ACTIVITY REPORT

March 2003

Natural Gas & Oil Technology Partnership

bringing department of energy national laboratories capabilities to the petroleum industry

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Note: Natural Gas and Oil Technology Partnership projects are reported according to the following schedule:

January, March, May, July, September, November	**February, April, June, August, October, December**
Drilling, Completion, and Stimulation Technology Oil and Gas Recovery Technology Diagnostic and Imaging Technology	Natural Gas Technology Upstream Environmental Technology Downstream Environmental Technology

Natural Gas and Oil Technology Partnership on the World Wide Web: http://www.sandia.gov/ngotp/

Drilling, Completion, and Stimulation Technology

Downhole Seismic Source for Look-Ahead Pore Pressure Prediction While Drilling

(Halliburton and INEEL)

Highlight:

- Capacitive Discharge Downhole Source (CDDS) "at pressure" testing complete.

The Capacitive Discharge Downhole Source (CDDS) repair is complete and both the CDDS and Regenerative Combustion Source (RCS) are ready for testing. Additionally, the CDDS "at pressure" testing is complete. The seismic trailer was moved to the test wells near the Idaho Research Center for the first series of downhole tests. The seismic data system is set up and testing has started. CDDS discharges produced 30 microsecond pressure impulses in excess of 1200 psi at ambient pressures in excess of 3600 psi. The ambient pressures exceed the super critical point of water (3200 psi) by 400 psi.

Last month researchers reported that the power source for the RCS and CDDS was not producing the required 375 Vdc when powered by the generator and inverter. The problem was traced to a fault in the tool and was repaired.

Acoustic Telemetry (MWD)

(ABB, Electroacoustics Research Laboratory, Extreme, and SNL)

Highlight:

- Acoustic Telemetry system entered in the R&D 100 Awards contest.

Extreme Engineering and SNL entered the Acoustic Telemetry system in the R&D 100 Awards, a contest sponsored by R&D magazine to recognize 100 outstanding new products of the past year.

Development of Chemically Bonded Ceramic Borehole Sealants

(GPRI, ANL, and LANL)

Highlight:

- Composition limits and permafrost cement behavior finalized.

Tests were conducted with different weight ratios of binder and fly ash. Each test consisted of preparing the composition and running the test in the chilled consistometer at 30°F to determine the pumping time, and then curing the thickened slurry under water in the consistometer and in a refrigerator overnight. If the pumping time was less than 3 hours, or if the cement did not set after curing, the composition was considered to be unsuitable. The tests showed:

- A minimum of 50 wt.% binder is needed. Any reduction in the binder composition will reduce the content of monopotassium phosphate (KH_2PO_4) in the final composition. Because of lower content of this phosphate salt, the freezing point of the cement slurry is not lowered and hence the cement freezes even before it sets and hence softens when thawed. Thus, a certain minimum KH_2PO_4 is needed in the cement which 50 wt.% binder provides.
- Addition of extendospheres will produce excellent insulating cement. More than 10 wt.% addition of extendospheres made the cement too light; it tended to revolve with the paddle in the slurry cup and the thickening profile could not be tested. This may indicate that there may be pumping problem with this ultralight cement and hence 10 wt.% of extendospheres was considered to be optimal loading of these spheres.
- One may also use sawdust to improve upon the insulating properties of the cement. Again 10 wt.% was maximum amount that could be used. One of the problems of sawdust was that it absorbs water from the reacting cement and deprives it of water that is needed for reaction. Thus, extendospheres are preferred over sawdust for development of insulating cement.

Effect of hydrocarbon gases on setting of the cement

To test the effect of downhole gases on setting of cement, carbon dioxide (CO_2) was used. Dry ice was put in a container and was allowed to warm up so that it filled the container. The slurry was put in it and keeping the lid of the container closed, the slurry was mixed for half an hour at room temperature and then allowed to set. The slurry set well in several hours and no effect of CO_2 was observed on either the mixing or setting time or on the quality of the set cement. The set cement was a dense mass, with no evidence of porosity. This shows that the setting of the slurry is not affected by CO_2.

These observations demonstrate that the permafrost cement may be used for gas hydrate wells.

Coiled-Tubing Deployed Microdrilling with Real-Time, Downhole Monitoring

(DeepLook and LANL)

Highlights:

- A third local drilling site was located to conduct harder rock drilling demonstrations.
- A Land Use Permit application was submitted.

None of the local drill sites that LANL has drilled to date have provided a thick strata of consolidated sedimentary rock. Before demonstrating microdrilling technology in an oil field, a local site is needed to evaluate the present capability in harder sedimentary rock. A site located about nine miles north of San Ysidro was identified as providing an opportunity to drill sandstone in the Abo formation. This site is believed to be more representative of the formations expected at Rocky Mountain Oil Testing Center (RMOTC). Researchers completed a preliminary assessment of the site and a Land Use Permit Application was submitted to the US Forest Service for the short-term use of this new microdrilling site. Although an Environmental Assessment was not required, the US Forest Service requested a cultural inventory of the proposed site, which was performed by a LANL archeologist. The anticipated start date for the drilling at the new site is in early May 2003. Assuming that the San Diego Canyon site is successfully permitted, the attempts to seal off the loss circulation in the Fenton Hill well will be deferred and the summer drilling program will focus on rock drilling in preparation for drilling at the RMOTC.

A 1-3/4-in 1:2 lobe 3-stage high-speed motor was procured and will be delivered in mid-April 2003.

Effects of Well Conditions on Post-Perforation Permeability

(Halliburton, Penn State, and LLNL)

Highlights:

- High-resolution X-ray computed tomography scans of four Berea sandstone cores acquired.
- Evaluation of perforation clean-up model begun.

Systematic experimental measurements perforation and surge-induced clean-up are necessary to thoroughly evaluate process-based computational models. Recently completed experiments at the Center for Quantitative Imaging at Penn State University and Halliburton Jet Research Center are providing unique data with which to test the recently enhanced computational models. Ongoing efforts are focused on completing the experimental program and refining the computational models to better predict experimental results.

Researchers acquired high-resolution X-ray computed tomography (CT) scans of four Berea sandstone cores perforated at Halliburton Jet Research Center at underbalances of 750, 1500, 2000, 2500, and 3000 psi. The resulting 3D images provide unprecedented details of the geometry of the perforation tunnel and shaped-charge debris remaining after the post-perforation pressure surge.

Evaluation of perforation clean-up model was begun using recently completed flow tests, in which X-ray CT scans provided estimates of the radial distribution of post-perforation permeability.

Lifetime Performance Monitoring of Synthetic Fiber Mooring Ropes

(Petroleum Composites, Puget Sound Rope, Shell, Whitehill Manufacturing, and ORNL)

No noteworthy progress was made in the current reporting period, since project funding for FY2003 has not been received. The project team will resume the testing and development of the strain sensor as soon as the FY2003 funding is available, hopefully within the next reporting period.

Disposable Fiber Optic Telemetry System for Use With Coiled Tubing

(GTI, CTES, and SNL)

No report received.

Automatic Flaw Detection and Identification for Coiled Tubing

(U of Tulsa, INEEL)

Highlight:

- Initial signal measurement test matrix developed.

An initial signal measurement test matrix was developed to explore flaw detection sensitivity given differing levels of magnetic field saturation along with varying scanning rates. This matrix covered the measurement of eight characteristic flaws types via 15 magnetic field strengths and four scanning speeds. Based on initial indications of the signal characteristics shown within this test matrix, the addition of the axial sensor could lead to additional flaw indication information. Moreover, this test matrix library will be used to design the remainder of the flaw measurement studies to be conducted next.

Using the signal measurement test matrix data obtained during February, it was verified that travel speed did not contribute to significant changes in flaw detectability, i.e. the qualitative shapes of the flaws appear unchanged due to travel speed changes. In addition, it was found that the effects due to increases in coil current did not significantly change the detectability of the test matrix flaws, i.e., in the region of test there was a near-linear increase in flaw signal with current increase. A margin of about 5 to 1 signal-to-noise ratio for the largest flaw under investigation appeared overly sufficient for visual detectability of these flaws. Based on this information, in conjunction with coil heat dissipation rates observed during the initial test matrix development, it was decided that the remaining experiments would be conducted using a coil current of 5.0 amps and a travel speed of 700 mm/second.

Finally, a new set of characteristic flaws were developed, introduced into a tube and measured for investigation this month. This set of flaws was designed to investigate axial and cross-axial flaw sizes and shape detectability. It was made up of three groups of flaws based on multiples of a base flaw diameter of 3/32 in at a depth of 1/16 in**:** three round holes, 1D, 2D, and 3D; three axial slots of length 2D, 3D, 4D; and three cross-axial slots of length 2D, 3D, 4D. Once a full library of flaw measurements is available, work will begin on choosing an appropriate algorithm for autonomous flaw detection and characterization.

Laboratory Study on Borehole Stability and Sand Production in Weakly Cemented Sand

(ChevronTexaco, Shell, and LBNL)

Highlight:

- Researchers continue constructing a triaxial cell.

Researchers are currently constructing a triaxial cell that will be capable of applying three independent axial loads to a rectangular sample of weakly cemented sand. This apparatus will allow the circulation of fluid through a borehole drilled in the sample (axial flow). Researchers can also introduce fluid flow into the borehole from the surrounding medium (i.e., radial flow). The test cell is made of aluminum, which will permit the use of X-ray computed tomography (CT) imaging during the borehole breakout and sanding experiments.

As an intermediate step of the cell construction, researchers performed X-

ray CT scans on cell components. This test was important because the complicated geometry of the metal (aluminum) parts and thick cell wall could significantly decrease the quality of the reconstructed sample images. For this test, a rectangular block of weakly cemented sand was fabricated from pure silica sand and calcium-aluminate cement. Porosity of the sample was approximately 30%. A single borehole (diameter=0.6 inches) was drilled in the sample. Four loading platens containing conduits for circulating fluid were attached to the sample, and then the whole sample assembly was inserted in the cell and scanned using X-ray.

Although this test was conducted without confining fluid and pore fluid, which is expected to be the worst case for the CT imaging, reconstructed images were very clean, with the image resolution better than 1 mm. Since this result was quite satisfactory, researchers are continuing to construct the rest of the cell.

Development of Smart-Proppant Technology for Hydraulic Fracturing

(U of Tulsa, and INEEL)

Highlight

- Project re-scoped due to funding reduction.

Project accomplishments include a project re-scope in response to a funding reduction, as well as development of applicable work packages to document these changes. Briefly, scope for the remainder of this fiscal year will be limited to an evaluation focused on the application of biocatalytic systems as vis-breakers.

The application of chemical (e.g. oxidizers) technology is readily accepted as appropriate with the only issue being controlled release. Biocatalysis however, does not have the general utility or acceptance for several reasons. Biocatalytic (specifically enzymatic) systems were evaluated in the past for application as vis-breakers and were found to have an insufficient half-life for application. Although the enzyme(s) have insufficient thermostability, the organisms that produce the enzymes are extremely robust and are not limited by this restriction. This effort proposes the inclusion of active biomass in engineered systems for the continued supply of catalytic materials at the expense of the viscosifying agent. Applicable organisms will be selected from the organisms currently being grown in the laboratory (see last month's report). This approach will potentially:

1. Mitigate thermostability issues of isolated enzymes
2. Provide a dynamic source of catalysis
3. Allow for the induction of additional enzyme systems and provision of required co-factors.

Project researchers believe this approach is novel.

Technical work performed during this period focused on the continued development of encapsulation techniques relevant to microbiological systems. For those systems being evaluated, two techniques will be important: 1) dynamic inclusion of biomass during manufacture, and 2) inclusion by growth.

Application of High-Powered Lasers to Drilling and Completing Deep Wells (GTI, PDVSA, Parker Geosciences, Colorado School of Mines, and ANL)

The report "Lasers and Beam Delivery for Rock Drilling", by K.H. Leong, Z. Xu, C.B. Reed, and R.A. Parker, ANL/TD/TM03-01, finds that beam delivery for laser drilling is feasible but is subject to constraints and requirements. Fiberoptic beam delivery is an attractive option because of the complexity of sending a laser head downhole. However, improvements in fiber transmission are needed for more efficient delivery to deeper depths. For a Nd:YAG laser beam, the report says transmission through a 1-km-length of standard silica fiber that is available today results in approximately 50% loss in power. Current fibers, screened for quality, may have lower attenuation losses of only 2.0 dB/km for a Nd:YAG beam, which means a 1-km-fiber would deliver approximately 63% of the power injected at the surface. For a COIL (Chemical Oxygen Iodine Laser) beam, the fiber length increases to 3km for a 50% loss.

The report also finds that diode and fiber lasers can be designed to be inserted downhole, but require development of power and cooling systems.

Ultra-low loss hollow fibers that can transmit carbon dioxide (CO_2) wavelengths are also currently under development by a new start-up company. The hollow core is surrounded by a solid multilayer structure of high refractive-index contrast, leading to large photonic bandgaps and omnidirectional reflectivity. The large photonic bandgaps result in very short electromagnetic penetration depths within the layer structure, significantly reducing radiation and absorption losses while increasing robustness, thus enabling the use of fewer multi-kilowatt CO_2 systems at the surface.

If one of several possible fiber manufacturers is engaged, improvements in preform material and fiber drawing technology may lead to substantial improvements in transmission, enabling longer fibers and lower losses. This finding is in agreement with an earlier analysis by the petroleum industry in Europe.

Oil and Gas Recovery Technology

Measuring Sucker Rod Pump Parameters Downhole (Harbison-Fischer, UT-Austin, and SNL)

Highlight:

- New load cell installed at UT-Austin.

The new load transducer was installed below the stuffing box at the test well at UT-Austin. This allows the stuffing box friction to be removed from the total polished rod load.

The internal flow area of a traveling valve was determined by filling the valve with water. The valve was placed on a balance and the weight recorded as a function of water height in the valve. This is much simpler than trying to determine the flow area from geometric measurements and drawings. Pressure drops predicted from the flow area determined this way will be compared with previous work to determine if this approach is better.

A pump instrumented with a compression chamber pressure transducer is being fabricated for Texas Tech.

Formation Logging Tools for Microboreholes (DeepLook and LANL)

Project completed. Results of the project are being prepared for publication.

Coupled Geomechanical Deformation, Fluid Flow, and Seismic Modeling (ExxonMobil, Schlumberger, UT-Austin, and SNL)

Modifications were made to the IPARS/JAS3D coupling algorithm to include an equilibrium geomechanics step as part of the initialization procedure. This step brings the applied overburden loads, initial pore pressure distribution, and initial stress field into an equilibrium state prior to the start of the problem. The equilibrium stress distribution is maintained but the displacements are set to zero. This was done previously in an ad hoc fashion by subtracting the initial equilibrium strain from the total strains computed at each step.

Revisions were completed for the paper, "Coupled Fluid Flow and Geomechanical Deformation Modeling," which is now in press for publication in the *Journal of Petroleum Science and Engineering*. This paper details the basic governing equations and two-way staggered in time, loose coupling algorithm researchers employed for this project. It also shows validation experiments against a fully-coupled simulator. Revisions are being made to a second paper, "Coupled Geomechanics and Flow Simulation for Time-Lapse Seismic Modeling," submitted to the journal *Geophysics*. The revisions include a careful sensitivity study of the parameters which impact time-lapse velocity changes in numerical simulation of production for weak-formation reservoirs.

Invited Presentations:

Minkoff, S.E., C.M. Stone, M. Peszynska, S.L. Bryant, M.F. Wheeler. "Coupled Flow and Mechanics for Time-Lapse Seismic Modeling," SIAM Conference on Mathematical and Computational Issues in the Geosciences, Austin, TX, March 17, 2003.

Stone, C.M., J. G. Arguello, S.E. Minkoff, M.F. Wheeler, and M. Peszynska. "A Coupling Approach for Fluid Flow and Nonlinear Geomechanical Deformation Modeling," SIAM Conference on Mathematical and Computational Issues in the Geosciences, Austin, TX, March 18, 2003.

Mechanisms of Oil Recovery and Validation of Corefloods (ChevronTexaco, ConocoPhillips, and LBNL)

Highlight:

- Paper prepared for a Society of Petroleum Engineers (SPE) meeting.

Statistical analysis of thin sections with regard to developing an optimal criterion for verification of computer-generated 3D images continues. It was observed that due to local heterogeneity, only normalized correlation functions can provide representative information about the type of the rock.

Computer-generated images of sandstone were compared with high-resolution computer tomography. The computer images were obtained by modeling sedimentation, compaction, and mineralization of the rock. A good similarity between synthetic and natural rock was achieved.

A paper was prepared for a Society of Petroleum Engineers (SPE) meeting. Another paper was approved and is under preparation.

Direct Simulation of Near-Wellbore Mechanics (ChevronTexaco, Halliburton, Schlumberger, Shell, MIT, NM Tech, and SNL)

Highlight:

- Dave Boutt's poster presentation was selected for an Outstanding Student Paper Award.

Research continued on the refinement and application of the 2D code, and on the implementation of the 3D code. In addition to the principal investigator, contributing project staff included graduate interns Dave Boutt (NMT) and Scott Johnson (MIT), and postdoctoral associate Erik Strack. Dave Boutt's recent poster presentation of work at the American Geophysical Union (AGU) (Abstract H71B-0819, see reference below) was selected for an Outstanding Student Paper Award.

Efforts during this project period have focused on two activities: 1) the evaluation of the current numerical bond implementation in the 2D code; and 2) the implementation and validation of the 3D fluid solver. Work on the bond implementation was motivated by a need to investigate the role of cohesion (i.e., cementation) in the simulation of sanding. Researchers reviewed the literature to identify the state of knowledge of bond characterization (through experiments), and the associated numerical idealization and algorithms. A refined bonding scheme that captures shear and moment-carrying capacities in addition to the existing tensile/compressive bond in the 2D code is currently being validated.

On the 3D code, the D3Q19 lattice Boltzmann model was implemented and is being validated. To facilitate this effort and the subsequent visualization of model results, researchers developed a visualization module that is being integrated into the 3D application framework.

Project Presentations / Publications:

Boutt, D.F., B.J.O.L. McPherson, B.K. Cook, and J.R. Williams. "An Analysis of the Role of Fluid Pressure Gradients in Fracture Initiation and Propagation using Direct Simulation of Coupled Fluid-Solid Mechanics," *EOS Trans. AGU*, 83(47), Abstract H71B-0819, 2002.

Boutt, D.F., Cook, B.K., McPherson, B.J.O.L, and J.R. Williams. "Application of a Coupled Lattice-Boltzmann-Discrete Element Model to Problems in Geomechanics and Geohydrology," poster presentation at the Third International Conference on Discrete Elements Methods, Santa Fe, NM. September 22-25, 2002.

Boutt D.F., B.J.O.L. McPherson, B.K. Cook, and J.R. Williams. "Application of a Directly Coupled Numerical Model of Fluid-Solid Mechanics," accepted to *Soil and Rock America 2003*, 2003.

Boutt D.F., B.J.O.L. McPherson, B.K. Cook, and J.R. Williams. "Fluid-Induced Fracture Initiation and Propagation in Geologic Systems: A Discrete Analysis," accepted for presentation at the 7th U.S. National Congress on Computational Mechanics, Albuquerque, NM, July 2003.

Cook, B.K., D.R. Noble, and J.R. Williams. "A Coupled DEM-LB Model for the Simulation of Particle-Fluid Systems," *Proceedings of the 3rd International Conference on Discrete Elements Methods*, Eds. Cook and Jensen, ASCE, 2002.

Cook, B.K., D.R. Noble, and J.R. Williams. "A Direct Simulation Method for Particle-Fluid Systems," submitted to *Engineering Computations*, 2003.

Cook, B.K. "Coupled Discrete Element and Fluid Flow Model with Applications to Wellbore Stability Problems," Internal Briefing to Hughes Christensen Research, January 23, 2003.

Cook, B.K., M.Y. Lee, A.A. DiGiovanni, D. R. Bronowski, E.D. Perkins, and J.R. Williams. "Discrete Element Modeling Applied to Laboratory Simulation of Near-Wellbore Mechanics," accepted for publication in the *International Journal of Geomechanics.*

Johnson, S. "An Efficient Pseudo-ellipsoidal Contact Detection Scheme," poster presentation at the Third International Conference on Discrete Elements Methods, Santa Fe, NM. September 22-25, 2002.

Johnson, S., B.K. Cook, and J.R. Williams. "Application of an Ellipsoidal Approximation for Discrete Element Modeling," accepted for presentation at the 7th U.S. National Congress on Computational Mechanics, Albuquerque, NM, July 2003.

Johnson, S., J.R. Williams, and B.K. Cook. "Contact Detection Algorithm for an Ellipsoid Approximation for Discrete Element Modeling," submitted to *Engineering Computations*, 2003.

Lee, M.Y., B. K. Cook, A.A. DiGiovanni, E.D. Perkins, and J.R. Williams. "Simulation of Borehole Failure Phenomena Using Discrete Element Modeling," *Eos Trans. AGU*, 82(47), T51A-0846, 2001.

Strack, O.E., and B.K. Cook. "Three-Dimensional Coupling of Particle Motion and Fluid Flow Using the Discrete Element and Lattice Boltzmann Methods" accepted for presentation at the 7th U.S. National Congress on Computational Mechanics, Albuquerque, NM, July 2003.

Well Integrity Assurance for Sub-Salt and Near-Salt Deepwater GoM Reservoirs

(BHP, BP Amoco, ChevronTexaco, ConocoPhillips, ExxonMobil, Halliburton, Kerr-McGee, Shell, and SNL)

Highlight:

- Individual participant meetings held with Shell and ChevronTexaco.

Reservoir-scale finite element stress analyses continues. Post-processing and data analysis efforts were expanded based upon the input of the participants. Calculation of initial in situ stresses around salt bodies is near completion. Ultimately, nineteen individual 3D finite element models were meshed to represent four idealized deepwater GoM geometries: spherical salt body, horizontal salt sheet, salt diapir, and salt diapir with tongue.

The non-linear finite element analyses quantify the stress perturbations around salt bodies and show that at certain locations for specific geometries: 1) shear stress may be highly amplified as compared to the far-field; 2) horizontal and vertical stresses may be significantly perturbed from their far-field values; 3) principal stresses may not be vertical and horizontal (i.e., the vertical stress may not be the maximum stress); and 4) anisotropy in the horizontal stresses may be induced in the near-field adjacent to salt bodies. Additional work was performed to enable calculation of the principal stress directions adjacent to salt bodies, and on developing a capability to visualize this information in 3D. Work in this latter area is leveraging an unrelated project being conducted in SNL's Computation, Computers, Information and Mathematics Center. Unique developments required for the application, which is serving as a demonstration problem, are sponsored by another DOE project.

Individual company meetings were held at Shell Exploration and Production Co. in New Orleans, LA on February 18, and at ChevronTexaco's Drilling Center in Houston, TX on February 19. Fifteen to twenty staff members attended each meeting, and besides broadening awareness of the project and its technical results, these meetings also serve to identify the areas of most critical interest at each participant company and avenues for future work.

An overview of the project was also provided for Anadarko staff on February 19 to explore their potential interest in joining the project. The next bi-annual Participant's Meeting is scheduled to be held in Houston, TX on April 16 and will be hosted by ExxonMobil. An individual meeting with ExxonMobil staff is scheduled for April 17.

A paper proposal, "Stress Perturbations Adjacent to Salt Bodies in the Deepwater Gulf of Mexico" was accepted for presentation at the 2003 Society of Petroleum Engineers (SPE) Annual Technical Conference and Exhibition (ATCE) to be held in October 2003. Also, at the request of the DOE, an abstract "Well Integrity Assurance for Sub-Salt and Near-Salt Deepwater GoM Reservoirs" was submitted for a special session at the 2003 American Association of Petroleum Geologists (AAPG) Mid-Continent Section meeting to be held in Tulsa, OK in October 2003.

An Integrated Approach to Assessing Seismic Stimulation

(Aera Energy, ASR, BP Amoco, ChevronTexaco, ConocoPhillips, Halliburton, Marathon, OGCI, Piezo Sona-Tool, Schlumberger, Shell, UC-Berkeley, LBNL, and LANL)

Report not received.

High-Resolution Microseismic Monitoring of Reservoir Processes (ABB Offshore Systems, ChevronTexaco, Shell, and LANL)

Project received no further funding. Results thus far are being prepared for publication.

Direct Quantification of Uncertainties Associated with Reservoir Performance (ChevronTexaco and LANL)

Project researchers continue to validate the code by comparing the proposed moment-equation approach (ME) against the Monte Carlo simulation (MC) using more complicated but more realistic cases, which involve not only uncertainty on permeability of reservoirs but also on boundary conditions. The project is waiting for further funds in order to proceed.

Diagnostic and Imaging Technology

Advanced Sensor Technology for Microborehole and Other Seismic Instrumentation (Input/Output and LANL)

No activity this reporting period.

Inversion of Full Waveform Seismic Data for 3D Elastic Parameters (Amerada Hess, ChevronTexaco, ConocoPhillips, Fairfield Industries, GX Technology, Marathon, Unocal, and SNL)

Report not received.

Next-Generation Seismic Modeling and Imaging (Advanced Data Solutions, Anadarko, BHP, BP Amoco, ChevronTexaco, ConocoPhillips, Core Laboratories/Tomoseis, ExxonMobil, Fairfield Industries, Fugro Geoservices, GeoCenter, Geophysical Development, GX Technology, Marathon, Mitchell Energy, Paradigm Geophysical, PGS, Shell, Unocal, Veritas DGC, WesternGeco, Society of Exploration Geophysicists [SEG], Stanford, U of Houston, LANL, and LLNL)

Highlight:

- New synthetic elastic data computed for almost 50 shots.

Synthetic elastic seismic data was computed for nearly 50 shots in Phase II of the 3D synthetic elastic data calculations in the SEG/EAEG salt structure. Phase II calculations require nearly 700 cpu-hours per shot, and produce more than 400 MB of trace data per shot. In addition to trace data, wavefront snapshots are produced every 100 time steps. These snapshots are extremely helpful in interpreting the various arrivals that are seen in the trace data. Synthetic trace data for selected shots will be made available electronically. The full data represent a greater data volume than can be made available on the project's web server.

Rapid Imaging of Interwell Fluid Saturations Using Seismic and Multiphase Production Data

(BP Amoco, ChevronTexaco, ConocoPhillips, ExxonMobil, JNOC, Landmark, RC2, Statoil, Tomoseis, Total-Fina-Elf, Texas A&M, and LBNL)

Highlight:

- Permeability variations within the 7100 sand at the Bay Marchand reservoir imaged.

Researchers completed testing on the three methods (iterative, conjugate gradient, quasi-Newton) for inverting time-lapse amplitude changes. Of these three methods, the quasi-Newton and iterative methods were found to give the best convergence and reliable performance.

Researchers applied the iterative and quasi-Newton approaches to the time-lapse amplitude changes observed at the Bay Marchand reservoir, where they were able to image permeability within the 7100 sand using 3D time-lapse seismic data. Convergence was accomplished after 12 iterations, and researchers are now writing up investigation results.

Preliminary work was begun on the inversion of time-lapse pressure estimates. To do this, researchers first set up a test model and developed a preliminary inversion code based on theory. The next task will be to apply the algorithm to a set of time-lapse saturation and pressure changes for the Lost Hills oil field, CA, the data for which were supplied to us by ChevronTexaco.

Offshore Oil Field Characterization with EM Methods

(Scripps, Texas A&M, and SNL)

Highlight:

- Deliverable schedule revised.

In response to recent budget restructuring within the NGOTP program, researchers have embarked on a revised schedule of deliverables after consultation with the collaborators in the Scripps Seafloor EM Consortium (SEMC). The scope of the proposed research was scaled back to address only the hybrid 2D-MT/2.5D-CSEM response of offshore deepwater oilfields. Researchers intend to have a fully vetted forward modeling code specifically designed for joint MT/CSEM analysis of marine electromagnetic data (such as that collected in January 2003 over the Gemini prospect, Gulf of Mexico) available by end of FY04.

In addition, researchers are actively pursuing alternative funding mechanisms to support this project and its original goals, using NGOTP funding as seed money. Thus, through combined governmental and industrial support researchers aim to develop a broad funding base for continued research on marine electromagnetic (EM) exploration methods. Recent accomplishments, such as the magnetotellurics (MT) modeling over Gemini, will be spotlighted at a booth during the upcoming Society of Exploration Geophysicists Annual Meeting, this October in Dallas, TX.

Innovative Wave-Equation Migration

(Advanced Data Solutions, Amerada-Hess, Applied Geophysics Services, Baker Atlas, BHP, ConocoPhillips, ExxonMobil, Fairfield Industries, GX Technology, Petroleum GeoServices, Screen Imaging, Shell, TomoSeis, Unocal, Veritas DGC, and LANL)

Highlight:

- Wave-equation migration code modified to numerically implement the common-azimuth wave-equation migration.

Researchers modified the wave-equation migration code to numerically implement the recently proposed common-azimuth wave-equation migration that has the potential to improve the imaging accuracy of the conventional common-azimuth migration. Researchers plan to generalize the globally optimized Fourier finite-difference method for the improved common-azimuth migration. The code was verified using the impulse response and two synthetic datasets. In addition, a new migration imaging condition was proposed for obtaining a physically well-defined image. Researchers are testing the new imaging condition using synthetic datasets.

Testing and Validation of High-Resolution Fluid Imaging in Real Time

(DeepLook, KMS Technologies, KJT Enterprises, U of Wisconsin, LBNL and SNL)

Successful tests of the new LBNL high-frequency orbital vibrator continued at the LBNL borehole test facility. Results were obtained to 1000 Hz with a power output of up to 250 G's. This is significantly higher than the power output of the current commercial orbital source. Optimization of the source continued by testing various configurations of the weights in the source. The initial concerns of temperature rise in the vibrator were not an issue when the source was operated in a borehole (due to heat sink effect of the borehole).

Autonomous Monitoring of Production

(Aera Energy, ChevronTexaco, SteamTech Environmental Services, TomoSeis, and LLNL)

Highlights:

- Data processing for December field deployment finished.
- ERT data acquisition system redesigned for networking through a satellite data link.

The field deployment in early December 2002 was used to expand the survey area and collect an additional time-lapse survey. The data processing for that deployment is essentially finished. This processed data will act as a baseline for subsequent surveys for this expanded area of coverage.

The remote-controlled electrical resistivity tomography (ERT) data acquisition system that was previously tested and proved successful was redesigned for networking through a satellite data link. The previous link was through a land-line and was not suitable for the remoteness of the location at the Hobbs Operating Unit, Buckeye Field. The entire system now is configured in an enclosed trailer that can be parked on site to run unattended. The only external support it will need is standard utility power, which will be available. The satellite dish antenna is mounted on the trailer so that no surface mount will be needed at the site.

A full test of this system was conducted at LLNL before moving the system to the field. The system remained stable and reliable during a full run test of over a week's duration. Based on the test results, a field deployment for the trailer-based system is scheduled for late April 2002.

Anisotropic Properties of Compacted Clay-Rich Rocks

(BP Amoco, ChevroTexaco, ConocoPhillips, and LBNL)

There is no progress to report. The project is awaitng FY2003 funding.

Realistic Anisotropic Velocity Estimation in Complex 3D Environments

(BP Amoco, ChevronTexaco, ConocoPhillips, Kerr-McGee, Shell, TomoSeis, and LBNL)

Report not received.

Joint Geophysical Imaging

(ChevronTexaco, Core Laboratories, Electromagnetic Instruments, ExxonMobil, and SNL)

Highlight:

- Development of improved 3D electromagnetic imaging codes for inverting long-offset marine data continues.

The objectives of this research are two-fold. The first objective is to investigate the feasibility of simultaneously inverting different types of geophysical data (electromagnetic and seismic) linked through a rock physics model to produce a single self-consistent earth model parameterized by hydrologic parameters (porosity, fluid and gas saturations, etc.) rather than geophysical parameters. Second, if such inversion is feasible to develop specific algorithms to use surface (land or marine) data and assess these algorithms in terms of parameter resolution and computational requirements.

Last month work focused on developing improved 3D electromagnetic imaging codes for inverting long-offset marine data, offset measured from the EM transmitter. Previous results have shown that data collected for short offset locations are fit better than long offset data.

Unfortunately the long offset data contain most of the information related to characterizing oil and gas reservoir fluid properties. It is therefore imperative that better convergence be seen for long offset data, before integrating EM imaging codes with seismic and gravity imaging schemes.

Researchers are looking at new types of data weighting to improved data fits for long offset positions, as well as running the inversion iterations out much further to improve data fits. The later effort indicates that long offset data can be fit to within the estimated noise, but convergence is slow. Numerical experiments are now underway for accessing the ability to image oil and gas reservoirs, where the image domain is confined to known boundaries of the reservoir. It is hoped that significant improvements in image resolution can be achieved.

Partnership Office

For several years, Cheryl Allen of TechReps has been the coordinator of many of the partnership communication activities. Cheryl has moved on to start her own business. We thank Cheryl for all her help over the years and wish her well in her new endeavors. Sara Sabol, who has worked on several of the Partnership communication activities, will assume Cheryl's role. We welcome Sara to her new role.

In April, the Partnership projects will begin to receive their funding for FY03. The selected projects will be able to continue their efforts to bring the talents and technologies within the national laboratories to the domestic oil and gas industry.