U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Technologies for Tomorrow's E&P Paradigms

Microhole Technology

Change your perspective

June 2005

Microhole Technologies

Reduce Drilling Costs and Environmental Impact

Increase Reservoir Imaging Resolution and Real-time Data Acquisition

DOE's Microhole Initiative is developing technologies that enable Coiled Tubing Drilling of 3½-inch diameter and smaller boreholes using innovative, hybrid coiled tubing drill rigs.

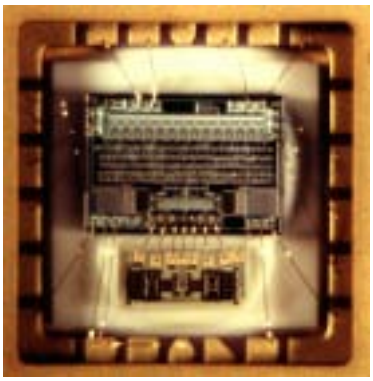
These new technologies will support business models for:

- Development of Shallow (≤5,000 feet), Currently Uneconomic Oil and Gas Resources.
  - Lower Drilling Costs result from reduced rigtime, materials, labor, and support equipment.
  - Less Environmental Impact results from reduced drilling waste, smaller footprints, and increased transportability for remote, fragile terrains. Pad drilling allows extended wellbore reach without increased environmental risk.

Tom Gipson, New Force Energy Services

- New Economic Seismic Technologies for Reservoir Imaging.
  - Decrease finding costs by proving exploration targets more economically.
  - Acquire high-resolution, real-time reservoir information from dedicated boreholes with permanently installed reservoir monitoring systems. Monitor and optimize Improved Oil Recovery (IOR) processes for maximum recovery efficiency.
  - Control data collection locations with "designer seismic" concept, which allows data to be collected where and when they are needed rather than where production/injection wells have been drilled.
  - Reduce time of production interruption while collecting reservoir data.
  - Miniaturize instrumentation using MEMS (MicroElectroMechanical) technologies.

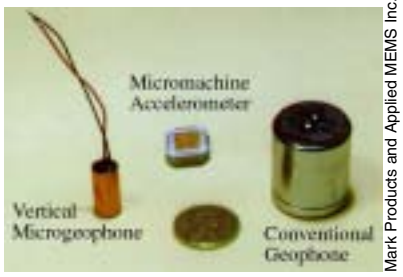
Microhole technologies are expected to:



Silicon Designs

A MicroElectroMechanical (MEMS) accelerometer.

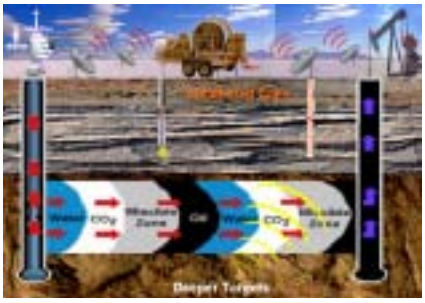
- Enable independent producers to invest in a new wave of infill drilling of shallow development wells.
- Be an enabling technology for new high resolution seismic imaging utilizing MEMS technologies. This technology program is expected to result in unprecedented seismic imaging using miniaturized sensors for:
  - High-resolution exploration methods for developing exploration targets.
  - Low-cost, long-term monitoring for improved imaging of fluids moving through the reservoir during IOR operations. This capability is expected to significantly enhance recovery of the 218 billion barrels of oil resource known to be less than 5,000 feet deep.



Mark Products and Applied MEMS Inc.

Miniature seismic sensors now under development have a performance approaching that of conventional geophones.

- Allow low-cost dedicated boreholes for reservoir monitoring, eliminating interruption of production. This new-found geophysical capability utilizing Vertical Seismic Profiling (VSP) is referred to as "designer seismic" because, for the first time, the geophysicist will be able to pick the location of the instrument package rather than utilize an existing well for a short time while production is shut-in.



Kinder Morgan

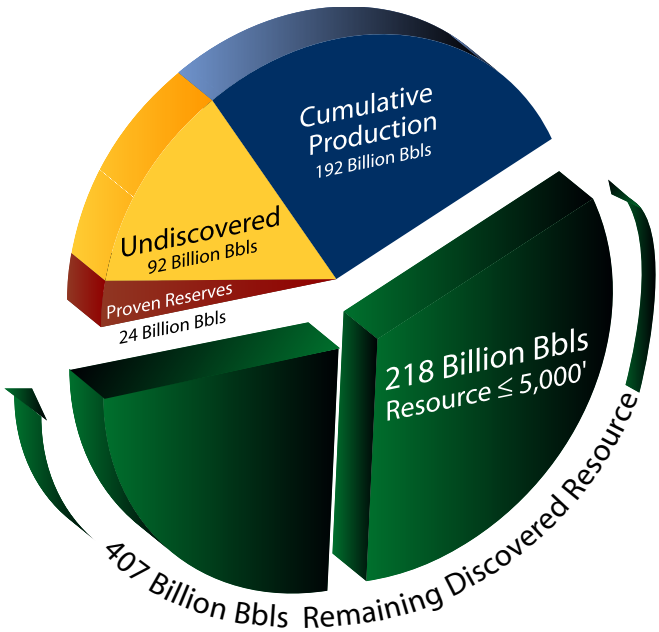
Permanent seismic reservoir monitoring allows imaging of a CO_2 flood.

- Allow economical re-entry of existing wells to increase production from by-passed zones. It will also provide a reliable capability to deepen thousands of boreholes across the U.S. This will encourage deeper exploration in existing fields because the top section of the hole already has been drilled.

why is it needed?

Only about one quarter of technically recoverable domestic oil resources is considered economically recoverable even at today's high oil prices. The attraction of microhole drilling is the prospect of greatly reducing the cost of drilling shallow- and moderate-depth holes for exploration, field development, long-term subsurface monitoring, and to a limited degree, actual oil and gas production. If the costs of these activities can be reduced, oil and gas reservoirs that are uneconomic to produce today could be rendered economically viable.

The fact that microhole technologies reduce the costs of overall operations makes exploration and production of domestic resources economically attractive to the independent operators that produce most of the domestic oil. These new low-cost production and reservoir monitoring capabilities are needed to invigorate the domestic oil and gas industry and enable it to recover significantly more of the petroleum resource in America's mature basins.



what are the expectations?

Microdrilling technologies along with micro-instrumentation are expected to provide low-cost wells for exploration, long-term reservoir monitoring, and increased production. Reduction in materials, labor, and support equipment all serve to reduce drilling costs by as much as one half the cost of drilling a conventional well. Volumes of drilling fluids and cuttings could be lowered by one fifth, reducing disposal costs. Smaller footprints and lower disposal volumes lower the environmental impact of drilling activities, making microhole drilling applicable in environmentally sensitive areas. Overall coiled tubing drilling efficiency improvements are expected to be a carryover benefit from this program that may be applied in ultra-deepwater operations.

The economic and environmental benefits resulting from the Microhole Initiative are expected to increase E&P activities, thereby increasing domestic oil and gas production and revenues from Federal Lands. An additional 10% recovery of the remaining 218 billion barrels of oil from reservoirs less than 5,000 feet deep is a conservative estimate of the potential results of the Microhole Initiative—this represents 10 years of OPEC imports.

Microhole Solicitation I

The Microhole Initiative was based in part on miniaturization of seismic sensors, microhole rig development, and feasibility studies conducted by Los Alamos National Laboratory (LANL) and its industry partners. The successful feasibility study and demonstration of coiled-tubing-deployed microdrilling provided a promising indication that microholes could assume an important role in increasing recovery from domestic oil and gas fields.

The first solicitation from the Microhole Initiative focused on field demonstrations and development of technologies needed to employ coiled-tubing microhole drilling in the field. Specific areas addressed were:

Field Demonstration

Conduct demonstrations of existing 4¾-inch commercial microhole technology and applications in selected regions of the United States.

Built-for-Purpose Microhole Coiled Tubing Rig

Design Microhole Coiled Tubing Rigs that can drill 1-inch through 2⅜-inch coiled tubing boreholes with low-density, compressible drilling fluids.

Self-Contained "Zero-Discharge" Drilling Mud System

Develop microhole-specific mud systems that are truck-, trailer-, or skid-mounted and that meet USDOT regulations. The mud system must be able to mix, circulate downhole, clean and hold diesel- or water-based drilling mud and be compatible with an underbalanced drilling system.

Microhole Coiled Tubing Bottomhole Assemblies

Develop Measurement-While-Drilling, Logging-While-Drilling, Directional Assemblies, and Positive Displacement Motors suitable for drilling 3-inch boreholes.

Microhole Completion and Production Equipment.

Develop completion and production equipment appropriate for ultra-small diameter boreholes.

Los Alamos National Laboratory coiled tubing microdrilling unit used in field demonstration.

Microhole Solicitation I Awards

Project Updates Spring 2005

Baker Hughes

Baker Hughes 2⅜ inch CoilTrak™ coiled tubing drilling assembly. The project will develop a geosteering device and a resistivity module to add to this commercially available drilling assembly.

Baker Hughes Inteq, Houston, TX

"Microhole Smart Steering and Logging-While-Drilling System"

Area: Bottomhole Assemblies

Baker Hughes Inteq is designing and fabricating a drillbit steering device along with a tool that measures the electrical resistivity of the rock. Both the drillbit steering device and the motor will be 2⅜-inch diameter to serve a 3½-inch or smaller hole size. The modules will be designed so they fit seamlessly in the currently commercially available 2⅜-inch CoilTrak™ coiled tubing drilling assembly module. These tools are expected to provide a modular and effective coiled tubing drilling system that enables the drillbit to stay within the target reservoir zone, thereby increasing production.

Status (April 2005): Initial work has determined the feasibility of modifying current technology for microhole applicability. Baker Hughes INTEQ is currently reviewing the design to determine whether to enter into the manufacturing stage. For more information, contact Sue Mehlhoff, phone: 918-699-2044; email: sue.mehlhoff@netl.doe.gov.

Bandera Petroleum Exploration, Tulsa, OK

"Advanced Mud System for Microhole Coiled Tubing Drilling"

Area: Self-Contained Zero-Discharge Drilling Mud System

Bandera Petroleum Exploration is designing a zero-discharge drilling mud system compatible with coiled tubing drilling that eliminates mud pits and incidental spillage of drilling fluid onto the ground. The mud system is expected to mix the required fluids, circulate that mixture downhole, clean and store the returned fluids, and be able to perform these functions in a contained system.

Bandera Petroleum

Bandera Petroleum Exploration will demonstrate a zero-discharge drilling mud system.

A second aspect of the project is to assess the application of abrasive slurry jet drilling to microhole drilling technology. Abrasive slurry jetting accommodates the non-rotating nature of coiled tubing and creates drill cuttings small enough to be cleaned from horizontal well sections.

Status (March 2005): The design of the mud system is complete. Mud system characteristics, hydraulics, composition of returned fluids, and operating parameters for the entire mud system have been defined. The mud properties have been investigated, and the underbalanced drilling hydraulics are confirmed. For more information, contact Jim Barnes, phone: 918-699-2076; email: jim.barnes@netl.doe.gov.

Gas Production Specialists

Gas Production Specialists slimhole electric submersible motor.

Gas Production Specialists, LLC, Lafayette, LA

"Development of Through-Tubing (Microhole) Artificial Lift System"

Area: Completion and Production Equipment

According to the Minerals Management Service, two thirds of the 17,402 active oil and gas wells in the Gulf of Mexico are shut in, many due to depleted reservoir pressure and resultant inability to flow. Gas Production Specialists is developing an artificial lift system with a 2⅛-inch outside diameter electric submersible motor with pump to remove downhole fluids that hinder gas production. The lift system developed is expected to address problems of mature, low-pressure gas reservoirs that can't overcome the weight of the well-bore fluids, thereby preventing gas production. The technology will allow operators, particularly those in the Gulf of Mexico, to reactivate wells that can no longer flow by natural reservoir pressures.

Status (April 2005): The downhole motor, pump, and gear for the lift system have been designed and are being manufactured. The electric submersible motors have been delivered. After the bottomhole assembly is complete, surface bench testing will begin. For more information, contact John Ford, phone: 918-699-2061; email: john.ford@netl.doe.gov.

Schlumberger

Example of a coiled tubing drilling rig currently used by Schlumberger. In this project a "built-for-purpose" microhole coiled tubing drilling rig will be developed and built that has a small footprint, is easy to move, and fast to mobilize.

Schlumberger IPC, Sugarland, TX

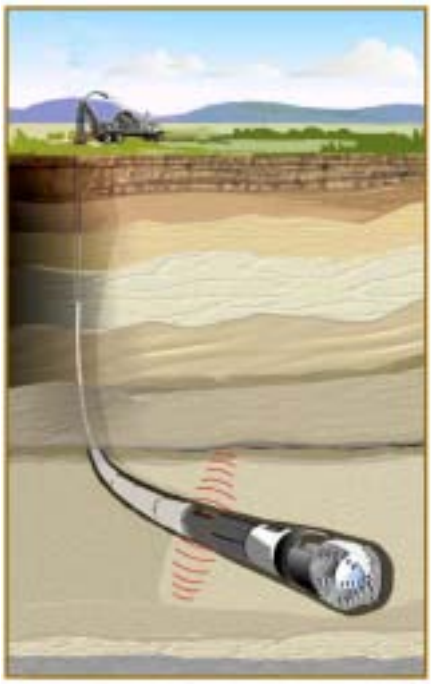
"A Built-for-Purpose Coiled Tubing Rig"

Area: Built-for-Purpose Microhole Coiled Tubing Rig

Schlumberger is designing and building a microhole coiled tubing drilling rig that is designed specifically for the abundant shallow oil and gas reservoirs found in the Lower 48 states. The rig is being designed to improve the economics of shallow well drilling by using small and purpose-built equipment that is easy to move and fast to mobilize, yet versatile in its application. The drilling rig will be able to perform overbalanced and underbalanced drilling work for both new and existing wells.

Status (March 2005): A market analysis showed that for microhole technology to emerge as a commercial technology, coiled tubing drilling would first have to compete with conventional rigs in the shallow drilling market. The study also showed that the economic success of microhole drilling technology depends on development of supporting well completion and reservoir characterization technology. For more information, contact John Ford, phone: 918-699-2061; email: john.ford@netl.doe.gov.

Stolar Research



Radar-guided drilling system will be integrated with a coiled tubing bottomhole assembly.

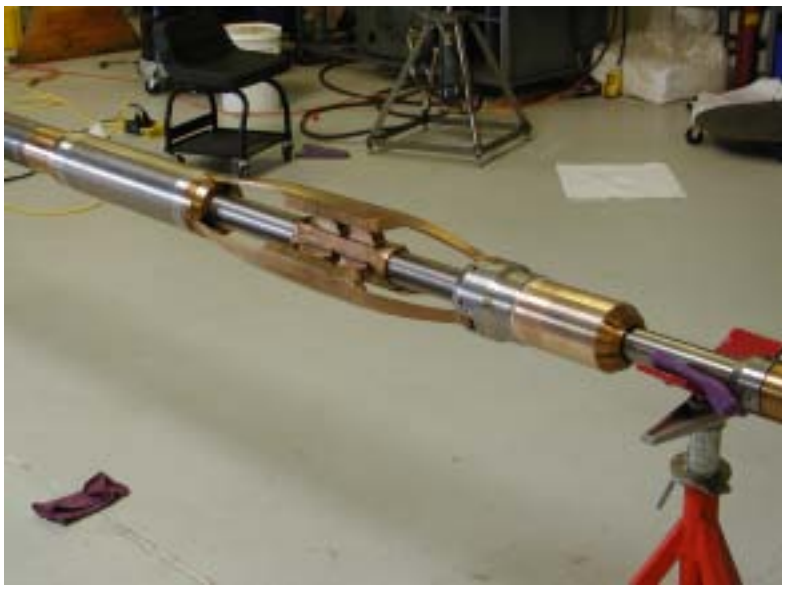
Stolar Research, Raton, NM

"Development of Radar Navigation and Radio Data Transmission for Microhole Coiled Tubing Bottom Hole Assemblies"

Area: Microhole Coiled Tubing Bottomhole Assemblies

A major problem during directional drilling is staying within the target zone. Stolar Research is developing a radar navigation tool to "see" ahead of the drillbit that will differentiate between rock and fluid types up to 200 feet in front of the bit. The radar electronics will fit into a 1½-inch diameter housing. Signal transmission to the surface will be accomplished with the concurrently developed radio data transmitter.

Radar is being used to determine the location of the drillbit, and radio data transmission communicates the measurement data to the surface. Radar is integrated with the coiled tubing bottomhole assembly, and radio data transmission is accomplished either directly along the coiled tubing or via an insulated slickline run to the surface inside the coiled tubing. For more information, contact Purna Halder, phone: 918-699-2084; email: purna.halder@netl.doe.gov.



Coiled tubing drilling tractor for drillbit transport in horizontal well sections.

Western Well Tool, Anaheim, CA

"Microhole Downhole Drilling Tractor"

Area: Microhole Coiled Tubing Bottom Hole Assemblies

The main purpose of horizontal oil well drilling is to drill through more of the reservoir than is possible with a single vertical well. Increased reservoir contact increases oil production. The length of a horizontal well is limited by drillstring drag in the borehole. Western Well is designing and building a reliable and economical hydraulically powered coiled tubing drilling tractor that transports the drillbit and measurement tools into long (3,000 ft+) sections of horizontal wells. The prototype drilling tractor will operate inside a 3½-inch borehole and be field-tested with a commercial coiled tubing rig. Multiple re-entry, inclined, and horizontal holes will be drilled.

Status (March 2005): The design of the microhole tractor is near completion. Design of the control assembly valve components and subassembly is being completed. Several design improvements for easier assembly have been created and designed. For more information, contact Ginny Weyland, phone: 918-699-2041; email: virginia.weyland@netl.doe.gov.

Microhole Solicitation II Awards

The Department of Energy in January 2005 announced the award of funding for 10 projects that are designed to push microhole technology another step closer to commerciality and widespread adoption by the U.S. oil and gas industry. Awards include two field demonstration projects conducted in 4¾-inch boreholes and new technology development projects for 3½-inch boreholes. It was the second round of funding under the Microhole Initiative.

The 10 new projects are:

Geoprober Drilling Inc., Houston, TX. This project calls for drilling three wells with an innovative composite coiled tubing drilling system and a 3⅛-inch diameter bottomhole assembly. The aim is to confirm the capability to drill low-cost, shallow slim/microhole exploration wells in water depths ranging up to 10,000 feet. (DOE share: $1 million; Project duration: 12 months.) Contact: Paul West; phone, 918-699-2035; e-mail, paul.west@netl.doe.gov.

Gas Technology Institute, Des Plaines, IL. This project entails a proposal to field-test a next-generation microhole coiled tubing rig. The MOXIE experimental rig, a dual-purpose rig capable of conventional and coiled tubing drilling, was fabricated by Coiled Tubing Solutions (Dallas, TX). GTI will assess field tests of this hybrid rig and lead a technology transfer program of the results. (DOE share: $1 million; Project duration: 12 months.) Contact: Jim Barnes; phone, 918-699-2076; e-mail, jim.barnes@netl.doe.gov.

Confluent Filtration Systems LLC, Houston, TX. Researchers will seek to develop a revolutionary elastic-phase, self-expanding tubular technology called CFEX. CFS's goal is to develop self-expanding well casings to any diameter, leading to improved methods and feasibility of monobore drilling and well construction. (DOE share: $1 million; Project duration: 36 months.) Contact: Rhonda Jacobs; phone, 918-699-2037; e-mail, rhonda.jacobs@netl.doe.gov.

Tempress Technologies, Kent, WA. The goal of this project is to develop a small, mechanically assisted, high-pressure waterjet drilling tool. A downhole intensifier would boost the pressure that can be delivered by coiled tubing, maximizing drilling rates. (DOE share: $800,000; Project duration: 24 months.) Contact: John Ford; phone, 918-699-2061; e-mail, john.ford@netl.doe.gov.

CTES LP, Conroe, TX. Researchers will focus on improving performance and reliability of microhole coiled tubing drilling bottomhole assemblies by significantly reducing downhole coiled tubing friction during inclined/horizontal drilling operations. The project will design, build, and test a prototype device that vibrates the coiled tubing from the surface to reduce friction along the length of the coiled tubing drillstring in inclined/horizontal well sections longer than 2,000 feet. The goal is to enable operators to economically use coiled tubing to drill microhole sections longer than 3,000 feet in horizontal wells. (DOE share: $700,000; Project duration: 24 months). Contact: Ginny Weyland; phone, 918-699-2041; e-mail, virginia.weyland@netl.doe.gov.

Technology International Inc. Kingwood, TX. This project entails developing and testing an effective downhole drive mechanism and a novel drillbit for drilling with coiled tubing. The high-power turbodrill will deliver efficient power at relatively high revolutions per minute and low bit weight. The more durable drillbit will employ high-temperature cutters that can drill hard and abrasive rock in 3½-inch boreholes. (DOE share: $800,000; Project duration: 24 months.) Contact: Dan Ferguson; phone, 918-699-2047; e-mail, daniel.ferguson@netl.doe.gov.

Ultima Labs Inc., Houston, TX. This project is intended to combine existing technologies for measurement-while-drilling (MWD) and logging-while-drilling (LWD) into an integrated, inex-

pensive measurement system to facilitate low-cost coiled tubing drilling of small-diameter (3½-inch) wells at depths shallower than 5,000 feet. Two prototypes are to be delivered ready for field testing. (DOE share: $800,000; Project duration: 36 months.) Contact: Rhonda Jacobs; phone, 918-699-2037; e-mail, rhonda.jacobs@netl.doe.gov.

Baker Hughes Oilfield Operations Inc. Houston, TX. Researchers will seek to provide a critical tool essential for an effective, modular coiled tubing drilling system: a wireless system to help steer drilling in a 3½-inch diameter or smaller hole. Plans also call for developing a downhole bidirectional communications and power module and a surface coiled tubing communications link. (DOE share: $800,000; Project duration: 24 months.) Contact: Dan Ferguson; phone, 918-699-2047; e-mail, daniel.ferguson@netl.doe.gov.

Gas Technology Institute, Des Plaines, IL. Rotating the drillstring is not an option in coiled tubing applications; excessive torque can lead to premature tubing failure. This project entails designing, developing, and evaluating a left-rotating motor and a drilling assembly consisting of a pilot bit followed by a counter-rotating stabilizer and reamer. Use of this counter-rotating drilling assembly enables the operator to cancel or minimize the torque on the coiled tubing and thus concentrate weight on the drillbit. This research is expected to result in increasing the effectiveness of coiled tubing drilling for a wider range of drilling environments. (DOE share: $600,000; Project duration: 24 months.) Contact: Jim Barnes; phone, 918-699-2076; e-mail, jim.barnes@netl.doe.gov.

Confluent Filtration Systems LLC, Houston, TX. Microhole completions pose a set of challenges due to the nature of fluid production in limited diameters. The use of gravel packs is impractical for completions in the microhole environment. Screens are necessary, but their emplacement is difficult. The greater fluid velocities inherent in microhole hydraulics tend to create excess sand movement toward the wellbore, accelerating screen plugging, erosion,and corrosion. This project is designed to prove and develop a concept for a self-expanding, high-flow sand screen that could be constructed from a wide range of materials. (DOE share: $200,000; Project duration: 24 months.) Contact: Rhonda Jacobs; phone, 918-699-2037; e-mail, rhonda.jacobs@netl.doe.gov.

Applications of Microhole Technologies

To assure industry relevance of the Microhole Initiative, a group of oil and service company representatives met to discuss the merit, needs, potential development, and applications of microhole technology. The group identified the following potentially significant applications of microhole drilling using coiled-tubing.

Shallow Development Wells

Among the advantages of drilling with coiled tubing microhole technology are that drilling requires about one third the space and one third the number of equipment loads when compared with a rotary drilling rig.

Reservoir & Seismic Data Holes

Small-diameter dedicated wells can be used to monitor reservoir response to production and injected fluids. The wells will not disrupt production and can be located at optimum locations to obtain 4-D images of reservoir fluid movement and bypassed oil.

Drilling Shallow Re-Entry Wells

Low-cost re-entry of existing wells allows drilling single or multiple lateral boreholes that allow “deep” perforations, imaging of lateral variations of reservoir properties by seismic array deployments, and vertical flooding projects that could significantly increase recovery, especially in mature Midcontinent fields, and return those fields to profitable operations.

Drilling Deep Exploration Tails

Microhole re-entry of existing wells can cheaply extend the wellbore to evaluate zones just below the targeted zone of interest.

Microhole Technologies

change your perspective...

A Team Building Data Sheet is provided on NETL's website to facilitate cooperation among technology developers and providers and producers interested in working together on microhole technology development and/or demonstration.

If you have a technology or producing property you would like to contribute to a field demonstration of microhole technologies, fill out the form at **http://www.netl.doe.gov/scngo/petroleum/index.html**

Information submitted on this form will be made publicly available on the Team Building Data Sheet.

Check out our website at
www.netl.doe.gov/business
for new project funding solicitations

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