The Application and Use of Microholes for Vertical Seismic Profiling

FWP ESD04-006

Goal

The project goal is to evaluate and develop vertical seismic profiling (VSP) technology for microholes to be used to enhance image resolution and depth penetration beyond current technology in a low-cost fashion.

Performers

Lawrence Berkeley National Laboratory
Berkeley, CA

Los Alamos National Laboratory
Los Alamos, NM

Sandia National Laboratory
Sandia, NM

Rocky Mountain Oilfield Testing Center
Casper, WY

Results

A low-cost vertical seismic instrumentation system that can be deployed in a low-cost manner was developed for use in microholes. VSP surveys were completed at the Rocky Mountain Oilfield Testing Center (RMOTC) using a 20-level hydrophone string and a 20-level geophone string. The surveys demonstrated that VSP data can be collected without using expensive rigs and extensive manpower. This work will serve as a baseline study in preparation for a future CO_2 injection monitoring program.

Benefits

The low-cost and easily deployed seismic system developed in this project will make VSP surveys more available to small operators with limited resources.

The increased resolution afforded by VSP can more accurately image subsurface reservoir rock and fluids and is particularly useful in understanding fractured and compartmentalized reservoirs.

Smaller equipment needed to run VSP surveys saves time, makes the system easily transportable through rough terrain and fragile environments, and reduces operational footprint.

Background

While VSP is not a new technology, the routine, low-cost application of VSP at the same scale of surface seismic has not occurred. As oil and gas resources become harder to find and produce in the United States, there is a critical need to enhance seismic resolution of the subsurface. While VSP offers such an increase in resolution, it has been held back by the use of expensive holes and large-scale deployments. Microhole technology offers a means to deploy VSP at lower cost and denser sampling than "conventional" VSP surveys.

The complete system used to acquire the VSP data. The simplicity of the system allowed for hand deployment, a rental vehicle for the "doghouse," and a small vibrator for the source. Note the small tripod used to support the sensor string; normally, a workover rig and many more personnel are needed.

Summary

The project achievements include:

- A low-cost, easily deployed system for conducting VSP surveys was developed and tested.
- The use of hydrophone (fluid-coupled) and geophone (directly clamped) sensor strings were compared. The test showed that geophones were the most effective type of sensor for the situation investigated.
- A new "vacuum-assisted" geophone clamping mechanism was developed and used to minimize the overall size of the sensor package.
- Initial VSP surveys have been completed in and processed from 800-foot microholes.

This project is an integrated program of modeling, instrumentation evaluation and testing, and data acquisition and processing. The effort is tightly coupled with the microdrilling program being conducted by Los Alamos National Laboratory at RMOTC in Teapot Dome, WY. The focus of the project is to model, design, carry out, and process multiple shallow VSP surveys (500-700 feet deep) in microdrilled holes in an area that is well-characterized. The VSP results will be compared with surface seismic and other information such as well logs, existing models, and core analyses.

Current Status (January 2006)

The project's 2006 work in progress includes the following:

- Extending the application of microhole VSP to commercial sites (in planning).
  - Tertiary Oil Recovery Project Kansas site. This includes active time-lapse monitoring of CO_2 injection and passive monitoring of the reservoir between time-lapse measurements.
  - Wyoming deep (>8,500 feet) CO_2 EOR (Perfection Oil).
  - Barnett shale hydrofracture monitoring.
- Investigating the next generation of instrumentation.
  - Fiber optic sensors.
  - Microelectromechanical systems and nanosensors.
- Adapting processing for improved "look-ahead" capability.
  - Improved methods of imaging vertical features in homogeneous geology.

Project Start / End: 3-12-04 / 3-11-06
DOE / Performer Cost: $400,000 / $0
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