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INTRODUCTION

This Report reviews the University of Wyoming's approach to implementing the DOE Traineeship Program, and briefly describes the research performed by our DOE/EPSCoR Trainees during Years 2 and 3 of the Traineeship Program, 1992-1994, as of August 1994. A summary then discusses the impact of the Traineeship Program at the University.

YEAR ONE, 1991-1992

In the first year of the Traineeship Program supported by Department of Energy EPSCoR funding, the University of Wyoming made good progress toward the objective of increasing the supply of highly trained engineers and scientists with interests in energy-related disciplines.

IMPLEMENTATION

After notification of the initial funding of our DOE-EPSCoR Traineeship proposal, the DOE-EPSCoR Committee decided to emphasize the recruitment of new domestic graduate students in targeted disciplines, with special attention to under-represented minorities. To maximize the impact of the DOE funding, a competitive award process was implemented, starting with a general notification to faculty that traineeships would be awarded for graduate students working on energy-related research projects. Faculty were invited to submit brief proposals documenting appropriate research projects, the academic records of the proposed students, and a proposed budget. A review committee, composed of the Project Director, the Dean of the College of Engineering, and the Dean of the College of Arts & Sciences, met to decide which students would be funded and what the level of funding would be. A stipend of \$1000/month, to include summer months, was deemed adequately competitive at the University of Wyoming. Considering the University's contribution toward tuition and fee costs and the mix of Wyoming resident and nonresident students, we found that the average funding needed for each student was approximately \$14,700 for the funding year, allowing the award of 17 DOE traineeships. Seventeen students were selected the

first year, distributed among departments as listed in Table 1.

Table 1. Number of DOE/EPSCoR Traineeships, 1991-1992, by University Department.

<u>Department</u>	<u>Number</u>
Chemical Engineering	2
Chemistry	1
Civil Engineering	1
Electrical Engineering	3
Environmental Biology	2
Geology & Geophysics	3
Mathematics	2
Mechanical Engineering	1
Petroleum Engineering	1
Statistics	1

RESEARCH ACTIVITIES

The research activities of each of these students is summarized in our 1992 progress report (DOE Report No. DOE/ER75665-1). As a group, these students and associated faculty had an important influence on research at the University of Wyoming, improving our focus on energy and the environment, increasing the number of students actively engaged in research at the University, and laying the foundation for increased student involvement in research in the following years.

YEARS TWO AND THREE, 1992-1994

During the second and third years of the Traineeship Program, the University of Wyoming continued to make good use of this funding to increase the supply of young engineers and scientists trained in energy-related fields by involving University graduate students in ongoing critical research.

IMPLEMENTATION

The competitive selection process developed during Year 1 of the Traineeship Program was again used successfully during Years 2 and 3. The DOE/EPSCoR Committee (rather than a committee composed of the Project Director and two Deans, as in Year 1) made the selection of trainees, starting with a clean slate at the beginning of Year 2 and meeting several times during the biennium as positions became available. The stipend of \$1,000 per month (a total of \$14,700 per year, with average tuition, fees, and travel added) was continued; the additional cost to the Trainees of tuition increases during 1992-1994 was absorbed by the University. The \$14,700 annual cost per Trainee allowed an average of 17 Traineeships to be active at any given time; 27 students were selected for the two-year period, 8 continuing their Traineeships from Year 1 and 19 newly selected during Years 2 and 3, distributed by department as listed in Table 2.

Table 2. Number of DOE/EPSCoR Traineeships, 1992-1994, by University Department.

<u>Department</u>	<u>Number</u>
Chemical Engineering*	2
Chemistry	3
Civil Engineering	1
Electrical Engineering	5
Geology and Geophysics	5
Mathematics	1
Mechanical Engineering	4
Petroleum Engineering*	3
Range Management	1
Zoology	2

*The Chemical Engineering and Petroleum Engineering departments were combined November 1, 1993 into the Chemical and Petroleum Engineering Department. In this report, they are treated as separate departments.

RESEARCH ACTIVITIES

Some phases of research have been completed August 31, 1994, the end of Year 3 of the Traineeship. Some phases were completed during the 1992-1994 period, and

several have been started or will end at different times during this period. This narrative covers all 27 Trainees active during Years 2 and 3.

Chemical Engineering Department. **Paul Jacobs** has been a Trainee during Years 1, 2, and 3 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1994. He will complete a Ph.D. dissertation on *The Chemical Modification of Cobalt-Molybdate Catalysts Supported on Gamma-Alumina to Improve Coal Liquefaction Performance* in 1994.

Paul spent a brief but productive internship at the Energy and Environmental Research Center in Grand Forks, North Dakota June 8 through June 12, 1992, where he studied work in progress, some of it supported by DOE. Under the general supervision of Warrack Willson, Paul was introduced to some bench-scale, early-stage research on coal liquefaction and gasification and some analytical instrumentation used to analyze feed and product materials; a pilot plant operation of a "Catalytic Bag House", sponsored by Owens-Corning, a process that reduces NO_x emissions from coal-fired power plants; mild gasification facilities, in which all parameters are controlled by one program on one computer; oil agglomeration float/sink and coal cleaning experiments; a coal-slurry rheology computer program that models coal-slurry flow with any type of viscosity and any pipeline configuration; and a briquetting operation that can be used to make form coke for the steel industry with mildly gasified coal. Paul had the opportunity to discuss various aspects of coal-liquefaction chemistry with Curt Knudsen. Paul also participated in departmental teaching activities.

Paul's research is in chemically modifying commercial coal-liquefaction catalysts and testing the ruggedness of these altered catalysts with a newly designed and built Catalytic Coal Liquefaction Microreactor (CCLM). The CCLM is designed to determine the effectiveness and longevity of hydrotreating catalysts in the presence of the severe coking environment that exists during direct, single-stage coal liquefaction. The test catalyst for this study was AMOCAT 1A, a cobalt promoted molybdenum catalyst supported on gamma-alumina with a relatively large bimodal pore structure.

The construction and shake-down of the CCLM having been completed, the first experiments focused on hydrotreating raw creosote oil. Two-week runs that processed a feed of coal paste consisting of powdered coal, heavy coal-liquid residual, and coal distillate as the solvent, were successfully conducted. Next, some catalysts modified with alkali and alkaline-earth metals were tested for liquefaction performance.

While liquefying Black Thunder sub-bituminous coal, Paul noted a shell, consisting mostly of calcite, covering the catalyst pellet and closing off the interior to reactants. It was thought that reducing the calcium content of the coal would lower the shell formation rate and increase catalyst longevity. Work then focused on removing the calcium, existing in both a carbonate and an ion-exchanged form, from the coal with a mild acid treatment. Several mineral and organic acids were tested. Two washes with dilute nitric acid gave the best and most reproducible results: 92% of the calcium was consistently removed. The next step was to make large batches of this "deashed" coal and process it in the same manner as the untreated coal. One serious problem arose: a constant plugging of the inlet line after only a short time on stream. A new reactor was designed and built which had superior cooling at the inlet and localized heating. A successful 20-day run was then completed. The shell, as seen under the electron microscope, did not form to anywhere near the extent it had when processing untreated coal.

Paul's faculty associate in his project is his advisor, Henry Haynes, and several publications have resulted from this work.

Mark Welegala was a Trainee during years 1 and 2 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1993. Mark hopes to complete his Ph.D. dissertation on *Sorption Rate Measurements on Single Zeolite Crystals* in 1994.

The objective of Mark's research has been to build an electronic containment device for single-crystal sorption uptake experiments and to obtain diffusion coefficients for a simple zeolite-adsorbate system. As the required cell geometry differs significantly from conventional designs currently in use, design software was also developed to aid in stability and applicability for his specific crystal size. To enhance the quality and tailor the size of his zeolites and to eliminate any possible commercial contamination, lab samples were grown for his use. Thus, Mark's research has led to the development of what he and Dr. Haynes believe will be a workable system, in which they can hold stable, single microscopic-size zeolite crystals in the desired adsorbate flows. Completion of the new, heated chamber will allow insitu decontamination and measurement of adsorption/desorption behavior to be carried out, and valid diffusion coefficients to be determined.

Mark's faculty associate in his research is his advisor, Henry Haynes.

No publications or presentations have resulted from Mark's work while a

DOE/EPSCoR Trainee, to date.

Chemistry Department. **Scott Campbell** has been a Trainee during Years 1, 2, and 3 of the Program, and will finish his DOE/EPSCoR Traineeship during 1994. He plans to complete a Ph.D. dissertation on *The Electronic Structure of Molecular and Solid-State Transition-Metal Sulfide Systems* in the spring of 1996.

Scott's research has focused on the electronic structure of molecular and solid-state transition-metal sulfide systems. His initial calculations, recently completed, considered several six-coordinate trigonal prismatic molybdenum-sulfur complexes. These calculations enabled Scott to interpret the bonding in $[\text{Mo}(\text{CO})(\text{PPh}_3)(\text{buS}_2)_2]$ ($\text{buS}_2 = 3,5\text{-di-}t\text{-butyl-1,2-benzenedithiolate}^{(2-)}$). This complex is unusual in that carbon monoxide (CO) doesn't normally bind to a high-oxidation-state metal; this complex formally contains a Mo^{4+} center. Scott's calculations showed that while it is correct to view the metal in this complex as a Mo^{4+} center, the sulfur-containing dithiolate ligands are very strong electron donors. They provide sufficient electron density to the metal center to bind the CO ligand. In effect, electron density is transferred from the sulfurs, *through* the metal orbitals, to the CO ligand.

The ability of a high-oxidation-state metal to bind CO in the presence of strong donor ligands has important implications for the interpretation of CO adsorption on the surface of the MoS_2 catalysts in hydrosulfurization (HDS) catalysis. Surface scientists have associated the adsorption of CO on coordinatively unsaturated Mo centers on the MoS_2 surfaces with the presence of reduced metal centers. The binding of CO to a Mo^{4+} center in the molecular complex suggests that CO adsorption on the MoS_2 surface does not necessarily imply the presence of reduced Mo centers. Since the only other ligands bound to the surface Mo centers are strongly donating sulfide groups, a binding mechanism similar to that observed in the molecular system may explain the CO adsorption.

Scott has also become interested in the geometric distortions which are sometimes observed in trigonal prismatic complexes containing dithiolate ligands. By carrying out molecular orbital calculations on a series of tris-dithiolate complexes, he was able to relate these distortions to the relative energies of the metal and sulfur orbitals.

Scott is now beginning to study the electronic structure of complexes containing thiophenic ligands. Upon completion of this study, he will begin to study both the surface electronic structure of several transition metal sulfides which are active catalysts

for the HDS reactions and the interactions of molecules such as CO and thiophene with these surfaces.

Scott's faculty associate in his research is his advisor, Suzanne Harris, and several publications are complete or in press.

Kevin Morris has been a Trainee during Year 3 of the Program, and will finish his current Traineeship August 31, 1994. He plans to complete his Ph.D. dissertation on *Vectoral Energy Transfer to a Synthetic Reaction Center* in the fall of 1996.

He looks forward to participating in an internship during the summer of 1995.

The goal of Kevin's research is to synthesize and understand the photophysics of polymers based on ruthenium polypyridine complexes that are capable of gathering light energy and directing it in a single vector to a terminal polymer unit capable of charge separation. The polymers contain d(Ru) ^{*}(bpy) metal-to-ligand charge transfer (MLCT) excited states whose excited state electron distribution has a high degree of charge separation. These are well studied systems that have a clear preparative sequence. A new oligomer, based on chemistry of trans-dicyano complexes that has been developed in our laboratory, is similar to recently synthesized cis-dicyano complexes.

Using a cascading series of well developed excited-state complexes varying in energy levels, it can predict that intracomponent energy transfer will occur in a certain way. Consider such a series, and let the rightmost terminus possess the lowest-energy MLCT excited state. Energy will flow from the other units in the oligomer to this rightmost site. These will act like light-harvesting antennae. At the same time, by virtue of the charge transfer characteristics of the excited state and the difference in energy of the ^{*} bipyridine orbitals, electrons will flow the opposite direction. By taking advantage of this charge separation, the free electron residing to the left will be capable of reducing a substrate like H₂O to H₂, while the right-hand terminus could be used for the oxidation of another substrate. Such an oligomer could promote vectoral energy transfer from the left-hand unit to the right simultaneously with charge separation in a fashion much like the natural photosynthetic reaction center.

Using a specific synthesis of poly-trans-[Ru^{II}(bpy)(L)(CN)₂]ⁿ⁺ (bpy is bipyridine; L is diphosphine), Kevin's initial photophysical studies are being performed in solution using standard luminescence and transient spectroscopic techniques. Later, attachment to fused SiO₂ surfaces will allow assessment of the polymer's properties in a device-like environment.

Kevin's research is of direct interest to the Department of Energy through the Office of Basic Energy Sciences. Similar projects are underway at both the National Laboratory for Renewable Energy Resources and Brookhaven National Laboratory.

Kevin's faculty associate in his research is his advisor, Pat Sullivan.

This is a new Traineeship, and no presentations or publications have yet resulted from his research.

Chris Schnabel was a Trainee during Years 1 and 2 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1993. He completed his Ph.D. dissertation, *(Fluoroalkyl)phosphine Complexes of Rhodium and Iridium*, in December 1993. He is currently a Postdoctoral Research Associate at Los Alamos National Laboratories, under the direction of Carol J. Burns, INC-1.

Chris spent a two-week internship at Los Alamos National Laboratory during the summer of 1992, where he worked with Carol Burns in the INC-1 (Inorganic and Nuclear Chemistry) Group. His research involved the synthesis of new (fluoroalkyl)phosphine complexes of the actinide elements, particularly uranium, with the goal of designing robust actinide complexes with novel physical and chemical properties. Preliminary results were obtained which indicated that such complexes are feasible, although in the limited time full characterization of these compounds was not achieved. A continuing collaboration with the INC-1 Group on developing the chemistry of (fluoroalkyl)phosphine actinide complexes resulted from Chris's internship.

Chris's research focused on the development of novel homogeneous transition metal catalysts for selective hydrocarbon cracking (petroleum reforming) and dehydrogenation using fluorocarbon-protected transition-metal complexes.

Chris's faculty associate in his research is his advisor, Dean Roddick.

During his DOE/EPSCoR Traineeship, he received a National Science Foundation Grant, *Hydrocarbon Activation and Decarbonylation Chemistry of Iridium and Ruthenium Fluoroalkylphosphine Complexes*, November 1993-1997, for \$293,500. Several publications have resulted from this research.

Civil Engineering Department. **Linda Williams** has been a Trainee during Year 3 of the Program, and will finish her DOE/EPSCoR Traineeship August 31, 1994. She plans to complete her M.S. thesis on *Essential Hydrologic Functions of Playas at the AMAX Coal Company Belle Ayr Mine in the Powder River Basin of Northeast Wyoming* in the spring of 1995.

Linda's experience as a hydrologist and a mining engineer have been invaluable in her research into the restoration of lands disturbed by mining. Her research has been focused on playas and small ephemeral ponds and lakes, specifically on the characteristics and functions of naturally occurring playas. Her goal is to determine appropriate methods for incorporating playas in the restoration of drastically disturbed surface mined land. Planned for investigation are (1) the relationship between basin size and configuration, and water quantity (both surface and ground water) stored within the playa throughout the year; (2) the quality of the water in the playa and the subsoil; (3) the effects of recharge from playas on maintaining shallow aquifers; and (4) the transport of salts and other chemical compounds and their effects on the soil profile. Vegetation and soil studies will also be included, in response to a request for proposals from the Abandoned Coal Mine Lands Research Program: our proposal is an interdisciplinary project that includes the departments of Range Management; Plant, Soil, and Insect Sciences; and Civil Engineering.

AMAX personnel have expressed interest in Linda's project. Negotiations with AMAX Belle Ayr on the proposed scope of work have been ongoing since November, and AMAX is considering funding portions of her research. Linda met with several industry and regulatory officials in October to discuss her thesis topic. On the basis of their comments and subsequent written suggestions, she updated her proposal. She has completed the literature review and is now gathering equipment for field work. She hopes for industry and other funding, as discussed above, for this effort.

Linda's faculty and mentor associates in her project have been her advisor, Victor Hasfurther and Thomas Edgar (Civil Engineering), Larry Munn and Jeff Murphy (Plant, Soil, and Insect Sciences), and Frank Munshower, Director of the Reclamation Research Unit, Montana State University.

Electrical Engineering Department. **Victor Bershinsky** has been a Trainee during Years 2 and 3 of the Program, and will finish his DOE/EPSCoR Traineeship August 31, 1994. He intends to finish his M.S. thesis on *An Instrument for the Measurement of Electrical Power Consumption, Efficiency, and Load Balancing of Electric Motors* in 1994. During the academic year, Victor works in the Electric Motor Testing and Training Center at the University of Wyoming.

Victor participated in internships during the summers of 1992 and 1993 at Naval Petroleum Reserve No. 1, under the direction of Lt. Commander Lee Thomas, U.S.N.,

and Naval Petroleum Reserve No. 3, under the direction of Lieutenant Bill Shoemaker. Research involved developing a testing procedure that would allow the testing of a large number of motors that were operating in these oil fields and determine if the motors were operating efficiently. In addition to developing the test procedure, Victor has been designing an instrument that will test the efficiency of an electric motor that is operating with only a small amount of process interruption. This meter estimates the operating efficiency of an electric motor on the basis of the input power to the motor and the motor's rated horsepower. The development of this meter is the topic of Victor's thesis.

There are no meters currently available that tell the user not only the energy consumption of an electric motor, but also whether or not the motor is operating efficiently and if not, indicate the correct motor for the job. The meter designed by Victor will, and will also measure the long-term power consumption of a rapidly changing load, a feature not available on many commercial meters. In addition, the meter will assist oil field operators in balancing oil well pumps correctly, which is a way of conserving a great deal of energy. In their testing of more than 1,000 pump jack motors at NPR 1 and NPR 3, Victor and his colleagues determined that approximately 20% of the wells were unbalanced. An unbalanced well causes the electric motor to do an excessive amount of work and use more power than it should. Until now, the field operators' methods of balancing pumps has been very primitive. Using Victor's meter, the wells can be balanced quickly and accurately.

In association with their advisor, Sadrul Ula, Victor and Trainees Thomas Nichols, and Damon Van Buren have worked as a group on electric power generation and distribution problems. Eight students were associated with Victor in his field work at NPR 1 and 3.

No publications or presentations have resulted from Victor's work while a DOE/EPSCoR Trainee, to date.

Thomas Nichols was a Trainee during Years 2 and 3 of the Program, and will finish his DOE/EPSCoR Traineeship during 1994. He completed his M.S. thesis, *A Practical Method for Load and Efficiency Estimation of Polyphase Induction Motors*, in December 1993, and is currently (January 1994) interviewing for energy-related jobs in industry.

The ability to accurately determine motor loading and efficiency in the field is crucial for implementing cost-effective energy saving programs. Thomas's research

resulted in a new method, based on the motor manufacturer's efficiency versus load curve, to estimate motor loading and efficiency. In his thesis, Thomas presented the two conventional methods, one based on slip and one developed by Konstantin Lobodovsky, in detail for comparison with his new method, and reported on tests performed on three different motors over their full operating range and calculations of their efficiency by all three methods.

Thomas's faculty associate in his work was his advisor, Sadrul Ula, and his research work has been published.

Damon Van Buren has been a Trainee during Years 2 and 3 of the Program, and will finish his DOE/EPSCoR Traineeship August 31, 1994. He will complete an M.S. thesis on *A Combined Series-Active, Shunt-Passive Filter Approach to the Removal of Power System Harmonics* in 1994.

Damon participated in internships during the summers of 1992 and 1993 at Naval Petroleum Reserve No. 1, under the direction of Lt. Commander Lee Thomas, U.S.N., and Naval Petroleum Reserve No. 3, under the direction of Lieutenant Bill Shoemaker. Field measurements involved comparing motor power input with rated output to get an indication of motor operating efficiency.

Damon's research involves the removal of harmonics from a power system using an active filter in conjunction with a shunt passive filter. The standard approach for correcting a problem with harmonics is to install a passive filter at the point where there is an excess of harmonics; this approach is often ineffective. Damon's research has found that the addition of an active filter will greatly improve the performance of the passive filter, without the need for large power handling capability. The hardware for his research has been constructed, and he has run extensive computer simulations on the effectiveness of the filter under different conditions. Damon has begun testing the passive/active filter combination with light loads, and this testing should be completed during 1994.

During his Traineeship, Damon has been involved in a number of DOE-related projects, besides his internship participation, described above: motor efficiency testing; writing several educational fliers on harmonics produced by energy-efficient lights and variable frequency drives; and helping demonstrate the Motor Training and Testing Center's work to interested groups.

In association with their advisor, Sadrul Ula, Damon and Trainees Thomas

Nichols, and Victor Bershinsky have worked as a group on electric power generation and distribution problems. Eight students were associated with Damon in his field work at NPR 1 and 3.

Christina Yearous has been a Trainee during Year 3 of the Program, and will finish her Traineeship August 31, 1994. She plans to complete her M.S. thesis on *Computer Simulation of an Assessment of Power Systems* in December 1994. Christina brings to her research two summers' experience working for the largest utility in Alaska. She has worked at the electric Motor Testing and Training Center at the University of Wyoming.

To minimize electrical energy costs, many large users of electricity have added capacitors to their systems to lower demand charges. With the availability of larger-capacity silicon-controlled rectifiers (SCRs or Thyristors), adjustable speed drives (ASDs) are becoming more and more economical for many users. The potential power system harmonic problem is due to (1) ASDs injecting harmonic current into the distribution system; (2) increase in other nonlinear loads, resulting from new technologies such as uninterruptible power supplies (UPSs), power transistors, and microprocessor controls, creating load-generated harmonics throughout the system; and (3) more critically designed power devices being operated into the saturated regions of the magnetic materials (to be economically more competitive), resulting in higher harmonics. Christina's project is to study and make harmonic measurements on various harmonic-producing electrical devices using a spectrum analyzer, then to design and implement a scheme to reduce harmonic distortion, thereby improving electrical power quality.

This is a new Traineeship, and no presentations or publications have resulted from it as of January 1994.

Brenda Bujanowski has been a Trainee during Years 2 and 3 of the Program, and will finish her DOE/EPSCoR Traineeship August 31, 1994. She plans to complete her M.S. thesis on *System Identification with Application to Power Systems* in December 1994.

Brenda participated in an internship at the Pacific Northwest Laboratories in Richmond, Washington, June 7 through August 6, 1993. PNL is operated by the Battelle Memorial Institute under contract with the Department of Energy. Working under Dan Trudnowski, Brenda evaluated recent commercial software for use in system identification of power systems, and performed related tasks.

Brenda has conducted a background study of system identification as applied to power systems, and has investigated the implementation and testing of three different algorithms; results of these investigations were presented in an Electrical Engineering Graduate Seminar April 16, 1993, and were expanded into a published paper.

Brenda's immediate research will include searching the available literature to investigate a problem occurring in the results of her current Prony algorithm and find a way to solve it. Once the Prony program is producing satisfactory results, they will be compared with the other methods researched. Different methods of model order reduction may also be researched and implemented to test their effectiveness, against the method currently being used. Since data from actual power systems is available, the algorithms will be tested to see how will they would perform on an actual system. She will determine other aspects of the system identification problem to be researched as her study progresses.

Brenda's faculty and mentor associates in her work have been her advisor, John Pierre, and Don Pierre and his students at Montana State University, and her research has resulted in one published paper.

Geology & Geophysics Department. **Derek Brooks** has been a Trainee during Year 3 of the Project, and will finish his Traineeship August 31, 1994. He hopes to complete his M.S. thesis on *Sequence Stratigraphy in the Upper Cretaceous of Wyoming* in May, 1995.

The goal of Derek's research is to evaluate predictive models of stacking patterns of river deposits as preserved in the rock record. The reservoir potential of fluvial sandstones depends, in large part, on how sandy deposits interconnect and how these connected sand bodies are preserved within the fine-grained overbank deposits that act as seals with respect to hydrocarbon migration. Models that emphasize subsidence as the dominant control on stacking patterns of this type of deposit are especially convenient for tectonic studies, because they suggest a simple linkage between fluvial deposits observed and the tectonically driven subsidence history of a basin. Such a model is of interest to the petroleum industry because it allows times of rapid versus slow subsidence to indicate where broad versus well-sealed reservoirs will occur in the subsurface. In addition, since hydrocarbon maturation is linked to subsidence history through changes in temperature with depth, such a model places a broad constraint on prediction of when source beds may have passed through the oil and gas production windows.

The difficulty with these models is that they assume random or quasi-random occurrences of river avulsion (times when a river jumps out of its channel and establishes a new course over the flood plain). Since river channels are the primary origin of sand bodies in this setting, the frequency and distribution of these avulsion events dictates their occurrence in the rock record. We now believe that avulsion events are not random, but rather are linked to sedimentation rate. Since the models use sedimentation rate as a proxy for subsidence rate, and sedimentation rate also controls avulsion rate, a problem arises in that both variables within the models (subsidence rate and avulsion rate) are in fact controlled by a single parameter (sedimentation rate). Since both variables are controlled by the same parameter, a more accurate modeling study would show no dependence of fluvial stacking pattern on subsidence rate; and these widely accepted models would be shown to be wrong.

However, we do see changes in stacking pattern in the rock record, and would like to be able to predict where these changes occur, for reasons of petroleum exploration. The goal of Derek's research is to examine two field examples of stacking pattern sequences, one in Wyoming and one in Utah, and collect data on those indicators that might show if changes in stacking are the result of changes in sorting of the sediment supply, water discharge, or sedimentation rate. These parameters will help us understand if changes in climate, source rock, or tectonic activity play important roles in the development of these fluvial reservoir systems, and lead us toward predictive models that more accurately capture how rivers work.

Derek's faculty associates in his research are his thesis advisor, Paul Heller, and Jim Steidtmann and Randi Martinsen. This is a new Traineeship, and no presentations or publications have resulted from it at this time.

Jack Diebert has been a Trainee during Years 2 and 3 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1994. He plans to complete a Ph.D. dissertation on *Sedimentology, stratigraphy, and sequence stratigraphic analysis of the Cenomanian-Turonian Greenhorn transgressive-regressive cycle of southwestern Utah* in the fall of 1994.

During the summer of 1993, Jack completed an industry-related internship. He examined Cretaceous sandstone outcrops in southern Utah with petroleum geologist Gus Gustason of British Petroleum, Alaska. The sandstone outcrops were ancient analogs for many shallow marine and fluvial sandstone reservoirs. The purpose of the internship was

to examine, discuss, and analyze lithologic variations within interbedded sandstone and mudstone units that produce flow heterogeneities within petroleum reservoirs. The internship provided valuable information concerning type, scale, and extent of flow heterogeneities involved in the production of hydrocarbons from these types of sandstone reservoirs. This information allowed Jack to more accurately quantify flow units and flow boundaries in his analog outcrop study.

Jack will continue to analyze data collected to date, using photomosaic cross sections indexed by careful sequence stratigraphy to derive the expected dimensions of shallow marine shoreface sandstone bodies.

Jack's faculty associate has been his advisor, James Steidtmann, and his chief mentor has been Gus Gustason of BP. Several publications have resulted from this research.

Anthony Hoch has been a Trainee during Years 2 and 3 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1994. He plans to complete his Ph.D. dissertation on *The Dissolution Mechanism of Iron-Bearing Augite in Volcanic Tuff, Snowshoe Mountain, Colorado* in the fall of 1995.

Early in the summer of 1993, Anthony became affiliated with the U.S. Geological Survey, Water Resources Division, National Research Program in Boulder, Colorado. He spent several days a week, through the summer, working in the laboratory of Michael Reddy of the U.S.G.S. It is from this association that his dissertation project emerged.

Anthony is currently running dissolution experiments in the Boulder lab and in the Geology Department laboratory in at the University of Wyoming. He is studying the mechanisms of dissolution of the mineral augite, a highly reactive mineral in volcanic tuffs, investigating the effects of pH and organic acids on augite dissolution. Next, he will conduct dissolution experiments on the Snowshoe Mountain Tuff, an augite-bearing rock from the San Juan Mountains of Colorado. These samples were chosen by researchers at the U.S.G.S. specifically because of their similarity to the Yucca Mountain high-level nuclear waste repository in Nevada. Anthony's research will be important in determining natural or "baseline" processes of contaminants at repository sites.

Although is working alone on this project, Anthony has made regular presentations at a weekly seminar on work in progress attended by Dr. Drever's six graduate students.

Anthony's faculty associates and mentors include his advisor, Tim Drever, Ron

Frost, George Vance (Soils Department), Daniel Buttry (Chemistry Department), and Michael Reddy (U.S.G.S.). No publications or presentations have resulted from Anthony's work while a DOE/EPSCoR Trainee, to date.

Scott Johnson has been a Trainee during Years 2 and 3 of the Program, and finished his DOE/EPSCoR Traineeship during 1994. He plans to finish his M.S. thesis on *Groundwater Circulation Along Fault-Cored Structures* in 1994.

The essence of Scott's thesis project is to identify the geologic factors that cause localization of permeability in the attenuated parts of major range-bounding thrust faults in the Wyoming Foreland Province. His project area straddles the Hanna Basin and Shirley Mountains, and his effort is focused on well-indurated Paleozoic and Mesozoic sedimentary rocks in the hanging wall of the Shirley Mountain thrust fault. The permeability architecture in this zone has been found to be dominated by minor fractures associated with the faulting and folding, and by intergranular permeability within the clastic units.

Scott's field work and spring sampling have been completed. All water quality samples have been analyzed, and those data are being compiled at this time. The geologic and potentiometric data is compiled and is being drafted at this time.

Scott's faculty associates and nonfaculty mentors are his advisor, Peter Huntoon, Tim Drever, Todd Jarvis (Weston Groundwater Engineering), Jim Case (Wyoming Geological Survey), and personnel at the Wyoming Water Resources Center (University of Wyoming) and the State Engineer's Office in Cheyenne.

Directly as a result of Scott's participation in the DOE/EPSCoR program, Scott's advisor, Peter Huntoon, obtained a grant, *Permeability Architecture along the Attenuated Traces of Major Range-Bounding Wyoming Foreland Thrust Faults.*, Wyoming Water Center FY 1994 States Grants Program, for \$25,917. Several publications have already resulted from this research.

Debi Maucione was a Trainee during Years 1 and 2 of the Project, and finished her Traineeship in May 1993. She finished her M.S. thesis, *Seismic Reflection Delineation of Abnormally Pressured Zones in the Powell Field of the Powder River Basin, Wyoming*, in December 1993. She is currently pursuing her Ph.D. in Geology under the direction of Dr. Ron Surdam.

Debi recently spent six months participating in an internship with Amoco Production Company, working in both the International Business Unit and the Worldwide

Exploration Business Group.

Debi's research as a Trainee contains two results of importance for the oil and gas industry. First, she has used older data that is available but currently not being used, and through application of modern technology (processing software and interpretative work stations) has obtained further information that helps to delineate accumulations of hydrocarbons associated with abnormally pressured zones in sedimentary basins. That is, her method uses available resources to find additional accumulations of hydrocarbons. Second, she has shown that additional information about rock properties can be obtained from attribute analysis of reprocessed seismic sections. This information in turn can help in the delineation of abnormally pressured hydrocarbon accumulations.

Debi interacted frequently with other students in Scott Smithson's geophysics research group, particularly Yue Wang, Dan Willert, Nathen Weber, John Buggenhagen, John Rivas, Nick Boyd, Paul Valasek, Sharon Kubichek, and, in Ron Surdam's diagenesis research group, Lars Hubert.

Debi's faculty associates and mentors were her thesis advisor, Scott Smithson, Ron Surdam, Bill Iverson (Petroleum Engineering Department), Vlademir Serebryakov (visiting researcher from Russia), Marty Williams (Amoco, Denver), and Roger Harris (Amoco, Houston).

Several publications have resulted from this research.

Mathematics Department. **John Spitler** was a Trainee during Years 1 and 2 of the Program, and finished his DOE/EPSCoR Traineeship in August 1993. He plans to finish his Ph.D. dissertation on *Modeling Nonlinear Elastic Waves Using a System of Conservation Laws* in the spring of 1995.

During May 1992, John visited the Oak Ridge National Lab, where he met with Dr. Robert Ward, Director, to discuss the possibility of incorporating techniques developed there for handling nonlinearities that arise in modeling contaminate flow in both porous media and the atmosphere. The visit led to attacking the seismic problem from the standpoint of a system of nonlinear conservation laws. John presented results of this work at the 1993 SIAM Geoscience Conference.

John worked on modeling techniques important in seismic prospecting. Forward solving routines for two- and three-dimensional finite difference models utilizing linearized versions of the governing equations have been developed in recent years, and work well away from sources and interfaces. The focus of John's research work was the

development and analysis of schemes that include the nonlinear terms at interfaces in particular.

John interacted frequently with other students in Richard Ewing's research group in the Mathematics Department, particularly Hong Wang and Jien Shen, both of whom will earn, or have earned, their Ph.D.'s at Texas A&M University with Ewing.

John's faculty associates and mentors include his former advisor Richard Ewing, his present advisor Myron Allen, Patrick O'Leary, and James Sochaki (George Mason University).

Several publications have resulted from this research.

Mechanical Engineering Department. **Wayne Foslien** has been a Trainee during Years 2 and 3 of the Program, and finished his DOE/EPSCoR Traineeship during 1994. He plans to complete his M.S. thesis on *Temperature Gradient Metamorphism of Snow, Using Mixture Theory* in 1994.

Wayne participated in an internship at Battelle Pacific Northwest Research Laboratories (PNL) in Richland, Washington from May 24 to July 24, 1993, working under Lucia Liljegren in the Analytical Sciences Department. His work involved deriving the particle-fluid interaction terms in the turbulent kinetic energy equations for two-phase flow. His work helped verify that Dr. Liljegren's work was correct. He also started deriving the turbulent dissipation interaction terms, and Dr. Liljegren is planning to perform experiments to verify that the form of these interaction terms is correct. She will submit a paper, with Wayne as coauthor, that includes his work to *Physics of Fluids*.

Problems of a multiphase nature were the driving force behind the development of the continuum theory of mixtures. Modern mixture theory is founded on the idea that a multiphase continuum may be modelled as a collection of superimposed continua so that each constituent is assumed present at every point on the continuum. Wayne is investigating application of the continuum mixture theory to problems involving thermomechanical interactions. The specific problem under investigation is the temperature gradient metamorphism (TGM) of a snow cover. TGM is one of the key mechanisms responsible for acid pulse flushing of snow packs. Acid buildup in snow is often attributed to pollutants from coal-fired power plants. Acid pulsing occurs when as much as 50-80 percent of the acid in a snow cover is released during the first significant spring melt, causing destruction of fragile environments. Wayne's current task is writing mathematical models of temperature gradient metamorphism of snow using mixture

theory.

Wayne's faculty associate is his advisor, Andrew Hansen, and his mentor for this research is Lucia Liljegren (PNL).

No publications or presentations have resulted from Wayne's work while a DOE/EPSCoR Trainee.

William Johansen has been a Trainee during Year 3 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1994. He plans to complete his M.S. thesis on *Erosion of Submerged Piping in Fluidized Beds* in the spring of 1995.

Bill arranged an internship at the Morgantown DOE Coal Research Center. He brings ten years of practical power plant experience to his project.

The fluidized bed environment gives heat transfer rates from the burning coal bed to heat removal equipment that are among the highest measured in any heat transfer equipment. An optimal way to remove heat from a fluidized bed combustor is through horizontal pipes submerged within the bed. The pipes commonly contain water that is to be boiled, and the resulting steam drives turbines that drive electric generators. One serious problem with the implementation of fluidized bed combustors concerns the erosion of pipe walls due to abrasion by the highly agitated coal particles. The objective of Bill's research is to study the erosion problem in a laboratory-scale fluidized bed apparatus with no combustion occurring. The rate of erosion will be characterized in terms of the variables identified by Bill, including air velocity through the bed, particle size, and bed/pipe geometry. Measurements will be made with advanced laser-based instrumentation at the University of Wyoming heat transfer laboratories. The next steps in Bill's research will be designing a test apparatus and investigating the impact of coalescing bubbles on submerged pipe.

The goal of Bill's research is to support world-wide efforts to make fluidized bed coal combustion a viable alternative to conventional ways of burning coal. Results of fluidized bed combustion research will eventually be very important to Wyoming's coal mining and electrical power generation industries.

Bill's faculty associates in his project are his advisor, Paul Dellenback (turbulent fluid mechanics and optical instrumentation) and Pradeep Agarwal (Chemical Engineering; fluidized bed technology).

This is a new Traineeship, and no presentations or publications have resulted from his work at this time.

Roland Miller has been a Trainee during Year 3 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1994. He plans to complete his M.S. thesis on *An Investigation of Negatively Buoyant Jets Impinging on a Flat Plate* in the spring of 1995.

Roland's research will improve the image processing capability of the fluid mechanics research program at the University of Wyoming, and at the same time will be directed toward specific flow application: flows in turbomachinery and mixing processes, as in combustion and atmospheric flows. Two image processing techniques being developed in the fluid mechanics laboratory, particle image velocimetry (PIV) and laser induced fluorescence (LIF), are advancing rapidly as they follow closely the improvements in image capture and analysis. Both systems will be used to study such diverse flows as the flow of mixing behavior in swirled turbine combustors and atmospheric mixing processes (related to such problems as plant siting in areas of complex topography).

Roland's faculty associates in his research are his advisor, William Lindberg, and Paul Dellenback.

This is a new Traineeship, and no presentations or publications have resulted from it yet.

Bradley Williamson has been a Trainee during Year 3 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1994. He plans to complete his M.S. thesis on *Fluid Particle Velocity Measurement with Particle Image Velocimetry (PIV)* in the spring of 1995.

Researchers at the University of Wyoming and other laboratories have been investigating turbulent flow and heat transfer problems associated with "can" or "dump" combustors as part of investigations of the combustion technology applied in gas turbine engines. Research in this area at the University of Wyoming includes laser-based velocity and turbulence measurements in a model combustor and extensive measurements of heat transfer from the fluid to the combustor wall. The heat transfer measurements are of interest to the engine community because current combustor designs typically operate at gas temperatures substantially higher than the melting temperature of the materials from which the combustor is made. The situation can only be mitigated by implementing highly sophisticated cooling schemes within the combustor itself, and research at the University of Wyoming has been focused on improved cooling techniques. The

motivation for operating at ever-higher temperatures is greater thermal efficiency, i.e., greater fuel economy.

A problem in state-of-the-art combustor design is lack of understanding about the effects of centrifugal forces in the mixing process. The flow inside dump combustors is usually strongly swirled to promote turbulence and mixing. Centrifugal forces associated with swirling flow tend to place hotter, less dense gases near the centerline of the combustor and cooler, higher-density gases near the combustor walls. Thus, centrifugal forces retard mixing. The object of Bradley's research is to examine the effects of centrifugal forces on the mixing process and on heat transfer in dump combustors. He is working on computer-controlled ways to capture images digitally, and will use the method that results to make fluid particle velocity measurements.

Bradley's faculty associate in his research is his advisor, Paul Dellenback.

This is a new Traineeship, and no presentations or publications have resulted from it yet.

Petroleum Engineering Department. **Shari Kenuit** was a Trainee during Years 2 and 3 of the Project, and left the University of Wyoming in the fall of 1993. She wrote a report on her work under the DOE/EPSCoR Traineeship, *Waters of the Lower Cretaceous Muddy Sandstone and Cloverly Formations, Big Hollow, Albany County, Wyoming.*

Spontaneous potential logs of wells in Big Hollow, a deflationary hollow, show saline water in the Muddy Sandstone at a depth of 870 feet and fresh water in the Cloverly Formation at a depth of 1,000 to 1,140 feet. These two sands are separated by an aquitard, the Thermopolis Shale. Groundwater recharge to the Cloverly Formation appears to originate at an outcrop southeast of Big Hollow. Because the Cloverly is continually being recharged, its water is relatively fresh. The Muddy Sandstone is very heterogeneous; it is a shaley sand with fluvial channels cut into the formation. It is these channel sands that make the Muddy an oil producer. The water present in the fluvial sands is probably not subject to surficial recharge because of the geometry of the sands. Because these channel sands do not receive recharge, the water seen on the well logs is probably irreducible connate water and is therefore more saline than the Cloverly Formation water. Verification of this idea is impossible at this time because of the paucity of subsurface data for the area.

Stan Lawrence has been a Trainee during Years 2 and 3 of the Program, and finished his DOE/EPSCoR Traineeship August 31, 1994. He plans to complete his Ph.D.

dissertation on *The Determination of Fracture and Joint Orientations in the Subsurface to Facilitate Hydrocarbon Exploration in Tight Gas Sands* .

Stan brings 17 years of work in major oil companies to his project. Researchers at the DOE Petroleum Energy Research Laboratory in Bartlesville, Oklahoma, who have similar interests to Stan's in oil and gas exploration and production in Wyoming, provided him with documents on his research topic not available in Wyoming. Stan's subject area requires a mature knowledge of several traditional engineering disciplines that must be integrated to produce a viable solution. Geology, geophysics, and petroleum engineering combined with digital signal processing of data acquired via remote sensing have dominated Stan's research efforts.

The vast gas reserves in Wyoming basins are locked up in very tight geologic formations that basically prevent existing technology from producing the resource economically. Researchers are attempting to delineate viable methods with which to harness the physics of the near-surface of the earth to spatially locate fracture and joint systems. These systems provide the optimum path of least resistance for hydrocarbon migration in the subsurface. Stan is working on a technology that correctly delineates the presence and subsurface orientation of fractures. Such a technology will aid in minimizing risk capital invested by hydrocarbon exploration companies, thus will make the production of hydrocarbon reserves in Wyoming competitive internationally and simultaneously reduce our dependence on imports.

Stan's faculty associates in his research are his advisor, M.P. Sharma, and Bill Iverson, because of Bill's expertise in geophysics.

No publications or presentations have resulted from Stan's work while a DOE/EPSCoR Trainee, to date.

Timothy Pope has been a Trainee during Years 2 and 3 of the Program, and finished his Traineeship August 31, 1994. He plans to complete his M.S. thesis on *The Scalability of Core Flood Data* in the spring of 1995.

Tim made a four-day visit to EGG Research Company at INEL in Idaho during the summer of 1993. Eric Robertson, a former student at the University of Wyoming, was Tim's sponsor for the visit: he gave Tim a tour of the facility, and demonstrated an interfacial tension machine that they had developed.

Tim is currently (January 1994) assembling and debugging a core flooding apparatus that he will be using to acquire unsteady-state, and possibly steady-state,

relative permeability data as well as dynamic capillary pressure data. He has also designed a data collection for the core flood experiments: the data collection system integrates the data from two pressure transducers and an analytical balance, all connected to a PC.

Tim's Traineeship has effected a number of students, as he has been the Teaching Assistant in both the Drilling Fluid Laboratory and the Rock and Fluid Properties Laboratory in the Petroleum Engineering Department.

Tim's faculty associates in his research are his advisor, Norman Morrow, and Brian Towler. Tim has contributed to a paper that may be published by Dr. Towler in the near future.

No publications or presentations have resulted from Tim's work while a DOE/EPSCoR Trainee, to date.

Range Management Department. **Susan Hasenjager** has been a Trainee during Years 2 and 3 of the Program, and finished her DOE/EPSCoR Traineeship August 31, 1994. She plans to complete a Ph.D. dissertation on *Computerized Plant Species Selection for Mineral-Land Reclamation* in the spring of 1995.

Susan brings 15 years of experience in industry to her project.

She is currently building a menu-driven computer model and compiling a database. A comprehensive literature review will be the basis of a technical review article for the Journal of Range Management. Susan's research will result in a user-friendly database and retrieval system, menu-driven model, manual, and technical review. The objective of her research is to provide a viable method for determining appropriate mixtures of plant species for mine reclamation.

Susan's faculty associates in her research are her advisor, Jeff Powell, William Laycock, and Gerald Schuman, Larry Munn, and Jeff Murphy (Plant, Soil, and Insect Sciences Department).

No publications or presentations have resulted from Susan's work while a DOE/EPSCoR Trainee, to date.

Zoology Department. **John Baldwin** was a Trainee during Years 1 and 2 of the Program, and finished his Traineeship August 31, 1993. He completed his M.S. thesis, *Foraging Ecology and Movements of Wintering Waterfowl in the Fraser River Delta, British Columbia and the Puget Trough*, in December 1993.

John participated in an internship at the Battelle Pacific Northwest Laboratories at

Sequim, Washington, during the summers of 1992 and 1993. He assisted for several weeks in seagrass research and the writing of management guidelines for the types of bays and estuaries in that area for the State of Washington.

John's study area was a large marine bay with extensive tidal flats in southwest British Columbia and northwest Washington. He completed two extensive eight-month field seasons in the area. His task was to describe the ecology of this system, the effects of the spread of an introduced seagrass, and the importance of this system to wintering and migrating waterfowl. There was a void of knowledge in these areas; and as this bay is very susceptible to oil pollution from several refineries and shipping lanes, data was needed to aid in protecting the wildlife, but also to protect oil companies from unnecessary litigation in the event of an accident.

Several publications have resulted from this research.

Aïda Farag was a Trainee during Years 1 and 2 of the Program, and finished her Traineeship September 31, 1993. She completed her Ph.D. dissertation, *The Physiological Impairment of Brown Trout (Salmo Trutta) and Rainbow Trout (Onchorynchus mykiss) Exposed to Metals Via the Water and Diet in the Clark Fork River, Montana*, in December 1993.

Aïda's planned visit to Oak Ridge National Laboratory in the fall of 1993 was postponed because of the hosts' scheduling problems. She later visited Oak Ridge, gave a seminar and discussed possible future collaboration.

Aïda has accepted (January 1994) a postdoctoral position with the U.S. National Biological Survey, at a field station of the National Fisheries Contamination Research Center in Jackson, Wyoming. The project leader, Dan Woodward, has conducted research of the effects of metals, fuel oil, products of oil shale, and pesticides on freshwater fish.

Metals transported via water and air may be deposited in the sediments of lake and river systems. Current water quality standards for metals other than Hg and Se only consider water-borne exposure of aquatic organisms and ignore dietary exposure. However, aquatic invertebrates living in river or lake sediments also accumulate metals, and fish that feed upon these invertebrates are at risk of exposure. Aïda investigated toxicological, physiological, and biochemical responses associated with dietary exposure to metals in order to assess the true health of an exposed fish population.

Tissue metal accumulation and physiological responses were measured in brown

trout and rainbow trout collected from a river site with high concentrations of As, Ce, Cu, Pb, and Zn in water and sediments, or the trout were exposed to metals in food and water typical of the Clark Fork River. In addition to tissue metal residues, five physiological responses were measured to determine the health of the fish population in the river: necropsy assessments, ionoregulatory dysfunction, oxidative stress (measured as lipid peroxidation), histology, and metallothionein in tissue.

Aida found the health of the fish population in the upper Clark Fork River to be impaired because of elevated concentrations of As, Cd, Cu, Pb, and Zn in the surface water and the aquatic invertebrates. The metals in the environment were associated with high concentrations of tissue metal residues, products of lipid peroxidation and metallothionein, and presence of microscopic Cu inclusions and scale loss. High concentrations of tissue metal residues and products of lipid peroxidation were also associated with decreases in growth and survival.

Several publications have resulted from this research.

SUMMARY

These brief descriptions of individual research projects demonstrate the wide scope of energy-related research that the DOE-EPSCoR Traineeships have initiated in Wyoming. The availability of this funding has encouraged many talented students to continue their education in fields of interest to DOE. These additional bright, energetic graduate students have improved the educational atmosphere for everyone. The visibility of the DOE program has sharpened the focus of the science and engineering departments on the energy-related research of importance to Wyoming and DOE.

The original proposal indicated that any increases in tuition and fees for graduate students would be absorbed by the University. These costs during the last two years increased from \$1,700 in 1991-92 (Year 1) to \$1,718 in 1992-93 (Year 2) and to \$1,997 in 1993-94 (Year 3). As promised, UW has made up this difference, and has considered it as a contribution to the DOE-EPSCoR Traineeship Program.

The DOE-EPSCoR Traineeship Program has been and continues to be coordinated with a university-wide effort to develop and improve graduate programs and undergraduate curricula, and to form interdisciplinary centers for energy-related research where the training of young engineers and scientists can be carried out in an optimal

educational environment. Three such new research centers have been formed: the new, multi-college School of Environment and Natural Resources (SENR), to implement undergraduate, graduate, and research programs in environmental and natural resource studies; the Institute for Energy Research (IER), to pull together the University's strengths in fundamental and applied research into the emplacement, history, delineation, and production of Wyoming's valuable hydrocarbon resources; and the Western Coal Consortium, initiated in the Chemical and Petroleum Engineering Department to bring major Wyoming coal companies into joint research efforts with University faculty. A new Wyoming DOE/EPSCoR Proposal is in preparation which will continue the Traineeship Program reflecting the importance of this program to the University in its efforts to make Wyoming a national leader in the training of young people in energy-related knowledge and skills.

The impact of the DOE Traineeships in Wyoming has been substantial and very positive. It has not only increased the number of students studying in energy-related disciplines, but has also increased the quality of their graduate research. The program has also increased the visibility of DOE in Wyoming and has helped us focus our attention on the energy and environmental graduate education which is so essential to our University and our State.