Oil & Natural Gas Projects
Exploration and Production Technologies

Fabry-Perot MEMS Accelerometers for Advanced Seismic Imaging

DE-FC26-09NT0005670

Goal

The objective of this project is to build and demonstrate LTI's accelerometer technology for the purposes of microhole seismic imaging.

Performers

Lumedyne Technologies Incorporated San Diego, CA 92101, Lawrence Berkeley National Laboratories

Background

Energy needs in the U.S. and across the world continue to grow; estimates by DOE and producing companies project an increase of up to 60 percent in energy demand over the next 25 years. National energy and economic security demand that domestic oil and gas recovery play an important role. Enhanced oil recovery (EOR) and natural gas from tight and unconventional resources are primary targets in the U.S. In a series of reports for the DOE, Advanced Resources International suggests that the domestic hydrocarbon production rates could increase several fold with the widespread application of state-of-the-art technology. Seismic imaging is a heavily used technology to image reservoirs of oil and gas. Great strides have been made in processing data to obtain sharper images. However, higher resolution is necessary to image in real time and in greater detail. Two heavily used technologies are high resolution 3D seismic and vertical seismic profiling, (VSP). Currently, sensors are placed on the surface or in shallow holes (few inches to a few feet deep) to record signals generated by seismic sources and image the subsurface. A key to obtaining the best data is adequate band width and signal-to-noise ratio. This must be done over large areas (tens of square miles) or by placing sensors in boreholes.

In addition to active measurements, "passive seismic" monitoring of micro earthquake activity induced by fluid movement and stress changes in the subsurface can be monitored given the proper signal-to-noise ratio. Seismic technology has relied upon decades old geophones. Alternatives like MEMS and fiber optic sensors show promise but up to now neither has the bandwidth or sensitivity to replace conventional geophones. But these technologies offer potential lower unit cost, higher bandwidth, and better noise levels in small packages that could be easily deployed on the surface or in boreholes. This approach reduces survey costs, enables "permanent" installations (due to low cost and installation ease) and gives better data for imaging the subsurface in greater detail.

Recent DOE funded research suggests a "designer seismic" approach is the solution: drilling a number of strategically placed, small diameter, inexpensive microholes and permanently installing small receivers for high resolution, relatively inexpensive seismic monitoring. The need for this technology will increase as industry moves toward increased reliance on enhanced oil recovery as well the need for the sequestration of CO_2 to combat global warming. One key element in the sequestration of CO_2 is long term monitoring of CO_2 movement, and if seismic sensors could be inexpensively placed in the subsurface it should be possible that an

order of magnitude increase in monitoring capability could be achieved. To achieve this, inexpensive drilling technology needs to be combined with ease of sensor installation.

Ultimately, it is envisioned that sensors can be installed on the drill pipe and wired in with the drilling tools so that the well can be drilled and all equipment can be cemented in place without tripping. This ultimate “one pass” installation saves time, reduces potential well problems and reduces the risk of redrilling of the wellbore. In an effort funded by the DOE, Lawrence Berkeley National Laboratories (LBNL) and its partners are developing a coil tube drilling technology installing sensors in the subsurface at dramatically lower costs (25 - 50%) with a reduced environmental impact through faster drilling time and smaller footprint. The remaining issue, however, is the instrumentation of these microholes. The new technique reduces the borehole diameter from 4 inches to approximately 1 inch. Packaging and emplacement of geophones at this reduced diameter is problematic and current MEMS accelerometers do not offer the required signal-to-noise ratio. Therefore a new sensor technology is needed. Lumedyne’s new optical MEMS accelerometer offers these benefits enabling this new microhole technique while simultaneously benefiting traditional land and seabed seismic imaging.

Potential Impacts

The greatest impact will be on the seismic exploration and monitoring industry for oil and gas applications. There is a great need to have low cost, high sensitivity, wide bandwidth sensors that can supply data to provide higher resolution imaging results, both in time and space. If successful it is anticipated that the subject technology will lower the cost of deploying seismic instrumentation such that surface and bore hole surveys will become routine and the vision of a truly “instrumented” oil field /gas reservoir will become a reality. Time lapse imaging to “watch” critical processes develop and change would be possible. Today, it is too expensive to deploy large numbers of sensors for over a few weeks, yet there is a current need to have “permanent monitoring” to fully understand changing reservoir conditions. For example, some applications would be real time monitoring of hydrofractures, reservoir production management (both active and passive monitoring) at resolutions of less than a few meters, fine scale imaging of potential and existing reservoirs and much improved imaging in general. This technology is meant to provide a much needed “leap” rather than a small incremental step in performance

Accomplishments

This project was started 10/01/2008. No technical accomplishments have been made.

Current Status

This project was started on 10/01/2008. This project has 4 phases which consist of accelerometer design and simulation, fabrication system integration, and field demonstration.

Project Start: October 1, 2008
Project End: September 30, 2011

DOE Contribution: $1,256,277
Performer Contribution: $513,704

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