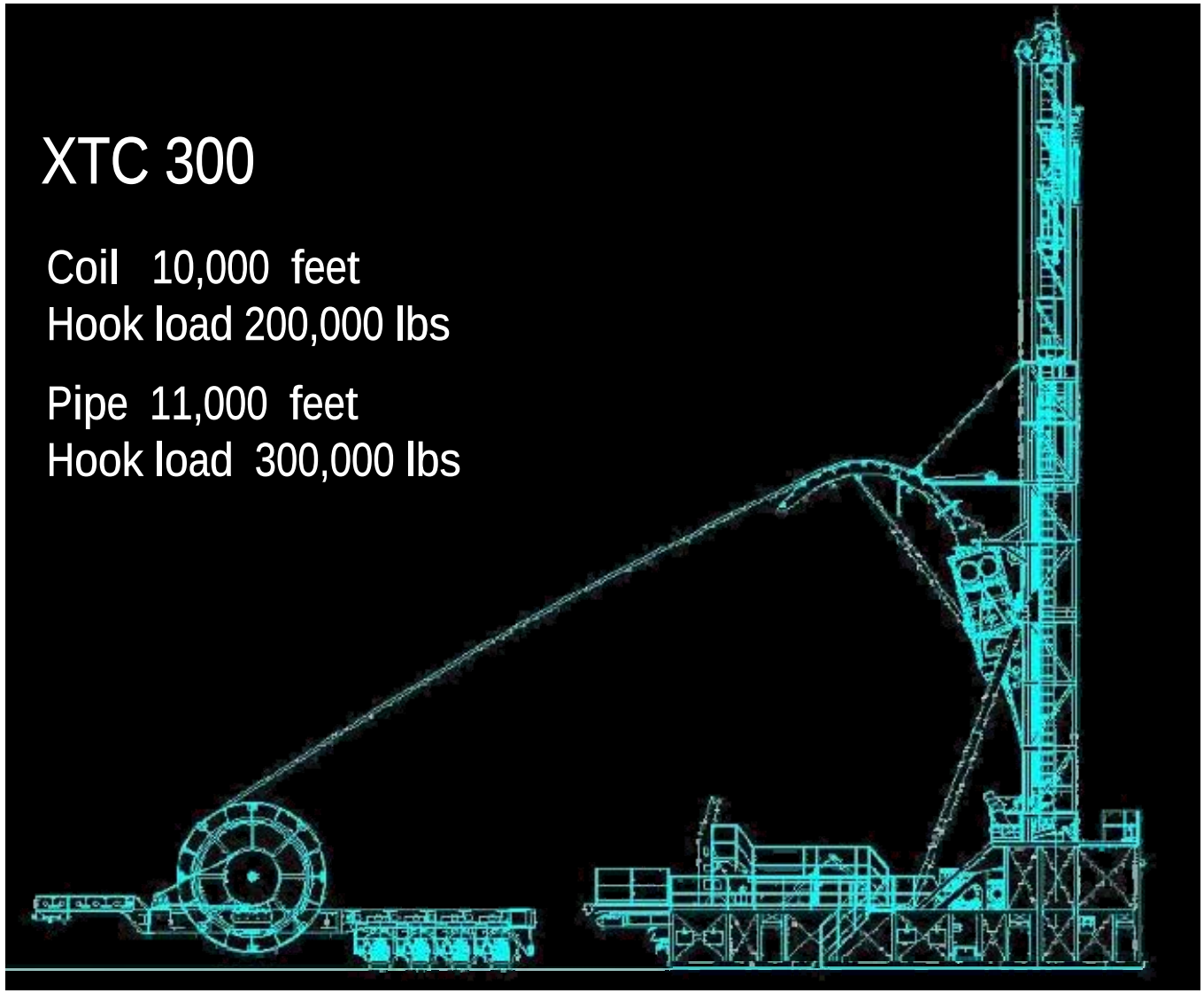
XTC 200DT^{Plus}

Coil 10,000 feet
Hook load 200,000

Pipe 8,200 feet
Hook load 200,000 lbs

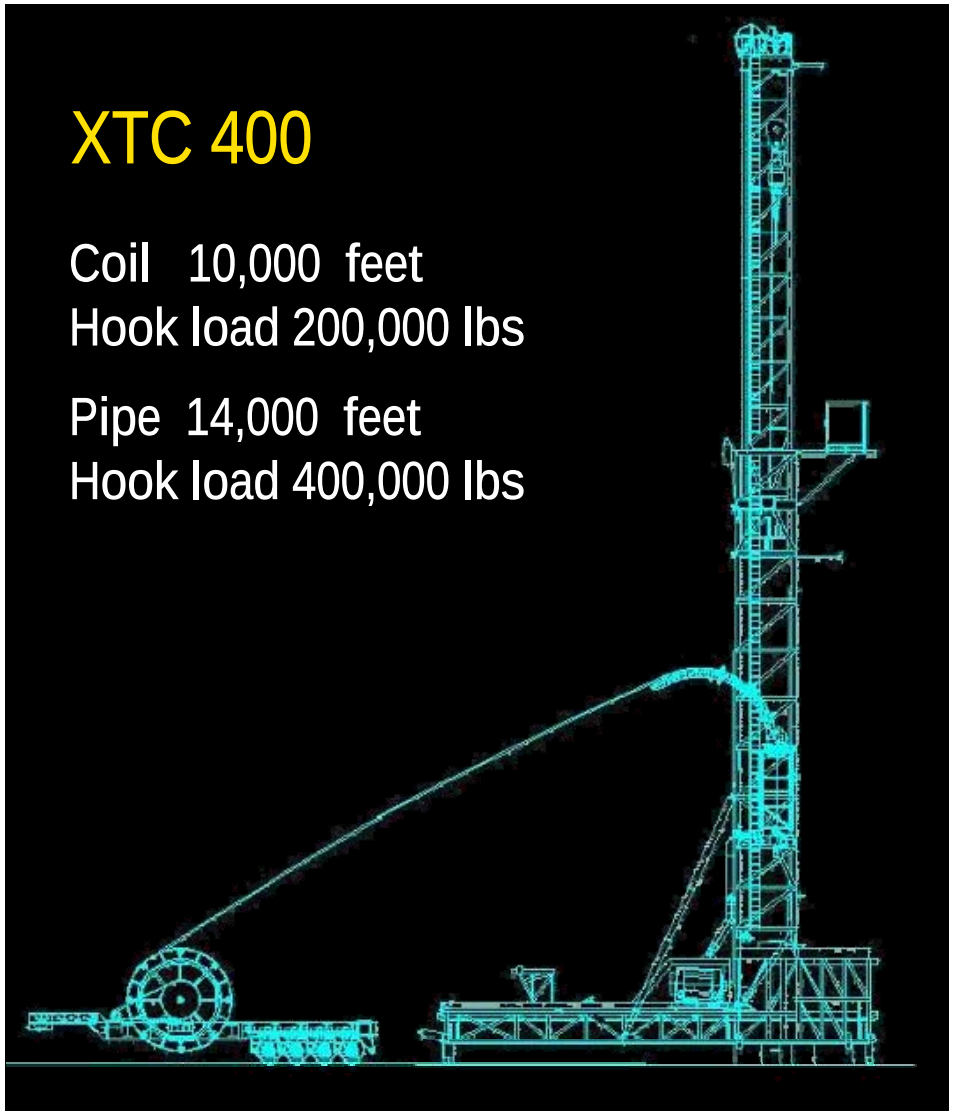
Source: XTreme Coil Drilling Corp.

Deep Hybrid CT Rigs Using 3-1/2” Coil XTC 300



Source: XTreme Coil Drilling Corp.

Deep Hybrid CT Rigs Using 3-1/2” Coil XTC 400



Updated 02/25/2008

Source: XTreme Coil Drilling Corp.

Coil Drilling Advantages

- **Coil Over Top Drive® technology**
  - flexibility to drill with coil and/or conventional drill pipe from spud to completion
  - 2 rigs in 1 – use whichever mode is appropriate
- **Constant circulation with coil**
  - reduces potential for getting stuck; reduces blow out potential
  - no surging and swabbing of well bore
  - lower risks in narrow mud weight window environment
    - can snub if required
- **Faster rig up and rig out – no cranes required on any rig**
  - XTC 200 can rig up in 2-4 hours and rig out in 45 minutes
  - XTC 300 can move and rig up in 8 hours
  - XTC 400 can move and rig up in 18 hours

Source: XTreme Coil Drilling Corp.

Coil Drilling Advantages

- **Small footprint; lower environmental impact**
- **Safe and efficient**
  - safe, clean, highly automated work environment
- **Faster penetration rates**
  - coil: up to 420 m (1,378 ft) per hour
    - conventional: 120 m (394 ft) per hour
- **Proven to out drill conventional 2 to 1**
  - in Canadian shallow natural gas reservoirs
- **Lower costs for E&P operators of 15 to 50 percent**
- **Average tripping is three times faster**
  - coil 900 m (2,953 ft) per hour
    - conventional 300 m (984 ft) per hour

Source: XTreme Coil Drilling Corp.

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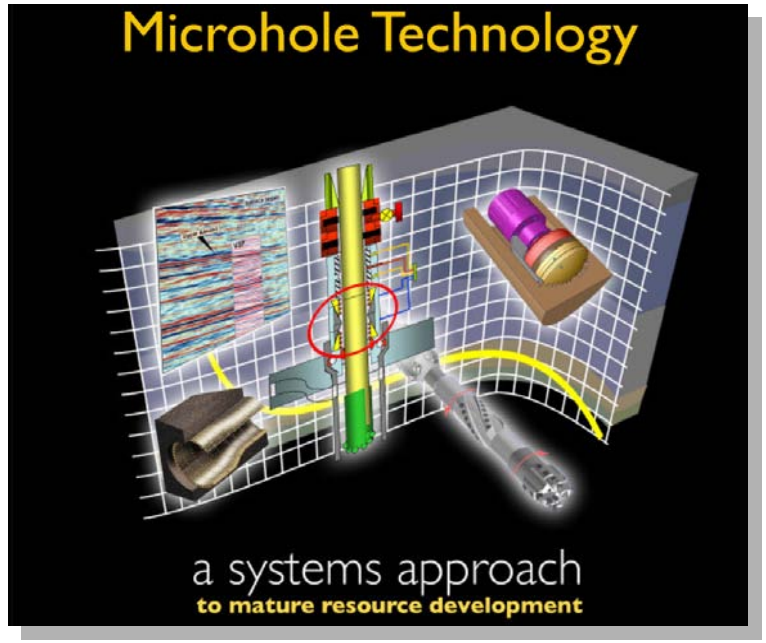
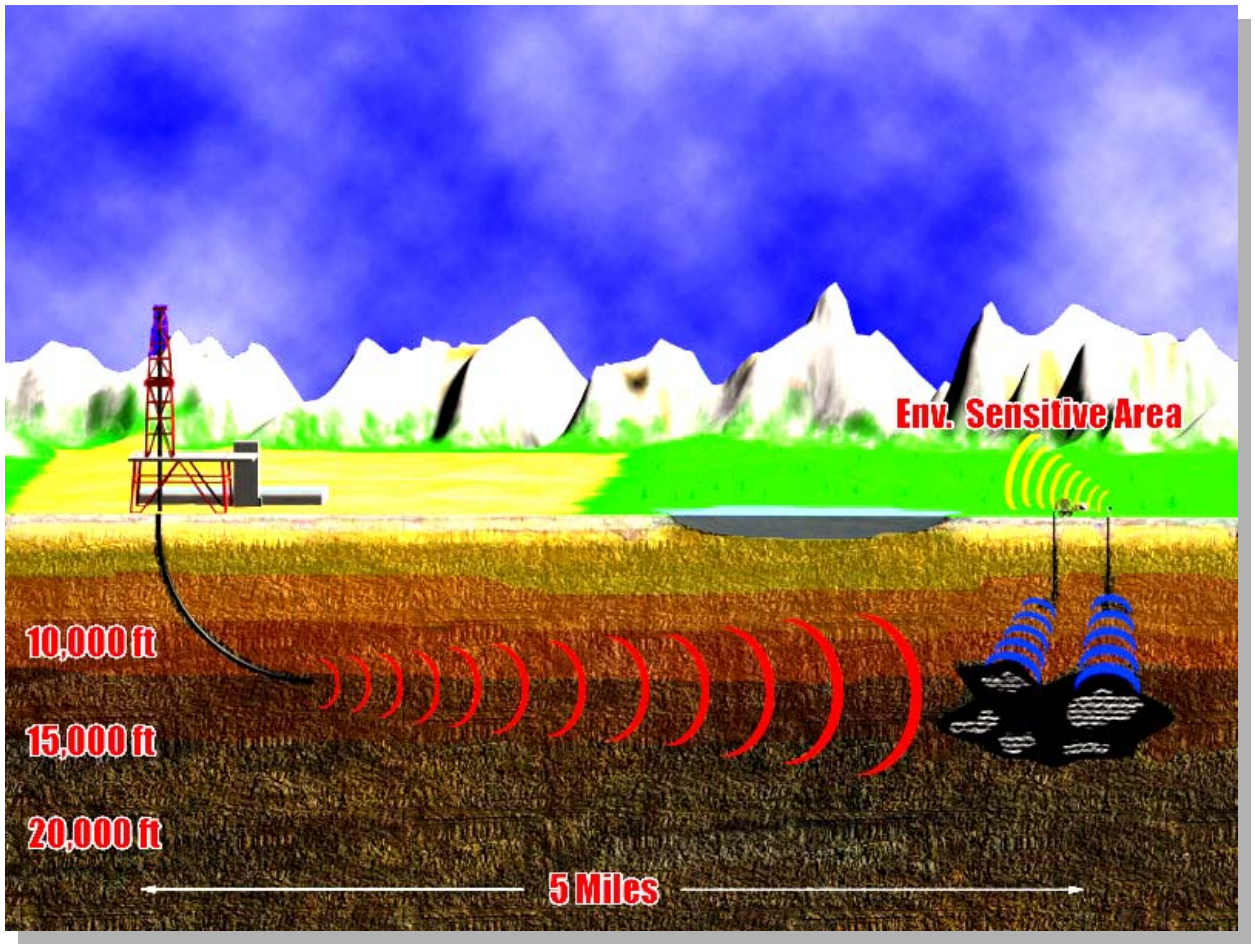


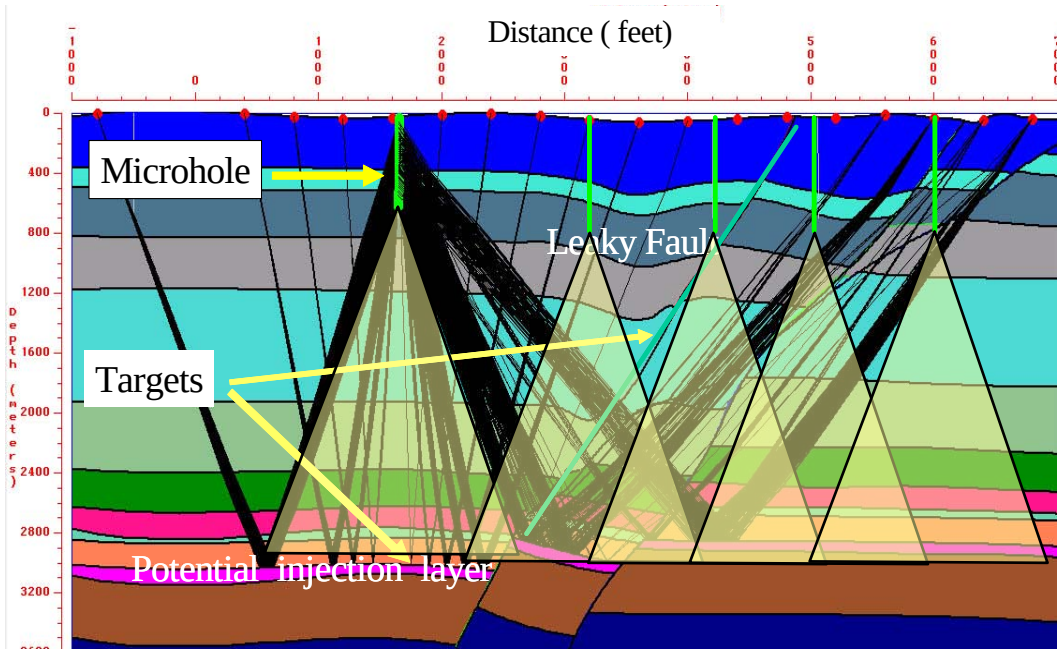
Continued Improvement in VSP Imaging Will Enable:

Deeper, Faster, Lower Environmental Impact Unconventional Gas Resource Development



Imaging: Downward Looking VSP Demonstration

LANL/LBNL



Objective: More & Better Data / Less Cost

- **Demonstrate improved high resolution active seismic**
- **Demonstrate cost effectiveness of shallow, low cost, VSP instrument boreholes for continuous monitoring with active and passive seismic**

Accomplishments

- **Shallow Microhole VSP "sees" up to 4 times (or more) shallow depth**
- **Up to three times better resolution than VSP in conventionally drilled boreholes (much better signal to noise ratio)**

Benefits

- **Permits use of microholes for low cost, rapid VSP deployment**
  - Sensors do not need to be placed at reservoir level
- **Faster, <u>much cheaper</u> high resolution seismic surveys**
  - Using permanently installed shallow, instrument boreholes
- **Could revolutionize complex reservoir characterization and long term EOR monitoring**

Demonstrate Microhole/VSP Imaging for CO_2 EOR (and for Unconventional Gas Monitoring/Modeling)

Objective

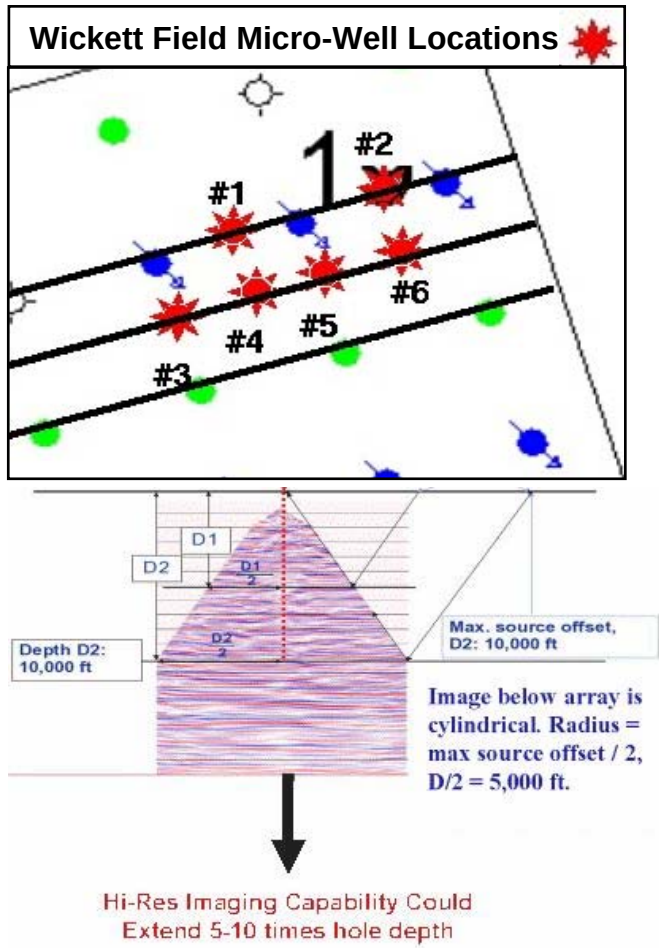
- Demonstrate that high resolution seismic imaging from "downward looking" VSP provides cost effective benefit for CO_2 EOR pilot monitoring

Accomplishments

- One of two successful DOE projects representing first seismic data acquisition R&D in over 20 years
- Successfully drilled 5 purpose built seismic instrumentation holes in December 2006 at Whiting Petroleum's new CO_2 pilot, Wickett Field, TX
- Accomplished active seismic survey in pilot area and installed permanent microseismic monitoring equipment in one of the wells
- Demonstrated autonomous operation capability of microseismic monitoring system monitoring local events
- Permanently installed geophones in July for increased acoustic coupling with higher frequency response and increased resolution
- Repeated second active survey after permanent installation in July to monitor CO_2 pilot
- Interpretation of first survey results, Jan 2008

Benefits

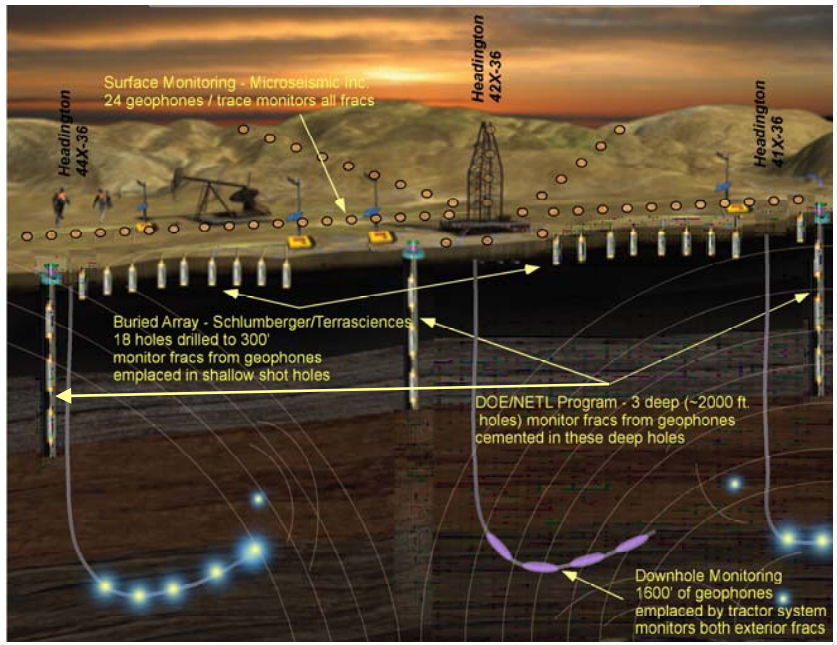
- Will result in lower cost, higher resolution imaging for complex reservoirs and EOR monitoring
- Initial results better than first VSP demonstration



LANL/LBNL (Whiting Petroleum)

Bakken Consortium Study, North Dakota

Latest Application of Downward Looking VSP



- **Bakken Consortium / Schlumberger Seismic Array**
  - 24,000 geophones covering 11,000+ acres
  - 18 holes with permanently installed geophones at 300'
- **NETL / LBL Deep Array**
  - 3 Wells Drilled to ~1,500' ft with permanently installed geophones providing 24/7 monitoring
  - Deep array continuing to collect data during production period that started mid June for seismic monitoring during depressurization
- **NETL / ORD Modeling**
  - ORD developing reservoir Model from hi-res seismic data obtained
  - Expected to accelerate Bakken development in North Dakota / Montana

Graphic courtesy of XTO Energy

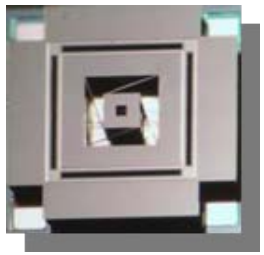
New Award: Lumedyne – "Fabry-Perot MEMS Accelerometers for Advanced Seismic Imaging"

Oil Exploration

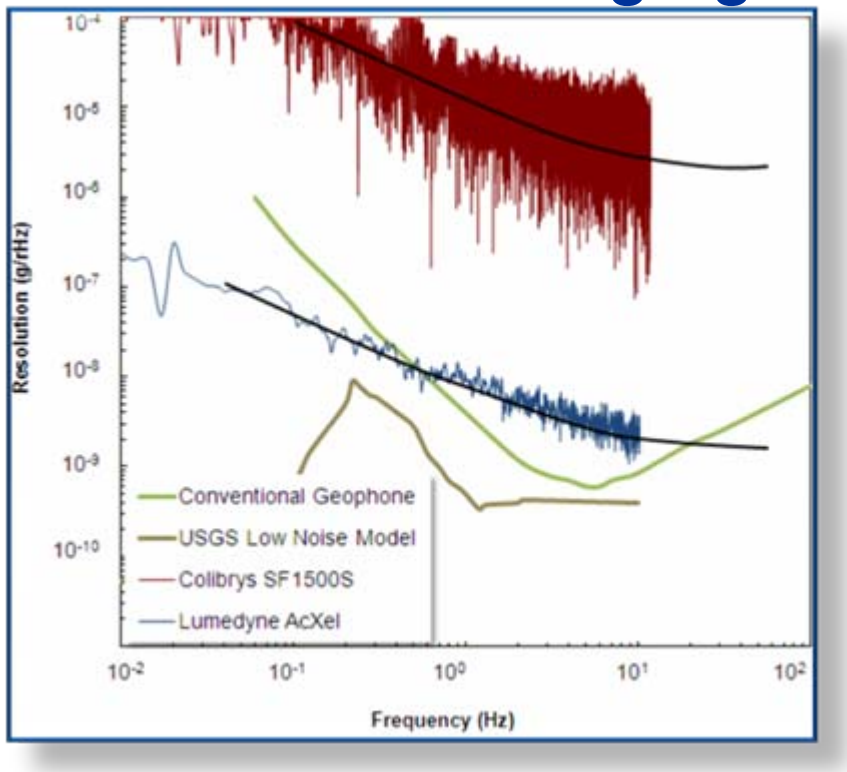
Structural Health Monitoring

Navigation

3mm

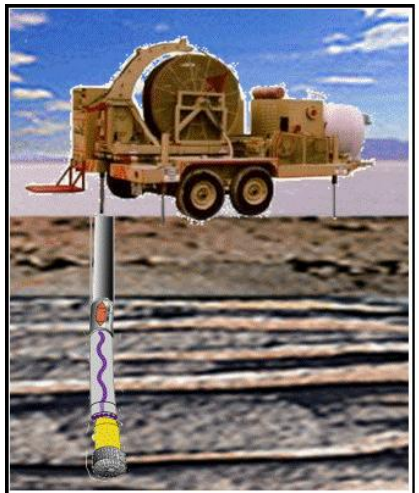


Lumedyne Technologies



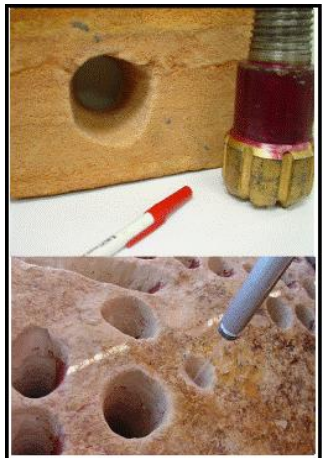
- Extreme Sensitivity: Highest transduction MEMS to date (>75mA/µm – ~10X better)
- Wide Bandwidth: DC to 2000 Hz (Unchallenged)
- Low Noise: <50 ngrms/√Hz (5X @ this bandwidth)
- Lowest Price: Less expensive than geophones

Status of Small, High Energy Drilling Systems
(for Rapid VSP Deployment)



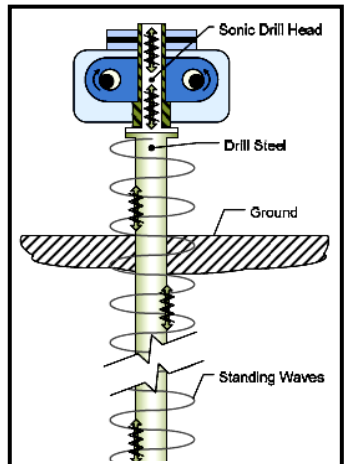
LANL System as Deployed

- **Strengths**
  - Very mobile
  - Small footprint
  - Two man crew
  - 7,500 PSI System
- **Weaknesses**
  - Relies on small oilfield motors
  - ROP limited
  - Mud based
    - **Lost Circulation**



Abrasive Jet Drill Impact Tech.

- **Strengths**
  - Very mobile
  - Small footprint
  - ~7,000 PSI System
  - High ROP in hard rock potential
- **Weaknesses**
  - Jet must be controlled
  - Hi Press motor needed if bit used
  - Mud/fluid based
    - **Lost Circulation**



ResonantSonic Tracking (RST) - Resodyn

- **Strengths**
  - Air transportable
  - Very Small footprint
  - One man crew
  - Almost no fluid/air
  - **1500' achievable with <u>30 HP system</u>**
- **Weaknesses**
  - SBIR PhI success only; no PhII demo
  - PhII SBIR not funded SBIR short of funds

For Additional Information

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www.fe.doe.gov