Seismic Stimulation to Enhance Oil Recovery

**Research Objectives**
This project seeks to determine if seismic stimulation can increase oil production in mature oil fields where production is declining. The research team will perform field tests of seismic stimulation in a mature producing field, as well as test the physical basis for how this stimulation process might work.

**Approach**
The field trial will take place in the Foraker oil field in Osage County, Oklahoma operated by Berkeley Geolmaging Resources, LLC (BGI). Production from individual wells will be monitored for eight months prior to stimulation and for at least eight months after stimulation begins. Using 3D seismic data, modern well logs, cores, and production data, a comprehensive 3D reservoir model will be constructed that allows numerical predictions to be made of where the stimulation is expected to liberate trapped oil. Comparisons between the numerical predictions and individual well-production histories will be used to draw conclusions about seismic stimulation. This research will provide the most complete test of seismic stimulation to date.

**Accomplishments**
The 3D numerical modeling of the potential for the seismic waves to release immobile has been performed for the Foraker field. This required combining hydrological modeling of the fluid pressure gradients surrounding each producer with 3D seismic modeling.

The well-by-well production monitoring that was desired for the project has proven to be problematic; however, LBNL and BGI have developed an adequate monitoring program based on tank batteries and have now collected five months of baseline data from the two new tank batteries that were constructed by BGI and made available to the project starting from October 2011. These tank batteries do not allow us to monitor production from individual wells but from small groups of two to four wells. For the 18 months prior to the tank batteries being available, well-by-well monitoring was attempted via two trailer mounted coriolis meters that would hook up to each well for 24 hours to monitor total fluid production and oil cut before moving to the next well. Because the gas-phase separators could never be made to work properly despite many attempts, the coriolis-meter approach to production monitoring was abandoned late in the fall of 2011.

A project website was created (http://esd.lbl.gov/research/projects/6seor/), and the participants have been involved in several technology transfer events including the RPSEA Onshore Production Conference at Midland, TX on April 10, 2012.

**Significant Findings**
On the theory front of numerically modeling the potential for seismic waves to mobilize immobile oil, we improved our understanding and model of what goes into a quantitative estimate of the potential. When we apply the model to the Foraker oil field, the model shows that the potential is not isotropically distributed about the stimulation well, but depends sensitively to the estimate of the fluid pressure gradient surrounding each production well. The radius of influence determined by our modeling at the Foraker field is roughly 500 m; however, this estimate will change once a field measurement is made of the amplitude of the seismic source.

In a very real sense, a lot of this project has been spent learning about the difficulties of measuring production data on individual wells using meters. We have learned that a reliable meter that can make accurate readings of oil cut in the presence of gas in the fluid stream does not presently exist. A company that can provide such a meter at an affordable price would have a popular product.

Additional findings will occur once the seismic source is turned on.

**Future Plans**
At present, the seismic source is planned to be turned on in June 2012. A significant perturbation to the project is that our cost-share collaborating oil company BGI has decided to sell the Foraker field that we have been preparing to stimulate. The field goes on the market the first week of April 2012. Whether the new owners will be interested in our turning on the seismic source (it requires them to install it at a cost of roughly $50,000) is not guaranteed. If the new owners are not amenable to this project going forward, there are other fields we could use that one of our cost-share collaborators (UNICO) has contacts with. The seismic tool company ASR has also offered to find us an appropriate field for the project should the new owners of the Foraker field walk away from the project.