ACTIVITY REPORT

August 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/

Upstream Environmental Technology

Ecological Framework to Evaluate the Effect of Size and Distribution of Releases at Upstream Petroleum Sites

(American Petroleum Institute, BP Amoco, ChevronTexaco, Exxon-Mobil, Gas Technology Institute, Unocal, ORNL, and LLNL)

No report received.

Estimation and Reduction of Air Quality Modeling Uncertainties

(Envair, EPRI, and LBNL)

1. Progress with Air Quality Modeling using EPA's Community Multi-Scale Air Quality Model (CMAQ)

A parallel implementation of EPA's latest version of CMAQ, CMAQ 4.2.2, has been run on our Linux cluster consisting of 24 Athlon processors. As a test we used a 100x120x15 layer grid describing a geographical area comprising the San Francisco Bay Area, Sacramento, and the San Joaquin Valley, and used a detailed chemical mechanism, SAPRC 99, to simulate a 2 day ozone episode from the summer of 2000. Tests with varying numbers of processors indicate that there are no errors due to parallelization. The processor scalability is good (75%) when 6 processors are used, and acceptable (50%) when 12 are used. (Scalability is by definition 100% when a single processor is used and is a measure of how per-processor performance declines as the number of processors utilized is increased. Causes for the decline are uneven load balance between the processors, and time spent in inter-processor communication.) We can now run a one-day simulation in just 4 hours of real time.

We are obtaining a version of CMAQ containing an implementation of the Direct Decoupled Method (DDM), an approach to sensitivity analysis that computes and time-evolves the first order sensitivities of the output variables with respect to the input variables at every grid point.

We obtained and installed MCIP 2.2 and reprocessed our entire repository of CMAQ input files to correct for an error found in EPA's MCIP 2.1 program that processes the output of the meteorological model MM5 to produce a CMAQ-ready format.

2.Progress on Uncertainty Visualization

A student was hired to implement visualization of uncertainties that will ultimately be propagated through CMAQ. We installed AVS, trained the student in Unix and AVS, and began the study.

Remote Sensing for Environmental Baselining and Monitoring

(ChevronTexaco, UC-Davis, US Geological Survey (USGS), and USDA Agricultural Research Service (ARS), and ORNL)

We are developing remote (airplane or satellite) hyperspectral sensor techniques to identify areas impacted by oil production. Our focus is Osage county, OK, (Osage Indian Reservation) which has been a major oil producing area (38,500 oil wells) since 1896. The county has 2,260 square miles of which 1,480 square miles are within a quarter mile of an oil well. The mineral rights are owned by the Osage Nation and there are 500 independent operators in the county. Many areas in the county have brine scars or weathered oil pits (the USGS has sample photographs: http://ok.water.usgs.gov/skiatook/Skiatook.Photo.html). Hyperspectral remote data will be collected in selected regions in Osage county and analyzed to detect brine scars, oil pits, and plant stress associated with brine and oil.

In November 2002, ORNL and the USGS obtained GPS coordinates for

potential sites in Osage County. ORNL has identified seven distinct areas to image that total 39 square kilometers. In May 2003, ORNL contacted the HyVista Corporation (http://www.hyvista.com/) and requested that they collect hyperspectral images of the seven sites. HyVista plans to collect the data in early October 2003. The USGS and the ARS plan to collect field data in October.

Modeling of Water-Soluble Organic Content of Produced Water

(ChevronTexaco, ConocoPhillips, Shell, Statoil, and ORNL)

Highlight:

- Published information on water-soluble organics in produced and formation waters is being compiled into a database.

Literature on produced water and crude oil characterization is being researched in order to develop a database on the type and content of water-soluble organics in produced water. This information will be used to develop a predictive model of water-soluble organics based on statistical analysis.

Analyses of the chemical composition of oil/water systems were found in a variety of formats, from peer reviewed scientific publications to non-footnoted references in trade journals, and on the internet. The quality of the information is highly variable, ranging from that derived from detailed analytical chemical methods (gas chromatography mass spectroscopy, isotachophoresis) to simple measurements of total organic carbon.

Much of the detailed analysis of deep-water crudes, and production and formation waters, is available for North Sea wells. Although short chain organic acids dominate the water-soluble organic component, their amounts appear to depend on exposure to air in production and sampling, and hence do not correlate with formation variables (such as age or depth of the formation, geographical location, or temperature). The challenges in building a statistical model based on this information are to choose variables or measurements that are common to a number of different literature sources on which to develop correlations, and to eliminate results arising from artifacts in the selection of variables, sampling, or analysis methods.

Science-Based Methods to Assess Risks Attributable to Petroleum Residues Transferred from Soil to Vegetation

(ChevronTexaco, PERF UC-Berkeley, UC-Davis, and LBNL)

Highlight:

- Completed experimental phase of wheatgrass study
- Exposure chamber air samples extracted and analyzed
- Continuing to extract and analyze soil and grass samples

LBNL and UCD researchers completed the exposure phase of the plant uptake experiment using wheat grass grown in soil spiked with a mixture of 12 different polycyclic aromatic hydrocarbons (PAH) and six different n-alkanes. The experiment included four different contaminant levels of the PAH mix. Each contaminant level was further spiked at three different levels with the n-alkanes mix resulting in 12 different soil treatments. Each soil was planted in duplicate (two different pots) along with three additional pots of native soil resulting in a total of 27 pots in the experiment.

Initial soil samples were collected before planting to determine starting concentrations. The wheatgrass was then grown and two cuttings of grass (10-15 cm each cutting) from each pot were collected over approximately 30 days. After the second cutting, the experiment was terminated and final soil samples were collected from each pot to determine final concentrations. Air samples from the exposure chamber were collected on filter and sorbent at three different times during the course of the experiment. Extraction and analysis of the air samples has been completed. Extraction and analysis of the grass and soil samples are continuing. LBNL researchers are evaluating how these results will impact exposure models that use regression equations to predict food-crop uptake from soils contaminated with petroleum-product residue.

Interactive Information System on Drilling Waste Management Practices

(ChevronTexaco, Marathon, and ANL)

Highlight:

- A paper describing the project was presented on March 11 at the SPE/EPA/DOE Exploration and Production Environmental Conference in San Antonio, TX. The presentation was well received by the audience.

A draft of the decision tree flowcharts for the Technology Identification module was completed and circulated for external peer review. These will be programmed so that users will be asked a series of questions. Depending on how the questions are answered, the module will narrow a long list of drilling waste management options to a shorter list that is more realistic for the user's site.

We are nearly done with the materials for the Regulatory Module. Programming is expected to start soon.

Use of Ionic Liquids in Produced Water Clean Up

(ChevronTexaco, Shell, Conoco-Phillips, ORNL)

Highlight:

- Extraction of simulated water soluble organics has been demonstrated with ionic liquids under physico-chemical conditions similar to that encountered in Gulf of Mexico produced water.

Ionic liquids (IL) are a novel form of solvent that have unique properties such as low vapor pressure, high ionic strength but low ability to form coordination compounds, and are liquid under ambient conditions. Their special properties have lead to research for application in environmental areas. In this project, the use of ionic liquids in produced water remediation is being investigated.

As a first step, the distribution coefficients of prototypical organic contaminants between water and ionic liquids were measured. The organic contaminants studied to date are hexanoic acid, 1-nonanol, toluene, butane diol and other fatty acids. The properties of ionic liquids, such as hydrophobicity and solubility, can be modified by changing the cation and anion, tailoring the IL for a particular application. Hence, in the current series of tests, three different ionic liquids were selected for investigation, butylmethylimidazolium bistrifluoromethylsulfonyl amide - bmim Tf2N, octylmethylimidazolium Tf2N - omim Tf2N, and bmim PF6.

Measured distribution coefficients (concentration in the ionic liquid divided by concentration in the aqueous phase) ranged from 100 to 800 for toluene and for 1-nonanol. The uptake of butane diol and the fatty acids were marginal in the ionic liquids tested. The highest distribution coefficients were observed with omim Tf2N. The distribution coefficients for hexanoic acid and 1-nonanol appeared to be pH sensitive; higher for the hexanoic acid at low pH, and higher for 1-nanonol at high pH. This pH sensitivity may assist in regenerating the ionic liquid.

Work continues with studies of regeneration, saturation, and investigation of uptake of alkanes and fatty acids into ionic liquids.

Hydrophobic Membranes for Removal of Organic Impurities in Production Water

(LLNL)

Offshore oil production in the US faces regulations dealing with drilling and production waters. These waters cannot be returned into the surrounding environment because of their high concentrations of organic impurities such as crude oil and drilling fluids. Treatment technology is available that removes the organics (such as electrostatic separators), but they are slow and inefficient. New methods that are more efficient and with less space demands are required due to the volume of the produced water and the current cost of disposal.

We are developing hydrophobic aerogel technology to remove organic compounds from drilling and production waters on oil production platforms. In the ultimate application, the aerogel will be used in a granular or membrane form, be in direct contact with the waste water to remove the offending organic compounds, and produce water that can be disposed of easily, economically, and in compliance with environmental regulations. The aerogel will be

designed in such a way that the organics can be extracted, allowing reuse of the aerogel. This technology will be available for use on drilling platforms, land-based production and refinery applications, as well as DOE contaminated water issues.

Information on the details of the research activities can be found in the following publications: *Chemical & Engineering News*, 81(14), 32-33 (2003), *Journal of Non-Crystalline Solids*, 292, 127-137 (2001), and *Energy Sources*, 23(9), 831-843 (2001).

Downstream Environmental Technology

A Predictive Model of Indoor Concentrations of Outdoor $PM_{2.5}$ in Homes

(Aerosol Dynamics, Western States Petroleum Association, and LBNL)

The galley proofs of the manuscript "The Use of Time- and Chemically-Resolved Particulate Data to Characterize the Infiltration of Outdoor PM-2.5 into a Residence in the San Joaquin Valley" were received from *Environmental Science and Technology* and reviewed.

The behavior of outdoor carbonaceous aerosols upon entrance indoors is being analyzed. This is the last of the important aerosol chemical species to be characterized by our study.

A manuscript describing the chemical dynamics of ammonia in the indoor environment is being prepared.

Progress has been ongoing to incorporate the previous results regarding the infiltration of sulfate and nitrate aerosols into a larger modeling framework that already has detailed mechanisms to predict ventilation rates in residences.

Technology Transfer

Nancy Brown gave a talk describing the research entitled "Field and Modeling Investigations of the Fate of Outdoor PM 2.5 in Residences" at a symposium on particulate matter at MIT's Endicott House. The symposium was sponsored by the MIT Laboratory for Energy and Environment, the MIT Integrated Program on Urban, Regional, and Global Air Pollution, and the Northeast States Clean Air Foundation. Co-sponsors of the symposium were the American Petroleum Institute, California Air Resources Board, Cummins, Inc., Diesel Technology Forum, EPRI, ExxonMobil, Ford Motor Company, Health Effects Institute, MARAMA, National Commission on Energy Policy, NESCAUM, PSEG, Sunoco, Inc., US Department of Energy, US Department of Transportation, and the US Environmental Protection Agency.

Melissa Lunden gave a talk on the research at NASA Ames in June. The talk was entitled "Inside Out: Understanding the Indoor Concentrations of Outdoor Aerosols in Residences." She also prepared an LBNL press release describing our findings regarding the disappearance of the ammonia nitrate aerosols indoors.

Nancy Brown formally responded to the external review draft of EPA's document "Air Quality Criteria for Particulate Matter." The response included a summary of the major findings of the research associated with this project.

A Predictive Model of Indoor Concentrations of Outdoor Volatile Organic Compounds in Homes

(American Petroleum Institute, Western States Petroleum Association, and LBNL)

Our work during this period continues to focus on the preparation of a manuscript describing experimental results and modeling of sorption for 20 gas-phase organics that cover a wide range of volatilities. The draft manuscript is currently being revised. The work described in this manuscript provides the foundation for the sorption component of our mass balance model for predicting indoor exposures to hazardous air pollutants from outdoor sources. Work on the manuscript includes expanded analysis of the primary experimental data, including temperature and humidity, and analysis of the model fitting metrics.

Developing Enzyme and Biomimetic Catalysts for Upgrading Heavy Crudes via Biological Hydrogenation and Hydrodesulfurization

(ChevronTexaco and ORNL)

Highlight:

- Initiated studies to investigate a dual bio-chem catalytic system for hydrodesulfurization.

Two approaches to improve hydrodesulfurization with the aid of biological catalysts were discussed in the last report. The second approach based on the use of the larger subunit of the hydrogenase enzyme was explored. The strategy is to isolate the larger subunit and use it with chemical hydrodesulfurization (HDS) catalysts to assess desulfurization of sulfur compounds at lower temperatures (< 100^{o}C) and pressures (15 psi). The larger subunit from a related hydrogenase enzyme has been reported in the literature to be separable in the presence of urea. Experiments were conducted with 6M urea and an incubation period of 16 hours, followed by size exclusion chromatography using a Tris buffer. Separation of the subunits did not occur in this first run. It is inferred that the urea must be present in the separation buffer itself. A second experiment is being conducted under these conditions.

The biocatalyst will be used in combination with two HDS catalysts provided by ChevronTexaco. A couple of preliminary experiments were conducted using the two catalysts and the hydrogenase enzyme and dibenzothiophene (DBT) as the substrate dissolved in 10% ethanol-buffer solution. The reaction was carried out at 60^{o}C under 15 psi of hydrogen. Analysis by HPLC (high pressure liquid chromatography) indicated no conversion. Other reaction conditions need to be investigated. However, one of the questions that must be answered is whether the HDS catalysts can bind the sulfur substrates under these conditions. To investigate this, Argonne National Laboratory is in the process of initiating studies using Extended X-ray Absorption Fine-edge Spectroscopy (EXAFS).

Characterization and Reaction Behavior of Sterically-Hindered Sulfur Compounds in Heavy Crudes with Nano-Sized Molybdenum Disulfide

(ChevronTexaco, BNL, and ANL)

We have developed a reproducible procedure to synthesize Mo-based nanophase materials, namely, unsupported MoS_2, CoS, and Co-MoS_2 and supported MoS_2 and Co-MoS_2. The materials are prepared by the sonolysis method in multi-gram quantities. We are now preparing several formulations of these catalysts with varied ratios of S/Co, S/Mo, and Co/Mo to understand the effect of each component of the catalyst on hydrodesulfurization (HDS) activity. Elemental analysis of each catalyst formulation is being completed to better establish the catalyst composition. The spectroscopic characterization of the synthesized materials is also underway.

Four $CoMoS_2/Al_2O_3$ catalysts having varying ratios of Co, Mo, and S were

received and tested at ANL for HDS using dibenzothiophene (DBT) and 4,6-dimethyldibenzothiophene (DMDBT) in hexadecane feedstocks. None of these catalysts had hydrogenation activity. Biphenyl from desulfurization of DBT and 3,3'-dimethylbiphenyl from desulfurization of DMDBT were the only products. Within experimental error, the yield of these products was equal to the conversion of DBT and DMDBT, respectively.

DBT and DMDBT conversion with these four catalysts was insensitive to the ratios of Co, Mo, and S used in their preparation. They all gave an experimentally indistinguishable 40-50% DBT conversion and about 20% DMDBT conversion.

Development of a Solid Catalyst Alkylation Process Using Supercritical Fluid Regeneration

(Marathon-Ashland and INEEL)

Experimental efforts focused on exploring Supercritical Fluid (SCF) regeneration using an alternate catalyst and exploring the effect of pressure on the regeneration of a completely deactivated catalyst. The previous regeneration work focused solely on a micro-porous ultra-stable Y type (USY) zeolite catalyst. Experimental studies were performed to explore the regeneration of a macro-porous sulfated zirconia catalyst. The macro-porous catalyst offers greater accessibility of the supercritical regenerant into the matrix of the catalyst particle, potentially enhancing regeneration effectiveness. However, the sulfated zirconia has about 1/3 the surface area and number of acid sites per mass of catalyst compared to the USY zeolite. The sulfated zirconia catalyst demonstrated low product yield and rapid deactivation and was determined to be an ineffective catalyst at the desired reaction conditions.

The effect of regeneration pressure was explored for a completely deactivated USY zeolite catalyst. The goal of this work is to determine the optimum pressure required for the regeneration process. Preliminary results suggest that as long as the regenerant density is close to the SCF's critical density the regeneration is efficient. At higher pressure, regeneration effectiveness decreases due to internal mass-transport limitations.

US Patent 6,579,821 B1, "Method for Reactivating Solid Catalysts Used in Alkylation Reactions" was issued June 17, 2003.

Publication

A manuscript titled "Recovery of Alkylation Activity in Deactivated USY Catalyst Using Supercritical Fluids: A Comparison of Light Hydrocarbons" was submitted for consideration for publication to *Applied Catalysis A: General.*

Biocatalytic Alkane Transformation for Viscosity Reduction

(ChevronTexaco and LBNL)

No report received.

Secondary Organic Aerosol Research in the Sierra Nevada Foothills

(Aerosol Dynamics, Independent Petroleum Association of Mountain States, and LBNL)

Substantial quality assurance and quality control has been performed on the 2002 data set. This work has included using highly time resolved wind direction data in order to remove points from the data set that have been effected by emissions from the diesel generator that powers the site. This data is currently being analyzed to understand trends with meteorology, oxidant levels in the atmosphere, and the biogenic emissions level from the canopy to understand the

extent to which the forest is affecting the aerosol concentrations.

Field work has been ongoing this summer to gather some additional data, including some filter samples to better understand the chemical constituents of the aerosol.

Proton Exchange Reactive Membranes for Conversion of Light Alkanes to Clean Liquid Fuel

(Ceramatec, Inc. and INEEL)

Performance of a surrogate palladium membrane in the experimental test system was evaluated at the INEEL. Hydrogen flux rates were investigated as a function of temperature, pressure, concentration, and gas flow rate. Temperatures between 300 and 600 °C, pressures between 50 and 100 psig, and concentrations between 10 and 100 % H_2 in argon were examined. Conditions that optimize flux rates or minimize reaction-side hydrogen concentrations were identified. The membrane-reactor system is being modified to focus on catalyst testing and catalyst materials are being developed.

A CRADA between the INEEL and Ceramatec has been signed. Team members from the INEEL traveled to Ceramatec in Salt Lake City, UT, in July to conduct a CRADA kick-off meeting. Ceramatec will develop proton conducting membrane materials to be tested at the INEEL. The first Ceramatec membrane has been received at the INEEL and will be tested in the vertical membrane test system.

Rosa Costello worked as a student intern on the Proton Exchange project sponsored through the DOE-FE Mickey Leland Fellowship Program. Rosa is an undergraduate student at the University of Puerto Rico, Mayagüez.

Bioupgrading of Heavy Crudes Using Temperature and Oil Tolerant Enzyme Catalysts

(ChevronTexaco and ORNL)

Highlight:

- Designed a hybrid thermostable enzyme for catalytic oxidation.

Project description: This project is aimed at developing catalysts that can be used at temperatures up to 90^{o}C in an oil environment with the goal of upgrading crudes via oxidative biotransformation or molecular weight reduction.

This project was initiated earlier this year for investigating oxidative enzymes that can transform compounds in oil by introduction of hydroxyl groups. This can result in viscosity changes of the oil due to formation of surface-active molecules or serve as a first step in oxidative breakdown of the compounds.

Enzymes called cytochrome P450s are capable of oxidizing various polyaromatic hydrocarbons (PAH) as well as some alkanes, resulting in diols and alcohols respectively. These enzymes were therefore selected for study. The purpose was to transform them into stable catalysts that can be used at higher temperatures and in the oil environment. The initial goal was to develop a thermostable catalyst. For this purpose, the functional portion of the PAH-transforming enzyme CYP101 was combined with the stability-imparting portion of the thermostable enzyme CYP119 to produce a hybrid. The resulting hybrid enzyme was tested for functionality, structural differences, and stability. The hybrid maintained the stability and the overall structure, however the ability to oxidize specific molecules was changed. To determine the substrates of this new enzyme, several alkanes and PAHs were investigated via binding studies. However, none of them seemed to bind the hybrid enzyme. Apparently the active site structure was sufficiently altered due to the combination and it lost its functionality. Two approaches are being used to regain the functionality. One is a targeted approach based on structural NMR studies and the other is based on directed evolution of the hybrid to change the structure via random mutagenesis.

Natural Gas Technology

Molecular Engineering: Next Generation of Gas Purification Technology

(ChevronTexaco, Virginia Commonwealth U, and BNL)

During this reporting period we worked on the development of imprinted particles against the C3-C4 molecular size range. We implemented a new strategy where we imprint to a template that is different in chemical structure but similar in size to the target molecule. The primary advantage of this strategy is that it allows us to take advantage of the chemical properties of a simulant template in order to prepare cavities with well-defined properties (e.g. size, shape, stability). The EPA monomer was used as a matrix and butanol was used as a template. Butanol has four carbon atoms, which is similar to the structure of butane but it also has a polar (OH) group, which we believe will help to maintain the template-monomer interaction during monomer polymerization.

By imprinting to a butanol template we were able to achieve a 500% enhancement in the specific sorption ability of EPA particles to the targeted lower hydrocarbons (C5-C6). This dramatic result not only extends our molecular imprinting capabilities to lower hydrocarbons, but improves upon our best previous sensitivity enhancement by at least a factor of ten.

Coiled-Tubing-Deployed Hard Rock Thermal Spallation Drill and Cavity Maker

(Nextant, NM Tech, and LANL)

Highlight:

- Progress made in burner design and testing

The parts for the burner, 10-ft drill stem assembly, and prototype burner were completed, assembled, and tested. A prototype spark igniter circuit design was installed on the burner assembly and demonstrated.

A number of Newpep combustion code runs were made to develop a theoretical performance matrix for propane-air combustion burners. The results of the runs will be used to evaluate the sensitivity of the burner performance to variations in excess air, combustion, chamber pressure, and input air and fuel temperature.

The portable spallation drill testing assembly was completed and is being used to conduct the initial evaluation of the redesigned prototype flame-jet burner assembly. A 1.5 ft deep, 6 to 8 inch diameter hole was produced in a 3 ft cube-shaped rhyolite sample excavated from a local outcrop before the rock fractured into multiple fragments. The air and propane flow controls did not work well enough to maintain a reliable and steady flame so the process flows were controlled manually. The flame-jet burner had a 0.4375-inch nozzle between the combustion chamber and the exhaust area. A 0.339-inch nozzle designed to support a supersonic exhaust stream may be tested to determine if it will produce a smaller diameter hole with an improved thermal spallation drill rate and reduced fuel consumption.

Scintillating Fiber Neutron Detectors for Well Logging

(CompuLog, Precision Drilling, Technology Services Group, and PNNL)

Highlight:

- The ambient temperature version of the scintillating fiber neutron is ready for testing.

Funding issues delayed detector fabrication. The two ambient temperature (high hydrogen content) detectors are complete. The high temperature detectors are nearly complete. A new curing procedure was developed for the high temperature polymer, and an additive was incorporatedto increase the hardness of the cured polymer. Neutron efficiency testing at room temperature begins in September.

39154 5 Alberta Ltd. has loaned a MAN A tool communications system for use in bench scale testing at PNNL. Use of the commercial system saves elec-

tronics development time and cost. The communications system can handle 14 channels of data transmitted on up to 20,000 ft of cable.

PNNL project staff met with Computalog Ltd and 391545 Alberta Ltd representatives at the Society of Professional Well Logging Analysts annual meeting. It was agreed that the maximum operating temperature of the system is validated after six hours of continuous performance at a given hold temperature. Computalog staff will provide PNNL with an MCNP neutron physics model of the MAN A tool down hole performance if the computer files are still readable. Acceptance of the new detector by the well logging community will require down hole data logs based on the presentations made at this conference.

225° C MWD Using Silicon-On-Insulator (SOI) Electronics

(Baker Oil Tools, Eagle-Picher, Honeywell SSEC, General Atomics, Noble Engineering, Quartzdyne, and SNL)

Highlight:

- Demonstration tool ready for deployment.
- Month of 200°C oven testing completed.

A demonstration tool is to be delivered to Welaco in Bakersfield, California for pressure testing on September 8. Assuming no leaks, the tool will be deployed in a 190°C well located on the Coso Navy Test Range, 3 hrs north of Bakersfield.

The Navy has agreed to allow public access to the data captured during the 2-year test. Quartzdyne is planning to display the real-time measurements at the upcoming SPE. Honeywell and other component manufacturers used to build the SOI tool will also have access to this data. .

Welaco is a good partner. They provide logging service for the Chevron-Texaco steam injection oil fields near Bakersfield. They understand the need for very high temperature (HT) logging tools, and will help in marketing this capability in the future by displaying continuous 190°C pressure/temperature data from the Navy well to potential customers. Other service companies can promote this technology as Sandia makes it available to anyone in the industry.

The Navy has been very cooperative. We could not ask for a better well for demonstrating this technology. They are giving us clear access and unrestricted publication of the collected information.

Status of tasks are as follows:

Task 1: Build and demonstrate SOI P/T tool in a long-term test at 175-200°C

Ready for deployment (see above).

Subtask 1.1: Completed.

Subtask 2.1: We have completed testing of a thermal battery design but have found assembly issues. This effort is being handed over to Eagle-Picher Industries (EPI). EPI is holding a major internal program review in mid-September. Their engineers are pushing for a major effort in 2004 to provide the drilling industry with prototype HT batteries.

Subtask 2.2: Work completed, but with an issue. The solid-state battery prototype has been fabricated and tested and provides approximately 3 volts from room temperature to 300°C. However the battery current is below expected values. The reason is unknown, but the test sample may have been exposed to air prior to assembly allowing an oxidation film to form, increasing the cells internal resistance. An investigation is underway.

Task 3: Design and field a testable "Memory Mode" MWD tool

Subtask 3.1: 60% Completed. Steven Rountree has designed both flux gate magnetometers and magnetic resistive azimuth circuits. He has written a report which is presently under review by Sandia. He is suggesting that Prime Directional Services and Sandia stay with current flux-gate technology over the Honeywell SOI magnetic resistive technology. The magnetic resistive technology has a significant DC offset making azimuth measurements difficult. However, it maybe possible to build the conventional flux-gate circuit using Honeywell SOI analog circuits for a 225^{o}C rating.