NATIONAL ENERGY TECHNOLOGY LABORATORY

New and Innovative Drilling Technologies

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U.S. DEPARTMENT OF ENERGY

Outline

- Introduction to DOE-NETL
- YMP Unsaturated Zone Sampling Program
  - Drilling/Sampling Objectives Summary
- Drilling/Sampling Concept
- Coring/Sampling Concept
- Anatomy of YMP's Purpose Built Drilling System
  - LM-300 Specifications
  - LM-300 Rig System Layout
- Purpose Built Concept Applied to Oil & Gas Industry
  - LM-700
  - Hybrid Coiled Tubing Rigs
  - Microhole Technology

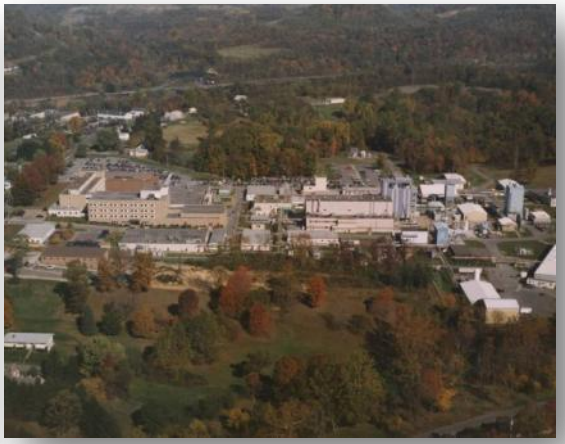
National Energy Technology Laboratory

MISSION

Advancing energy options to fuel our economy, strengthen our security, and improve our environment

Oregon

Pennsylvania

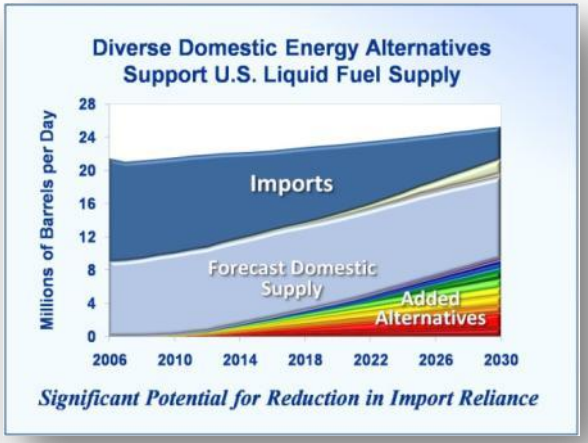


West Virginia

NETL Applies Basic Science to Technology Development, Demonstration & Deployment

Onsite Research and Development

Program and Energy Analysis and Planning



Extramural Research and Collaboration

Developing the critical science and technology to discover and commercialize advanced energy systems that efficiently utilize domestic resources in an environmentally sustainable manner

YMP Unsaturated Zone Characterization Program (Geologic and Hydrologic Requirements)

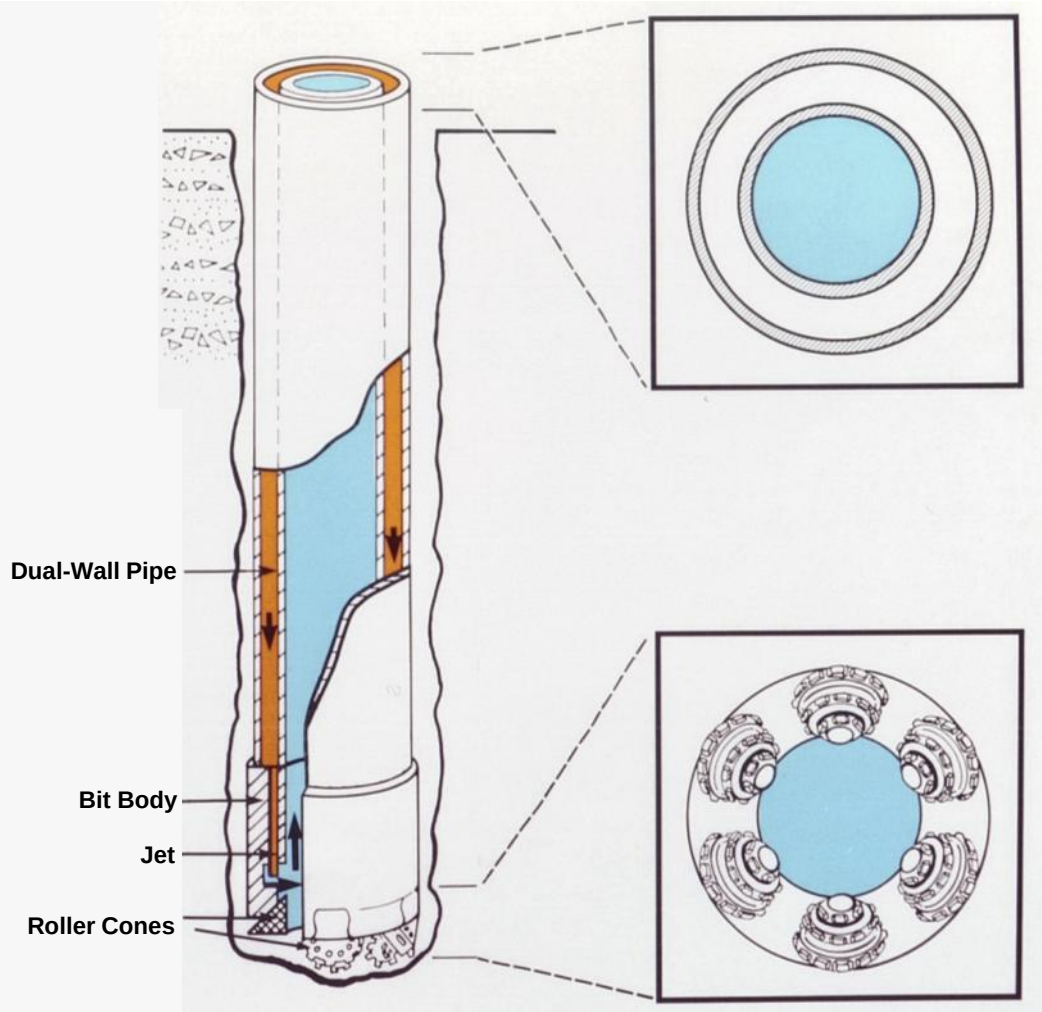
Drilling/Sampling Objectives Summary

- Obtain 2.4” diameter core containing the in situ conditions of the mountain
- Provide 12-1/4” boreholes for hydrologic testing without disturbing the in situ conditions of the mountain

Drilling/Sampling Concept Developed
(Based on Dry Drilling and Coring Technology Workshop Input)

Drilling

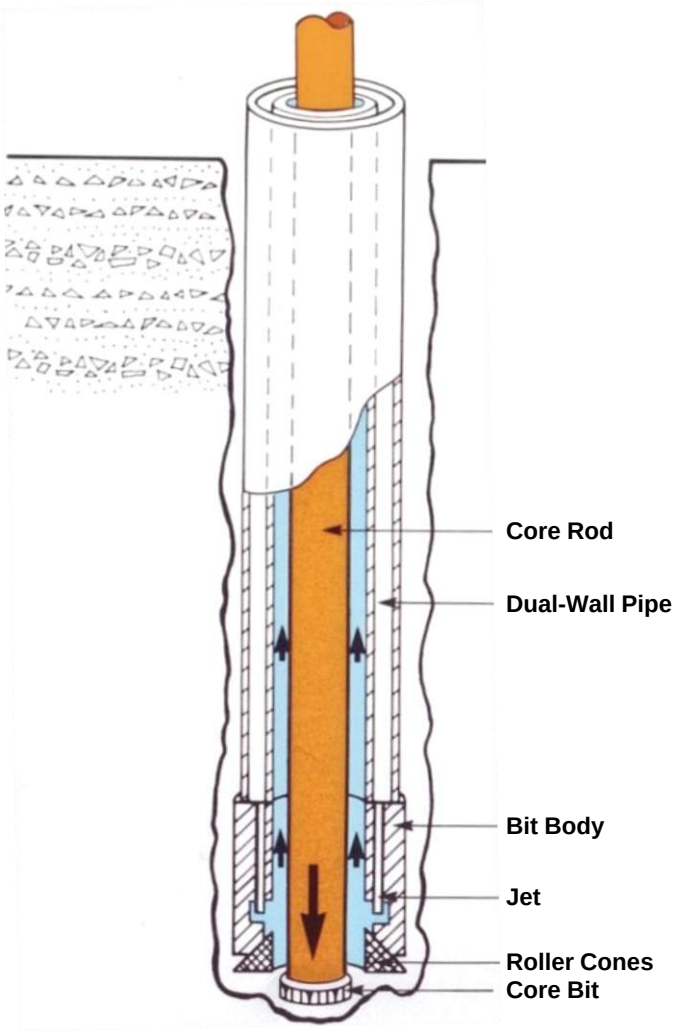
- **High Pressure Air in Orange:**
  - Transmitted to bit via dual wall pipe
  - Provides energy to move cuttings to center of bit/pipe
- **Vacuum Return in Blue:**
  - Vacuum system helps transport cuttings to surface up center of dual-wall pipe (DWP)
  - Injection and Return Air Volumes Balanced
    - No Net Air Charge at Bottom of Hole - Minimal Impact on Hydrology



Coring/Sampling Concept Developed
(Based on Dry Drilling and Coring Technology Workshop Input)

Coring

- **High Pressure Air in Orange:**
  - Transmitted to core bit via core rod
    - Normal Wireline Coring Operations
  - DWP Left in Place to Protect Core Rod from Highly Fractured Intervals
    - Core Taken Through Open Center of DWP
- **Vacuum Return Air in Blue:**
  - Vacuum system helps transport cuttings to surface up annulus between core rod and DWP



Surface System: LM-300 Specifications

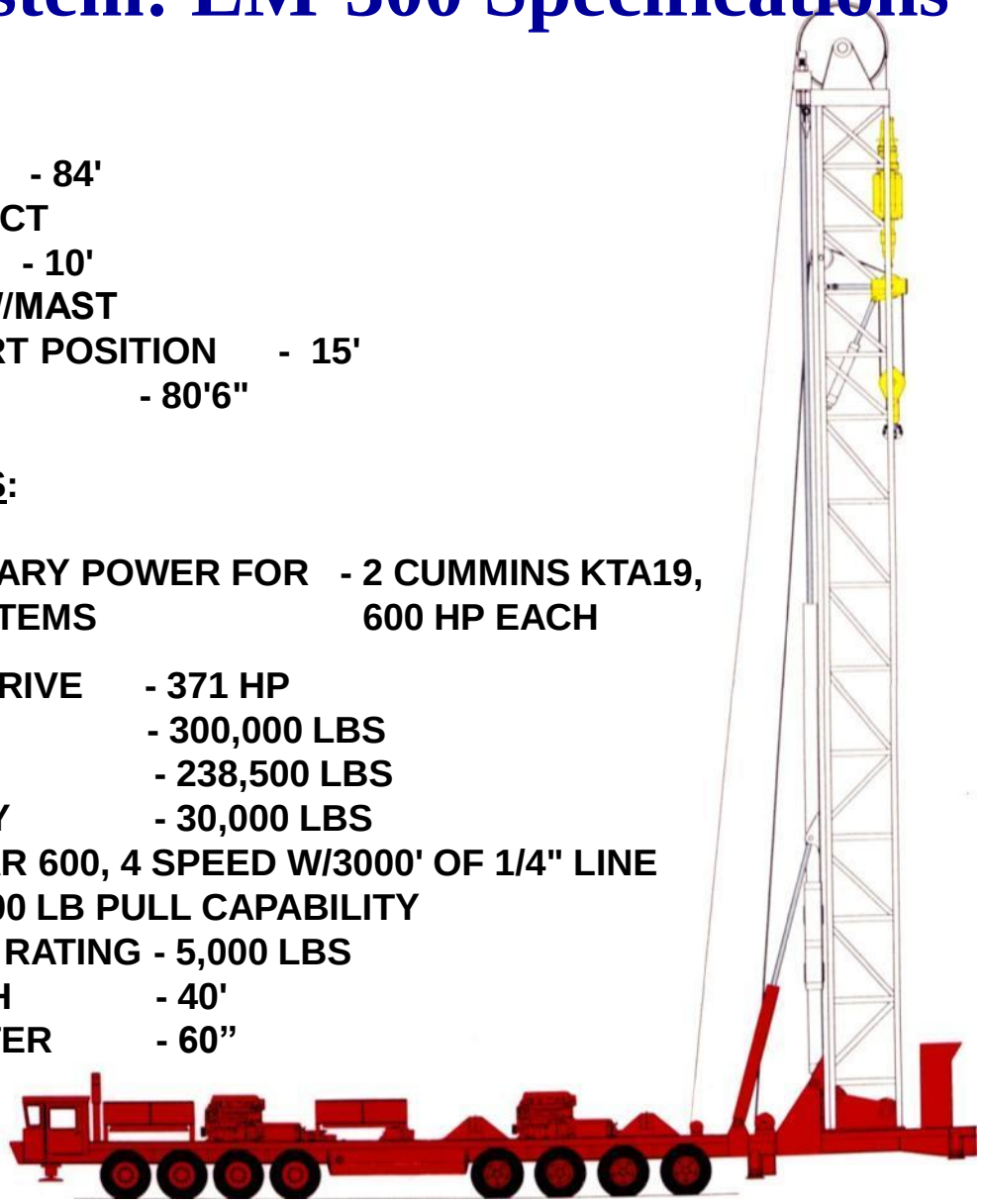
RIG DIMENSIONS:

- **OVERALL HEIGHT - 84'**
  W/MAST ERECT
- **OVERALL WIDTH - 10'**
- **OVERALL HEIGHT W/MAST**
  IN TRANSPORT POSITION - 15'
- **LENGTH OF MAST - 80'6"**

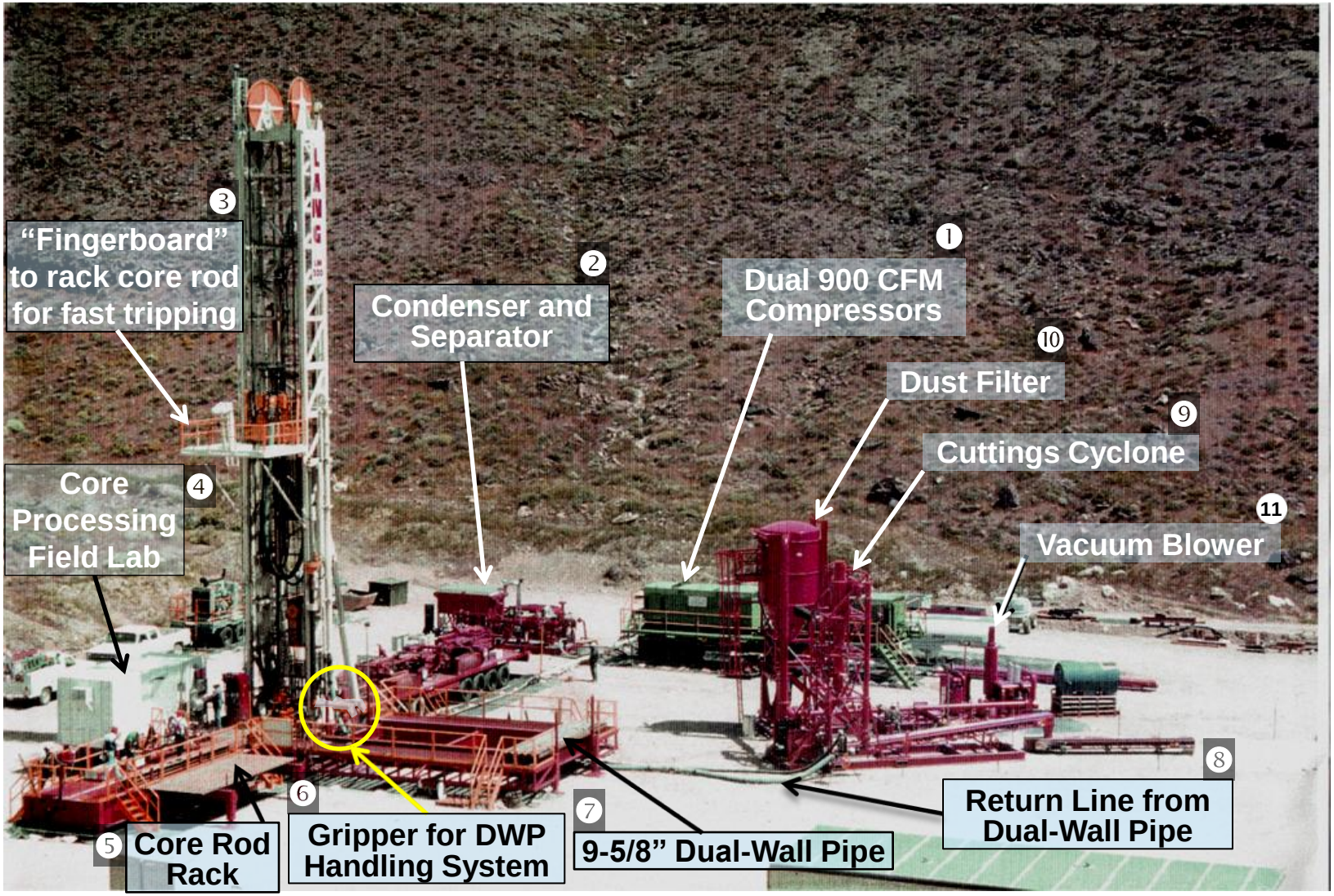
DRILLING CAPABILITIES:

PRIMARY AND SECONDARY POWER FOR HYDRAULIC/DRIVE SYSTEMS - 2 CUMMINS KTA19, 600 HP EACH

POWER TO TOPHEAD DRIVE - 371 HP
MAX. MAST LOAD - 300,000 LBS
PULLBACK CAPABILITY - 238,500 LBS
PULLDOWN CAPABILITY - 30,000 LBS
MAIN HOIST - LONGYEAR 600, 4 SPEED W/3000' OF 1/4" LINE AND 70,000 LB PULL CAPABILITY
PIPE HANDLING WINCH RATING - 5,000 LBS
MAX. TUBULAR LENGTH - 40'
MAX. TUBULAR DIAMETER - 60”



LM-300 Rig System Layout



LM-300 Concept Adapted for Oil & Gas Industry
The LM-700 Drilling Rig

LM-700 RC Drilled Severe Lost Circulation Basalt Zone to 7,800’

Conventional Rig Drilled Rest of Section to 14,000’

Photos courtesy of Oil and Gas Journal

CTD Demo for Marginal Oil and Gas Resources

High Efficiency Technologies for Unconventional Gas

Objectives

- **Demonstrate first high efficiency hybrid CT rig built and operating in U.S.**

Accomplishments

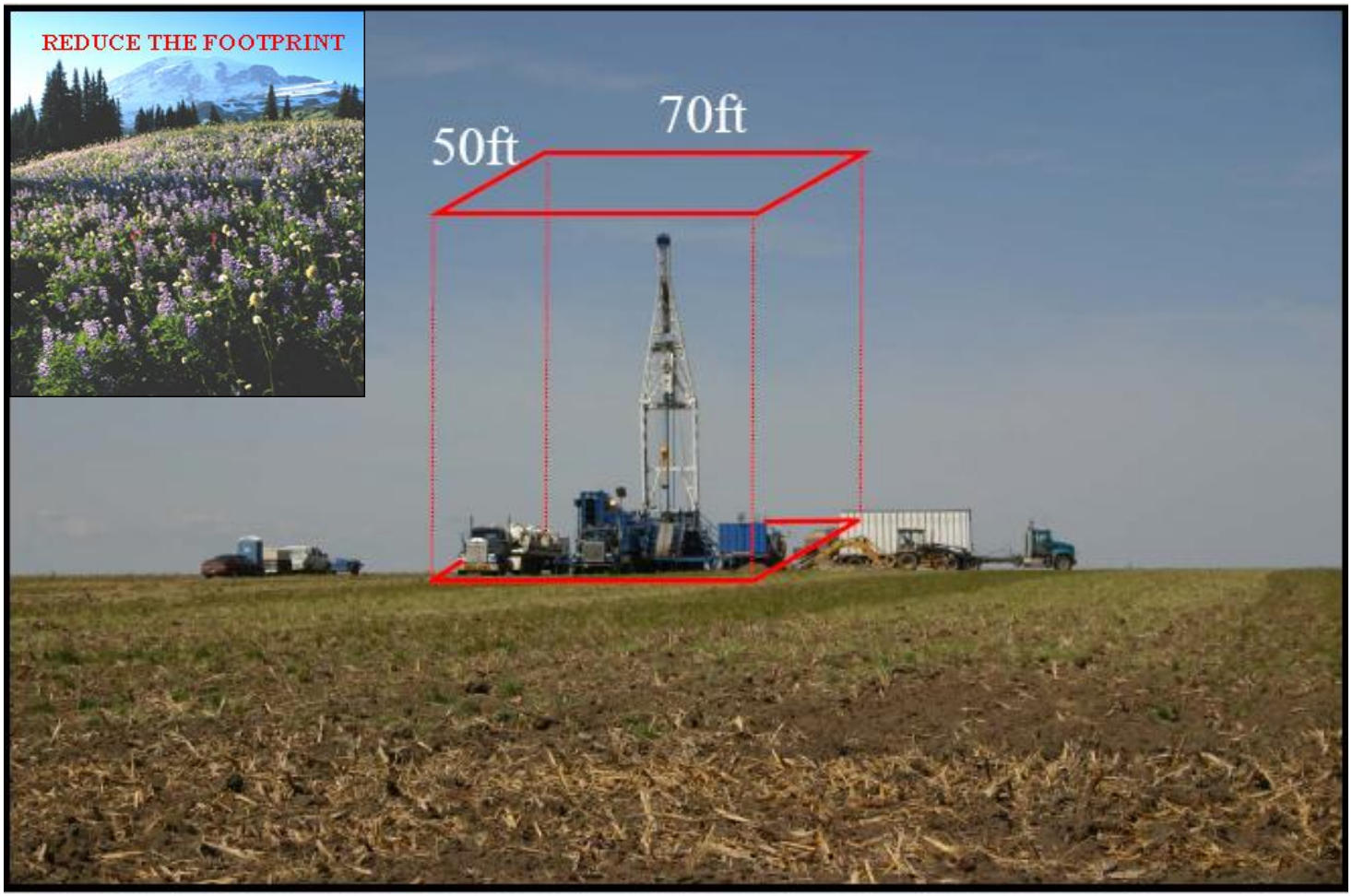
- **Drilled 25 wells in the Niobrara**
  - **300,000 feet of hole in 7 months**
  - **Drilled and completed 3,000' wells in 19 hours**

Benefits

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

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

Access: Coiled Tubing Drilling
Reduces Drilling Cost and Environmental Footprint



Rapid Growth of Coiled Tubing Drilling

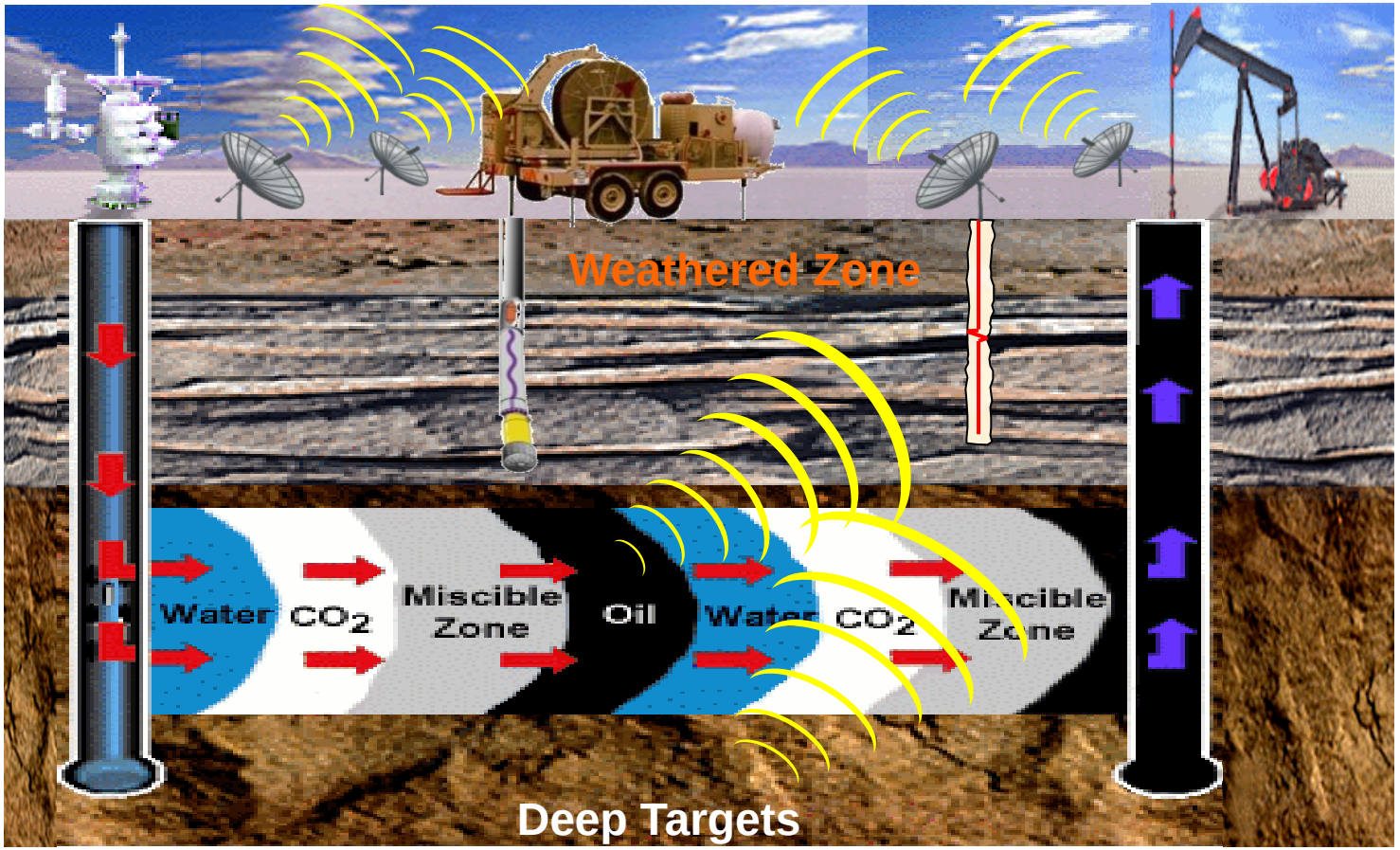
The New Wave of High Efficiency Technologies

- **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 12/14,000' coil/rotary capability

CO_2 Project Results at Teapot Dome, WY Using VSP Microhole Technology



(Ref. October, 2006 Issue of SEG's Leading Edge – "Cost-effective imaging of CO2 injection with borehole seismic methods": http://tle.geoscienceworld.org/

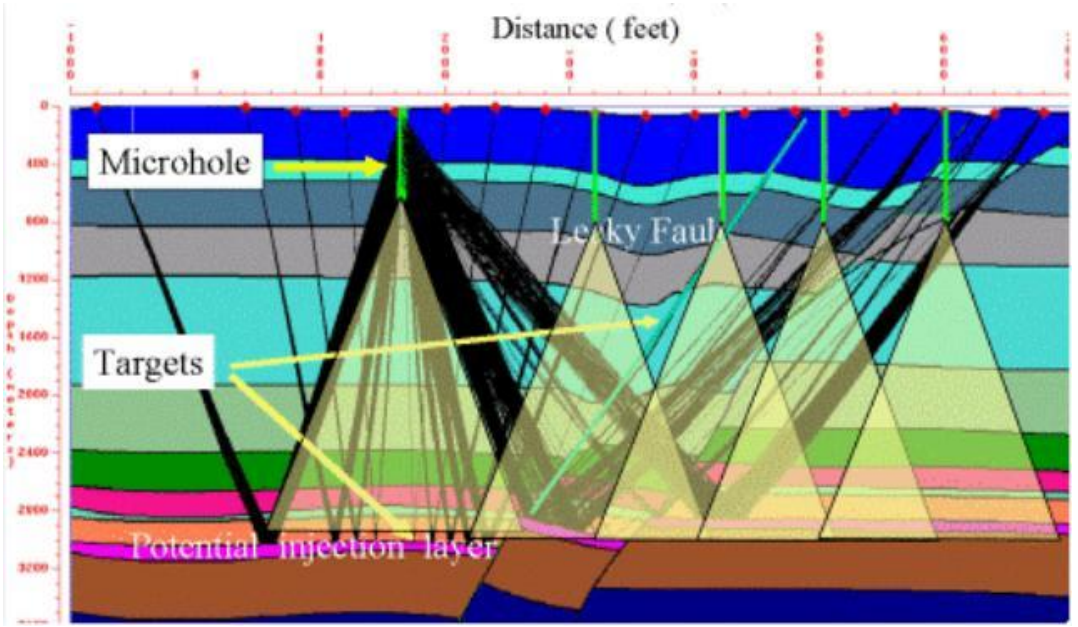
Note: Modified from Kinder Morgan CO_2 LP

Demonstrate Microhole/Downward Looking VSP

LANL/LBNL

Objective

- Demonstrate improved high resolution active seismic (uses man-made sound source)
- Demonstrate cost effectiveness of shallow, low cost, VSP instrument boreholes for continuous monitoring with active and passive seismic (uses naturally occurring sound source)



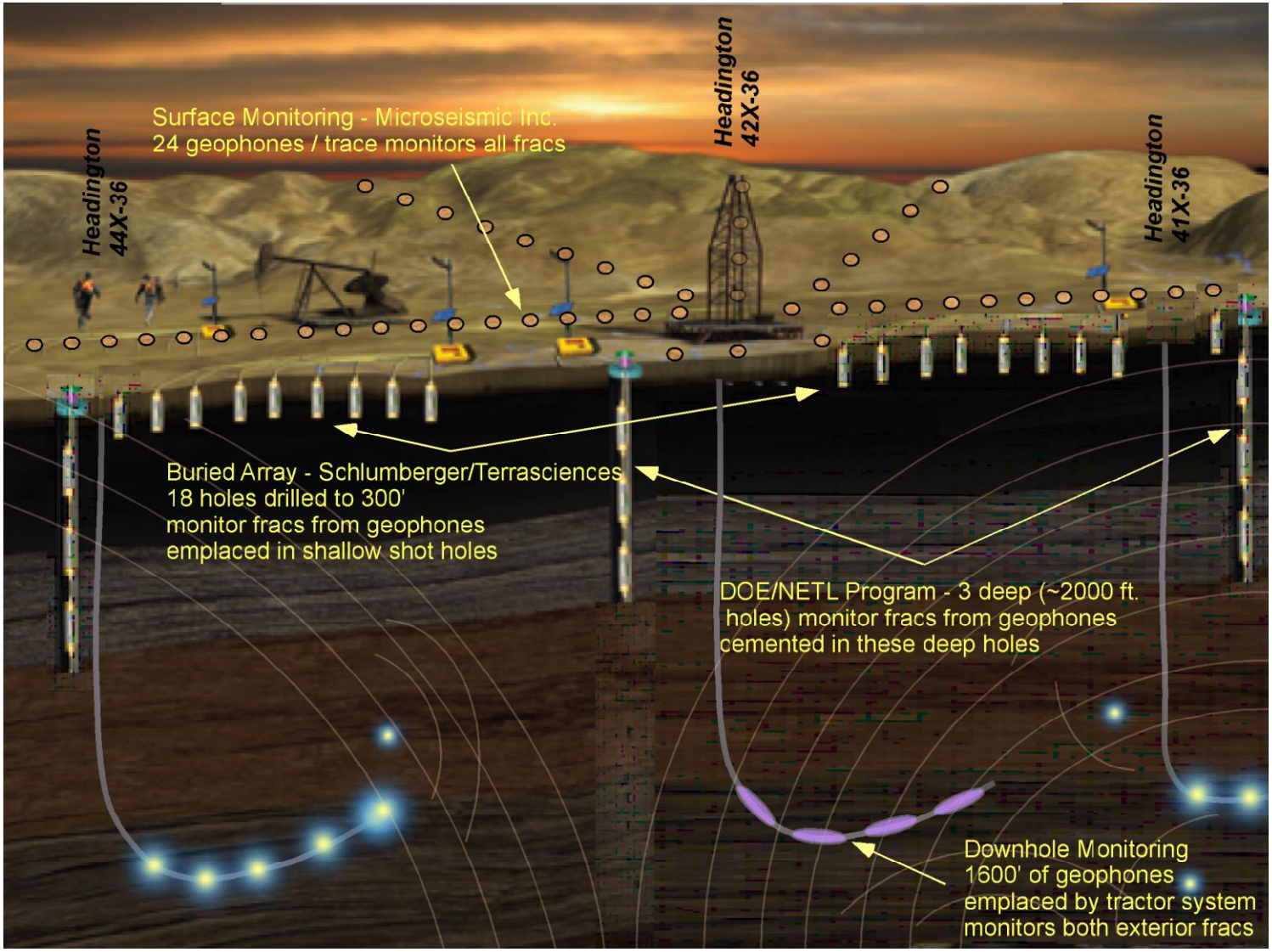
Accomplishments

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

Benefits

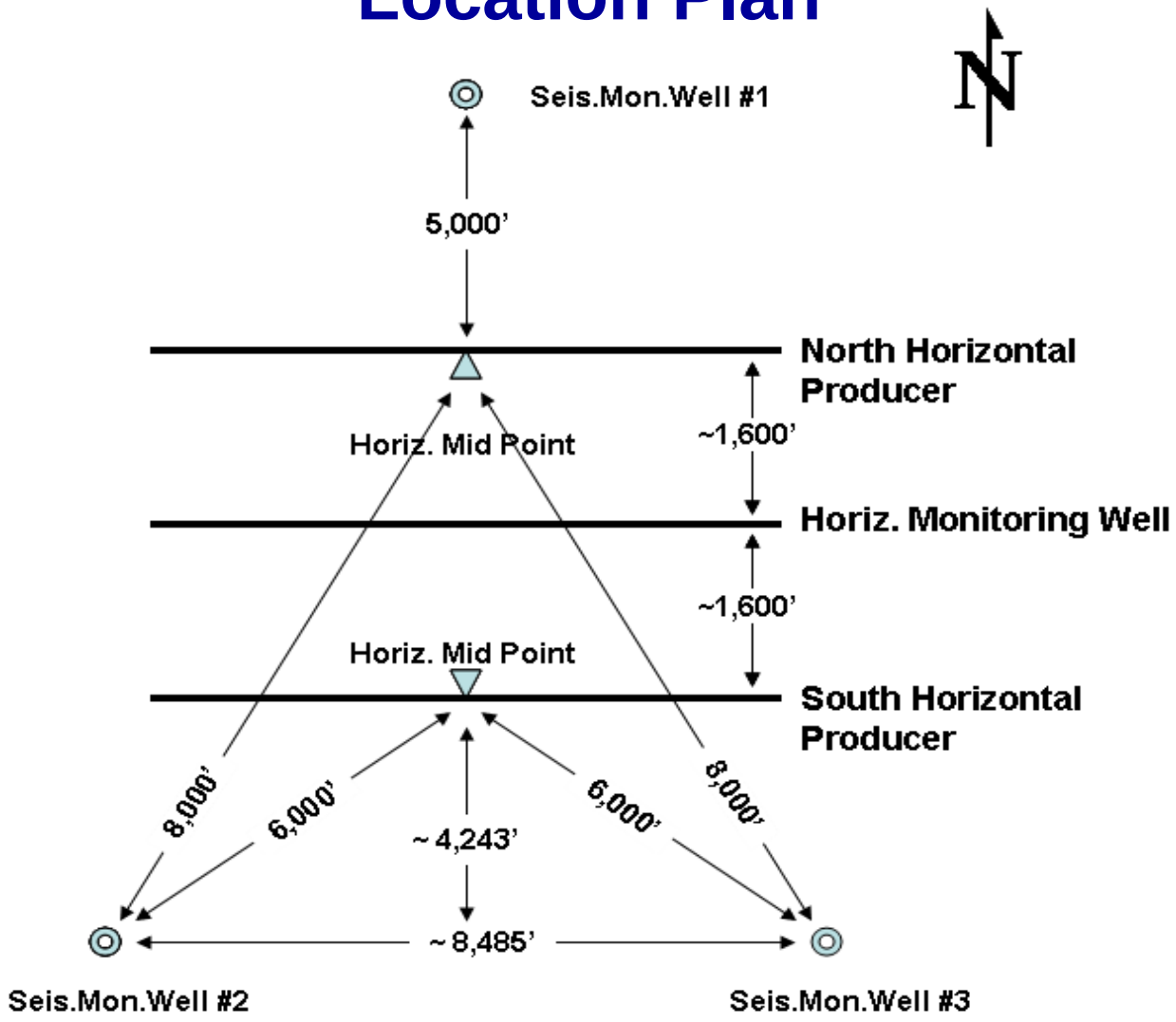
- Permits use of microholes for low cost, rapid VSP deployment because sensors do not need to be placed at reservoir level
- High resolution seismic surveys can be faster and much cheaper with permanently installed shallow, instrument boreholes
- Cost effective, permanent VSP boreholes could revolutionize complex reservoir characterization and long term EOR monitoring

Bakken Consortium Study, North Dakota

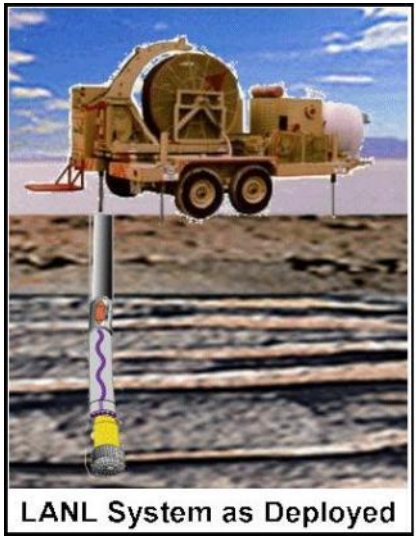


Graphic courtesy of Headington Oil Company

Seismic Monitoring Well
Location Plan



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

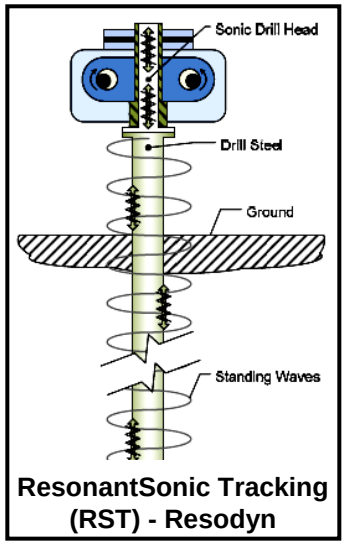


LANL System as Deployed

- **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**

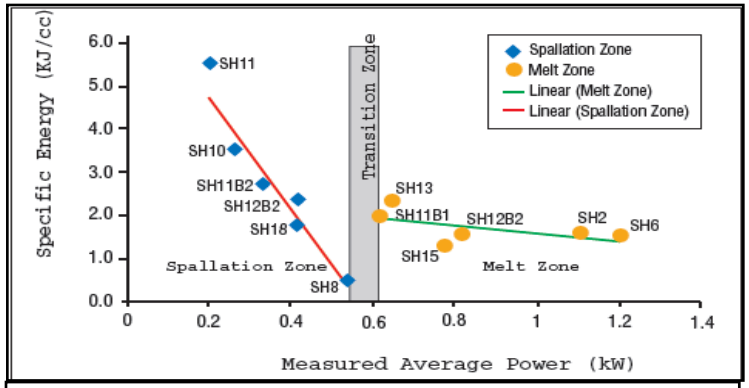


ResonantSonic Tracking (RST) - Resodyn

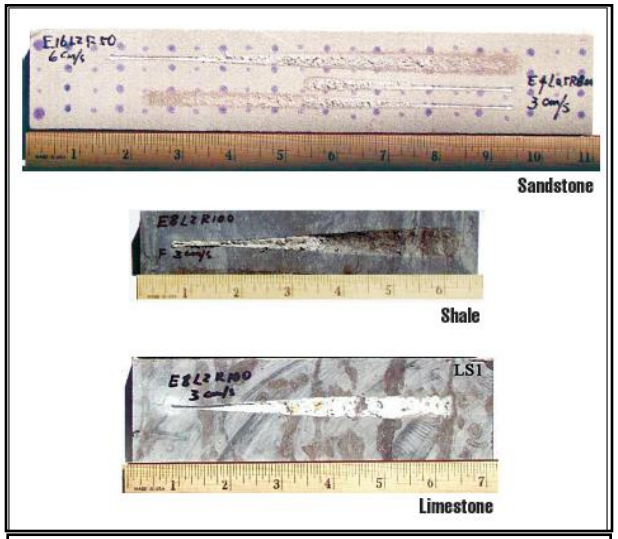
- **Strengths**
  - **Air transportable**
  - **Very Small footprint**
  - **One man crew**
  - **Almost no fluid/air**
  - **1500’ achievable with 30 HP system**
- **Weaknesses**
  - **SBIR PhI success only; no PhII demo**
  - **PhII SBIR not funded SBIR short of funds**

Future High Energy Drilling Systems?

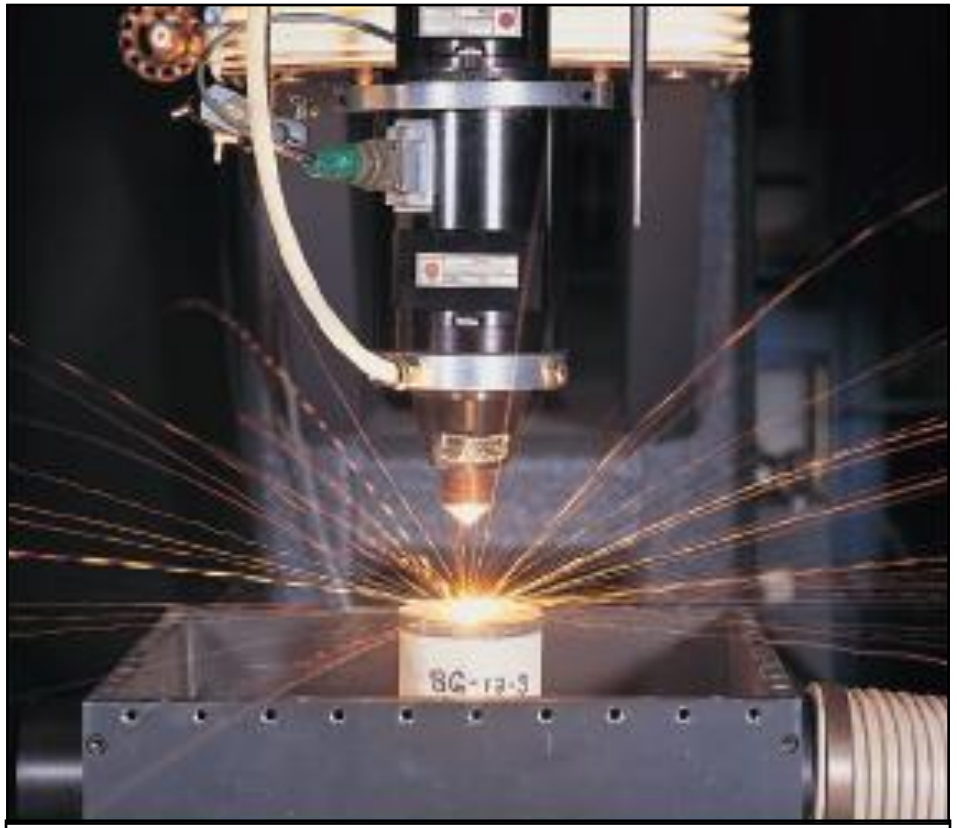
(for Rapid VSP Deployment)



Specific Energy vs. Power for 0.5 Second Laser Exposure



Laser-Rock Reaction Zones Across a Range of Calculated Power Densities



Nd:YAG Laser-Rock Reaction

Questions