PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Petroleum Exploration and Production

02/2004

ADVANCED SENSOR TECHNOLOGY FOR MICROBOREHOLE AND OTHER SEISMIC APPLICATIONS

Microborehole seismic instrumentation

PARTNERS

Los Alamos National Laboratory
Los Alamos, NM

MAIN SITE

Los Alamos, NM

Background/Problem

The cost and operational limitations of deploying downhole seismic sensors have often precluded the acquisition of important reservoir data. The need exists for a retrievable borehole seismic package or array that can be repeatedly deployed in production wells without pulling production tubing for each use. Engineering calculations, cost analyses and scientific discussion have shown the technical feasibility of using coiled tubing and miniaturized hardware for drilling 1.125 in. diameter boreholes to depths ranging form 100 to 10,000 ft. Modern electronics and advances in sensor technology make the miniaturization of borehole packages possible. Microboreholes have the potential to be drilled for less than one-fifth the cost of conventional wellbores. The goal was to develop, evaluate and field test miniature sensors for use in microboreholes.

Project Description/Accomplishments

The project designed, fabricated and tested the reduced size seismic array equipment termed, Microelectromechanical System Sensor Array (MEMS). In laboratory testing the MEMS array exhibited a sensitivity comparable to the commercially available geophone used in seismic surveys. The new geophones were reduced in size to 0.39-in diameter, while retaining the full range of reception of full-sized geophones. Other modifications included designing a way to reduce the noise caused by the array cables used in the seismic package, addition of filter units, and use of batteries to provide power directly to the downhole circuits of the sensor. All the components were designed to fit together inside a less than 1 in. diameter casing.

Miniature seismic sensors now under development have a performance approaching (the Mark Products microgeophone) or exceeding (the Input/Output Inc. micromachine accelerometer) the performance of conventional geophones.

The prototype 7/8 in. borehole package for the MEMS sensor was developed and tested in 1999. Since then the MEMS sensor has been substantially redesigned to serve as an interchangeable sensor pod in a multi-pod array system. The redesign improved the reliability of the locking arms of the pod assembly, fabricated connectors, feed-thru fibers to accommodate up to 40 electrical conductors, and designed a circuit board to pass power and transmit data to individual pods in the array.

Criteria for evaluation and field testing of the MEMS technology includes independent testing by several companies, using the new equipment in direct comparison to conventional seismic exploration, VSP, and crosswell seismic survey methods. The microborehole array has been successfully tested by Amoco (BP) and Texaco at facilities at the Los Alamos test site in New Mexico, and by Phillips Petroleum at a field in Texas.

Advanced Sensor Technology for Microborehole and Other Seismic Applications

Microborehole seismic instrumentation

CONTACT POINTS

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TOTAL ESTIMATED COST

$10.37 million

COST SHARING

DOE	- $2.38 million
Non-DOE	- $7.99 million

WEBSITE

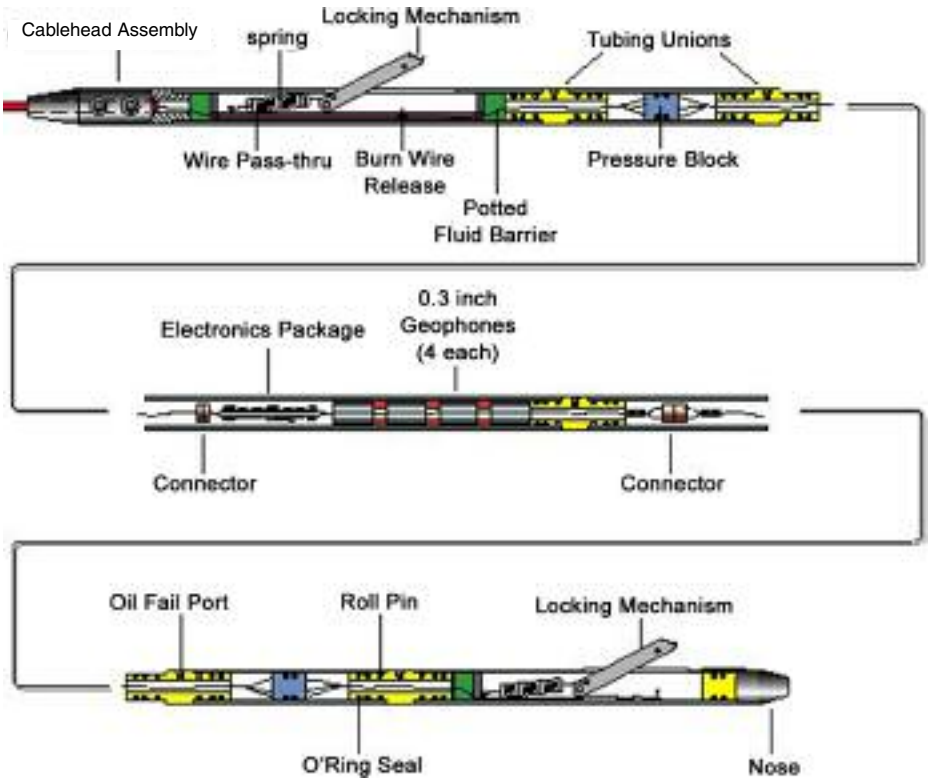
www.netl.doe.gov

Benefits/Impacts

Technological advances have resulted in smaller sensors with loss of performance. Development of the technology to drill small-diameter boreholes and combination with MEMS array technology will result in lower-cost, and deeper wells for exploration and production. This technology will allow cost-effective collection of samples, logs, and placements of long-term monitoring instruments in reservoirs where critical information is required.

Microborehole instruments will improve measurements, for example, cross flow between formations, and gas separation in the fluid column can be prevented in cased, well-cemented microboreholes. The high borehole noise environment typically associated with seismic measurements in production wells can be avoided and quality of the seismic data in a microborehole will be greatly improved.

Increased exploration and field development based on the MEMS will potentially add 1.8 billion barrels of oil and natural gas liquids and 12.8 Tcf of natural gas reserves. Production of these additional reserves will eventually result in generation of $2.8 billion in tax income, $7.8 billion in royalties and creation of nearly 9,000 new jobs across the US.



Design of microborehole instruments.

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