

Oil and Gas Research Program
North Dakota
Industrial Commission

Application

Project Title: Public-Private Partnership to Support Geology and Geological Engineering Education and Research at UND's College of Engineering and Mines

Applicant: University of North Dakota

Principal Investigator: Dr. Hesham El-Rewini, P.E.

Date of Application: August 14, 2012

Amount of Request: \$4,000,000

Total Amount of Proposed Project:
\$14,000,000

Duration of Project: 4 years

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ABSTRACT

Objective: At this critical time in North Dakota's history with oil development in the western part of the state at record levels, it is important that Geology and Geological Engineering play a bigger role in the education of its students that will be actively involved in the production and use of the State's resources. This project will facilitate the education of the best and brightest students who are interested in exploring petroleum geology and related earth sciences at the University of North Dakota's College of Engineering and Mines via the establishment of the Harold Hamm School of Geology and Geological Engineering. This project has several facets to it—an endowment for faculty positions and scholarships for students to be funded by the private partners in this project; funding which will provide students with hands on experience through field studies and research; funding for undergraduate scholarships and graduate assistantships; providing equipment to establish advanced laboratories; and joint funding to establish a high resolution image library enhancing the North Dakota Geological Survey's Wilson M. Laird Core and Sample Library. With the establishment of the Harold Hamm School of Geology and Geological Engineering, the University of North Dakota will attract and retain outstanding educators mindful of both scholarship and our nation's need to educate professional petroleum engineers, geologists and related earth scientists in an active learning environment. With the significant scholarships to be offered, the best and brightest students who are interested in exploring petroleum geology and related earth sciences will be attracted to North Dakota. The outstanding laboratories proposed will offer advanced equipment including mineral characterization equipment such as X-ray diffraction, automated Scanning Electron Microscopy with X-ray microanalysis and X-ray fluorescence. The student's petroleum geology and engineering education will be enhanced by new and expanded coursework, field studies associated with major oil and gas resource plays, exposure to professional geotechnical software applications and the establishment of the Continental Resources High Resolution Virtual Core Library enhancing the utilization of the North Dakota Geological Survey's Wilson M. Laird Core and Sample Library's educational value.

Expected Results: The establishment of the Harold Hamm School of Geology and Geological Engineering as a component of the College of Engineering and Mines at the University of North Dakota will highlight the importance of Geology and Geological Engineering in the State, not only in terms of North Dakota's financial well being, but also in terms of employment within the State. The School will promote broader interest and recognition to help attract high quality faculty members and the best and brightest students to North Dakota. Our goal is to produce future generations of petroleum geologists and engineers who can contribute to building a better world through professional service and research for safe, reliable, and affordable energy production and environmental protection. With the funding provided in this project, the following results will be expected:

- At least 50 Petroleum Geologists and Engineers will graduate every year. These graduates will be prepared and have the opportunity to make a difference not only in the Williston Basin but also around the world.
- A sustainable pipeline of the best and brightest students will be attracted to North Dakota.
- Distinguished faculty members in Petroleum Geology, Petroleum Engineering, and other oil and gas related areas would be attracted to North Dakota.
- Expertise in Petroleum Geology and related areas will be enhanced in the new school through existing and newly hired faculty members.

- Advanced laboratories will provide state of the art equipment for education and research. The laboratories will also provide collaboration opportunities with industry in North Dakota and the region.
- Enriched student experience through exciting and up to date curriculum complemented with hands on experience and field studies.
- Enhanced computer skills, which will provide students with ability to manage and analyze large geotechnical databases associated with a wide range of basin plays.
- Greater utilization of the North Dakota Geological Survey's Wilson M. Laird Core and Sample Library via the creation of the Continental Resources High Resolution Virtual Core Library, which will take the educational and research value of the Core Library resources to a new level.
- Exposure for students and faculty members through their participation in national and international conferences and professional activities.

Duration: The private gift from Continental Resources, Inc. and Mr. Hamm will be made available over the next four years, and the endowment portion will continue to return funding on an ongoing basis. The Oil and Gas Research Program funding being requested will be disbursed over a four-year period.

Total Project Cost: \$14,000,000

Participants: Continental Resources, Inc. and Mr. Harold Hamm

PROJECT DESCRIPTION

Objectives: The total project of \$14,000,000 includes \$10,000,000 provided as a gift from Continental Resources, Inc. and Mr. Harold Hamm, which will establish the Harold Hamm School of Geology and Geological Engineering as a component of the College of Engineering and Mines at the University of North Dakota. The \$4,000,000 of funding provided by the Industrial Commission/Oil and Gas Research Program will match the \$10,000,000 provided by the private partners. This funding will enhance the education of students in the field of petroleum geology, petroleum engineering, and related earth sciences. The education of future petroleum engineers and geologists is key to the ongoing and future development of the Williston Basin and the nation's petroleum resources. The funding will also help increase the research efforts currently conducted by faculty members and students in petroleum related fields, which will create new opportunities for collaboration with industry in North Dakota and elsewhere.

Methodology: This project has several facets to it—an endowment for faculty positions and scholarships for students to be funded by the private partners in this project; funding which will provide students with hands on experience through field studies and research; funding for undergraduate scholarships and graduate assistantships; providing equipment to establish advanced laboratories; and joint funding to establish a high resolution virtual library enhancing the utilization of the North Dakota Geological Survey's Wilson M. Laird Core and Sample Library. The establishment of the Harold Hamm School of Geology and Geological Engineering will enhance the students' education and research experience in many ways. The new faculty positions will enhance the expertise in Petroleum Geology, Petroleum Engineering and related areas, which will have a direct positive impact on education, research, and collaboration with industry. The proposed scholarships and assistantships will help attract the best and brightest students to North Dakota. The outstanding laboratories proposed will offer advanced equipment including mineral characterization equipment and automated scanning electron microscopy. The educational experience will be enhanced by new and expanded coursework, field studies associated with major oil and gas resource plays, exposure to

professional geotechnical software applications and the establishment of the Continental Resources High Resolution Virtual Core Library.

The following is a description of each of the five main components of this project:

1. Endowed Faculty Positions

Continental Resources, Inc. and Mr. Harold Hamm will contribute to the creation of the following endowed positions:

- *Harold Hamm Distinguished Professor of Petroleum Geology*
- *Harold Hamm Distinguished Professor of Petroleum Engineering*

2. Student Scholarships and Assistantships

Continental Resources, Inc. and Mr. Harold Hamm will contribute to the creation of the following endowed scholarships:

- *Harold Hamm Leadership Scholarships*

In addition, funding requested in this proposal will help offer undergraduate scholarships and graduate assistantships to help attract the best and brightest students to the School.

3. Continental Resources High Resolution Virtual Core Library

Funding requested in this proposal along with private contribution from Continental Resources, Inc. and Mr. Hamm will help establish the Continental Resources Virtual Core Library. This library will provide access and analytical tools to high resolution scans of thousands of feet of key North Dakota cores, cuttings, and thin sections, providing a high educational and research value. Advanced scanning technology and software will be used to allow students and faculty to conduct a variety of petrophysical, mineralogical, and hydrogeological exercises beyond what could be done with a microscope. Methods of high resolution digital core imaging have a wide range of application in reservoir characterization. The application for imaging of core samples allows for the analysis of macro properties of the mineral fabric as well as the analysis of micro properties such as grain size and permeability. Once the high resolution digital images of the cores are obtained, students and researchers can access and perform image analysis of the cores. For example, images obtained at 1200 dpi can be used to determine the macro properties of the reservoir that includes fracture density, fracture orientation, bed thickness, and degree of variability. Higher resolution images of thin sections and plug samples (5,500 to 55,000dpi) can be generated and used to determine grain size and permeability information. In addition, the images can provide a permanent archive of the core. It is expected that students, faculty members, and industry collaborators will utilize this library for both education and research purposes.

4. Advanced Laboratories

Understanding the petrophysical properties of oil and gas bearing shales is essential in exploration and production of oil and gas from these important resources. The shale properties that are important include pore size distribution, pore morphology, mineral types/abundance, kerogen maturity, and bulk inorganic composition. The combination of automated scanning electron microscopy/x-ray microanalysis (SEM), x-ray diffraction (XRD), x-ray fluorescence (XRF), nuclear magnetic resonance (NMR), and vitrinite reflectance optical microscope will enhance the research, which could lead to greater production of oil and gas from the shale. These methods when combined with existing geomechanical facilities in the School of Geology Geological

Engineering will provide specific information on permeability, porosity, shale brittleness, clay/silt content, and mineral-mineral associations/bonding. Requested funding will be used to purchase the following:

- SEM system will provide images of pores and minerals as well as the chemical composition of the minerals.
- XRD will provide the information on the crystalline structure of the mineral that aids in determine mineral type and abundance.
- XRF provides bulk composition of the shale materials.
- NMR provides information on the clay bound and free water that is related to the hydrocarbon potential of the rock.
- Vitrinite reflectance provides information on the maturity of the kerogen.

The information derived from these techniques is used to improve oil and gas recovery strategies, design of drilling methods, and projection of gas and oil flow behavior.

5. Students Experience Fund

The Students Experience Fund will enhance the hands on experience and professional development of students through field studies, participation in national and international conferences and workshops, and other development opportunities. It will also create research opportunities as an integral component of the undergraduate education.

Anticipated Results: Part of our vision, as stated in the College of Engineering and Mines' strategic plan, is to produce graduates who will advance society, be competitive in a dynamic global market, and contribute to the economic development of North Dakota, the nation, and the world. We will also be internationally recognized for excellence in research— fostering discovery, serving societal needs, and stimulating technology transfer. The proposed partnership between the private partners, the Industrial Commission, and UND's College of Engineering and Mines will help us bring this vision to realization. The expected results of establishing the Harold Hamm School of Geology and Geological Engineering will include the following:

- At least 50 Petroleum Geologists and Engineers will graduate every year. These graduates will be prepared and have the opportunity to make a difference not only in the Williston Basin but also nationally and internationally.
- A sustainable pipeline of the best and brightest students will be attracted to North Dakota.
- Distinguished faculty members in Petroleum Geology, Petroleum Engineering, and other oil and gas related areas would be attracted to North Dakota.
- Expertise in Petroleum Geology and related areas will be enhanced in the new school through existing and newly hired faculty members.
- Advanced laboratories will provide state of the art equipment for education and research. The laboratories will also provide collaboration opportunities with industry in North Dakota and the region.
- Enriched student experience through exciting and up to date curriculum complemented with hands on experience and field studies.
- Enhanced computer skills, which will provide students with ability to manage and analyze large geotechnical databases associated with a wide range of basin plays.
- Greater utilization of the North Dakota Geological Survey's Wilson M. Laird Core and Sample Library via the creation of the Continental Resources High Resolution Virtual Core Library, which will take the educational and research value of the Core Library resources to a new level.
- Exposure for students and faculty members through their participation in national and international

conferences and professional activities.

Facilities:

The College of Engineering and Mines is made up of seven units: School of Geology and Geological Engineering, Department of Petroleum Engineering, Department of Chemical Engineering, Department of Civil Engineering, Department of Electrical Engineering, Department of Mechanical Engineering, and Institute for Energy Studies. The College is currently located in a cluster of four buildings: Harrington Hall, Leonard Hall, Upson I, and Upson II. These buildings provide space for classrooms, laboratories, workshops, faculty and staff offices, conference rooms, and students and faculty gathering areas. The College will make space available for the proposed Advanced Laboratories and the Continental Resources High Resolution Virtual Core Library.

The School of Geology and Geological Engineering is housed in Leonard Hall, a three-floor 67,000 square-foot building (with a full basement). In many ways, the physical facilities, including lecture and laboratory space, faculty offices, and the F. D. Holland Jr. Geology Library, are superior to those in most geoscience departments at universities similar in size and mission to UND. Leonard Hall was built with geologists on the building committee and thus has the added touches noteworthy to an Earth science building (as well as reinforced load-bearing floors for samples).

F. D. Holland Jr. Geology Library is the largest geoscience library in the upper Midwest with more than 50,000 volumes, 500 journal titles, 100,000 maps, 18,000 microfiche records, 8000 air photos, and several hundred geological databases on CD. The library is also a depository for U.S. Government documents and specializes in U.S. Geological Survey publications, and has access to a number of electronic journals and geoscience search engines. The School employs a full-time staff librarian.

The Wilson M. Laird Core and Sample Library (North Dakota Geological Survey) is a climate-controlled facility, located directly across the street from Leonard Hall. The facility consists of 2000 square feet of office and laboratory space and 18,000 square feet of core storage. It currently houses approximately 80 miles of cores and approximately 40,000 boxes of drill cuttings. The cores represent about 80% of the cores cut and about 95% of the samples collected in the North Dakota part of the oil- and coal-rich Williston Basin. The facility also houses an extensive collection of water-well samples and cores. Over the past 50 years, students and faculty have been consistent users of the growing Laird library, producing a significant number of theses and dissertations derived from core, cutting, and geophysical data. Many thin sections were ground by students in the pursuit of accurate mineral identification and porosity determination. Upper level classes continue to use the Laird Library, and research projects continue to advance knowledge on North Dakota's petroleum and gas resources.

Resources:

Faculty and Staff

Regular Faculty

- Nels Forsman, Ph.D., University of North Dakota; Assistant Professor, Geology, with specializations in Sedimentary Petrology, Diagenesis, Planetary Geology, and Teaching Pedagogy.
- Phil Gerla, Ph.D., University of Arizona; Associate Professor, Geology, with Specializations in Hydrogeology, Environmental Geology, Wetlands, and Geographic Information Systems.
- Will Gosnold, Ph.D., Southern Methodist University; Chester Fritz Distinguished Professor, Geology, with specializations in Heatflow, Tectonics, Global Change, Isostasy, and Structural Geology.
- Joseph Hartman, Ph.D., University of Minnesota; Chester Fritz Distinguished Professor, Director SGGE, with specializations in Invertebrate Paleontology, Stratigraphy, and History of Science.
- Scott Korom, Ph.D., Utah State University; Associate Professor, Geological Engineering, with specializations: Groundwater Remediation, Modeling, and Denitrification.

- Richard LeFever, Ph.D., University of California, Los Angeles; Associate Professor, Graduate Program Director, Geology, with specializations in Sedimentology, Stratigraphy, and Basin Analysis.
- Ron Matheney, Ph.D., Arizona State University; Associate Professor, Geology with specializations in Hydrogeochemistry, Isotope Geochemistry, and Paleoclimatology.
- Dexter Perkins, Ph.D., University of Michigan; Professor, Geology, with specializations in Metamorphic Petrology, Mineralogy and Teaching Pedagogy.
- Jaakko Putkonen, Ph.D., P.G., University of Washington; Assistant Professor, with specializations in Geomorphology, Surface Processes, and Quaternary Geology.
- Lance Yarbrough, Ph.D., RPG, P.E., The University of Mississippi; Assistant Professor, Geological Engineering, with specializations in Engineering Geology, Remote sensing, Geospatial Cyberinfrastructure, and Drilling Engineering.

Research Faculty

- Dongmei Wang, Ph.D., Research Institute of Petroleum Exploration & Development of China; Petroleum Engineering Scientist, with specializations in reservoir engineering, production, reservoir simulation, and Enhanced Oil Recovery from the Bakken Shale.
- Raymond Butler, Ph.D., University of North Dakota; Research Scientist with specializations including sedimentology, stratigraphy, depositional systems, petroleum geology, and hydrogeology

Adjunct Faculty

- Jacek Majorowicz, Ph.D., Geological Institute, Warsaw; Northern Geothermal, Edmonton, Alberta; with specializations in Geophysics and Geothermics.
- Arthur Bogan, Ph.D., University of Tennessee, Knoxville; North Carolina Museum of Natural Sciences Research Curator of Aquatic Invertebrates, with specializations in modern freshwater mollusks.

Staff

- Hanying Xu, M.S., Hunan University; Director, Environmental Analytical Research Laboratory (EARL).
- Darin Buri, B.A., History, Minot State University; Manager, F.D. Holland Jr. Geology Library, with specializations in tours, public outreach, and technology.
- Katie Sugstuen, A.A.S., Rochester Institute of Technology; Administrative Secretary, with responsibilities over SGGE bookkeeping and student welfare.

Laboratories

- The Petroleum Laboratory is a 576 sq ft facility housed in the basement of Leonard Hall. The laboratory features a high pressure/high temperature acoustic core flooding system for research on enhanced oil recovery and CO₂ sequestration and Schlumberger's ECLIPSE and PETREL software for reservoir simulation operations.
- The Mining Engineering Laboratory is another 576 sq ft facility housed in the basement of Leonard Hall. The Laboratory contains a variety of equipment for testing rock properties and has computers and software for analyses.
- The Environmental Analytical Research Laboratory (EARL) is housed on the third floor of Leonard Hall. It is staffed by a full-time Director and includes an inductively coupled argon plasma-atomic emission spectrometer (ICP), a gas chromatograph-mass spectrometer (GCMS), an ion chromatograph (IC) a total organic carbon analyzer (TOC), ion selective electrodes (ISE) and ancillary equipment to support teaching, scientific research and engineering design projects in aqueous chemistry and water resources investigations.
- Geothermal Laboratory/Geophysics Facilities. This lab and related unit include two Geometric proton-precession magnetometers, a LaCoste and Romberg gravity meter, Trimble 5700 and Leica System 300

real-time-kinematic GPS with subcentimeter resolution, two high resolution laser range finders, three solar-powered weather stations, a divided-bar thermal conductivity apparatus, and a high precision temperature logging system.

- Hydrogeology Program. The hydrogeology program provides the course work and individual research necessary for the graduate to work as a groundwater professional in consulting, research, teaching, or governmental regulation. Course work and research in the program balances theory with practical field and laboratory skills. Auger rig and extensive field equipment.
- Paleontology Laboratory and Program. This lab and suite of specimen library rooms houses extensive microfossil, plant, invertebrate, and vertebrate specimens, as well as a specialized library and reprints. Students graduating from this program have become state paleontologists, presidents of national paleontological societies and academies, and hired as professionals and academics at many institutions.
- Geomorphology and Geological Engineering Laboratories. This currently combined teaching and research labs have technical tools available to them, including LiDAR (Light Detection and Ranging).
- Other Department facilities include: a Stable Isotope Geochemistry Laboratory for isotopic analysis of waters, rocks and fossils in paleoclimate and environmental investigations.

Techniques to Be Used, Their Availability and Capability:

Our goal is to produce the next generation of Petroleum Geologists and Engineers who can address the key challenges facing petroleum industry in North Dakota, nationally, and internationally. Petroleum geologists can study and provide detailed geological information on the oil and gas reserve properties that allow the petroleum engineers to establish the reserves, the distribution of oil and gas in the reserves, and the optimum production method. As shown in Diagram-1, we rely on the following 5 techniques:

- Provide students with a strong background in fundamental concepts and techniques using active learning environment.
- Expose students to advanced laboratories, the state of the art equipment, computer applications, and the Continental Resources High Resolution Virtual Core Library.
- Enrich students' experience through field studies, professional development, leadership skills, and research.
- Provide students with capstone experience in the form of senior theses and senior design projects.
- Utilize the curriculum in Geology and Geological Engineering to broaden the scope of the Petroleum Engineering program.

Diagram-1

Senior Thesis / Project

Demonstrate ability to perform exciting and integrative projects, analyzing surface and subsurface geotechnical data, and communicate findings orally and in reports.

Expanded Studies and Field Work

Study of major source and trap rock environments from classic geologic sections focused on the integration and applications of fundamental geologic principles, laboratory results, computer applications, and the communication of results.

Petroleum Engineering Applications

Provide oil and gas reserve properties for conventional and unconventional resources that allow Petroleum Engineers to establish the reserves, the distribution of oil and gas in the reserve, and the optimum production method.

Extraordinary Laboratories

Study of samples and geotechnical information from major resource plays and ND Core and Sample Library and the High Resolution Virtual Core Library.

Mapping Cross Sections Log Correlations Sequence Stratigraphy	Remote Sensing Geotechnical Data	Computational Methods Geotechnical Professional software applications	Mineralogy- Optical, SEM, and X-ray methods
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Innovative Curriculum

Active Geologic Learning Environments

Provide students with a strong background in fundamental concepts and techniques.

Surface Geology	Subsurface Geology	Geophysics	Petrophysics
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Environmental and Economic Impacts while Project is Underway:

As a result of its strong energy production, and in particular the unprecedented growth in the petroleum activity, North Dakota has expanded operations and is in need of trained experts (engineers and geoscientists) and technology that enhances the ability to find, extract, transport, remediate, and upgrade its energy resources efficiently with minimal impact on the environment. This project will enhance the educational experience of students to become top performing petroleum geologists and engineers. These students will have access to the advanced laboratories being established under this project and be given opportunities for research that could have significant impact on petroleum development. With outstanding faculty and leadership these students could have environmental and economic impacts on the development that is taking place in the Williston Basin.

Ultimate Technological and Economic Impacts:

At the Harold Hamm School of Geology and Geological Engineering, we will be producing world-class leaders in Petroleum Geology and Engineering as well as related Earth Scientists who can make a difference, who can compete in a global market, and who can contribute to the economic development of our state, nation, and the world. Taking advantage of our distinguished faculty members, advanced laboratories, and the enriched experience, our graduates will utilize their problem-solving skills, creativity, and innovation to overcome many of the problems facing oil industry today.

The school will contribute to the continued growth of North Dakota's energy industry by providing education and research opportunities that address key challenges in the energy field. This project will allow us to maximize student's exposure to the laboratory and field experience, increasing the value and uniqueness of the programs. Research efforts will address the clean and efficient development and utilization of North Dakota's energy resources.

The direct economic impact of the efforts conducted is related to the increase in the recovery of oil and gas from oil-bearing shales from the Williston Basin. This will be accomplished through the application of advanced methods of shale characterization combined with the extensive expertise of faculty, students, and staff at the Harold Hamm School of Geology and Geological Engineering to exploration and geomechanical properties. Specific emphasis of education and research effort is to improve fracturing and recovery of oil.

Why the Project is Needed:

North Dakota is now the second leading state in the production of oil and gas. This has been accomplished with less than 10% of the resources of the Williston Basin being captured. A key to the future of the oil and gas industry here in North Dakota is having a committed faculty and the best and brightest students to research and develop technologies which will enable the remaining and new undiscovered oil and gas resources to be mined. A well-educated and qualified workforce in North Dakota is important to insure that our resources are developed in a manner that will enhance the future of all North Dakotans.

STANDARDS OF SUCCESS

Standards of Success should include: The measurable deliverables of the project that will determine whether it is a success; The method to be utilized in measuring success; The value to North Dakota; An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way; The potential that commercial use will be made of the project's results; How the project will enhance the education, research, development and marketing of North Dakota's oil and natural gas resources; How it will preserve existing jobs and create new ones; How it will otherwise satisfy the purposes established in the mission of the Program; How it will be reporting on the success of the project.

Success will be measured in several ways:

- Successful graduation of students;
- Placement of students in rewarding careers;
- Completion of research that improves the methods for extracting the valuable natural resources now captured in the Williston Basin formations;
- Successful partnerships with industry;
- Utilization of the Advanced Laboratories and the Continental Resources High Resolution Virtual Core Library by undergraduate students, graduate students, faculty members, and industry collaborators.
- Published research by faculty members and students
- Number of theses and dissertations completed by undergraduate and graduate students.

BACKGROUND/QUALIFICATIONS

Please provide a summary of prior work related to the project conducted by the applicant and other participants as well as by other organizations. This should also include summary of the experience and qualifications pertinent to the project of the applicant, principal investigator, and other participants in the project.

Hesham El-Rewini, Ph.D., P.E. (Principal Investigator)

Dr. Hesham El-Rewini is the Dean of the College of Engineering and Mines at the University of North Dakota. He has been providing vision and strategic leadership to the College since 2008. Dr. El-Rewini has recognized Energy as one of the major focus areas for the College. He has created the Institute for Energy Studies and the Department of Petroleum Engineering to help the continued growth of North Dakota's energy industry. Under his leadership, three new energy-related degree programs were developed: B.S. in Petroleum Engineering, M.S. in Sustainable Energy Engineering, and Ph.D. in Chemical Engineering. Dr. El-Rewini is an expert in the areas of engineering, strategic planning, higher education leadership, and the development of new academic programs. He has been invited to conduct academic training at different universities worldwide. He has also been invited to deliver keynote lectures at several international conferences and meetings. Dr. El-Rewini is the coauthor of five books. His first book with Ted Lewis in 1992 was among the very early books written in the area of Parallel Computing and was widely adopted by universities all over the world. His two latest books have been translated to Chinese. Dr. El-Rewini has graduated many MS and PhD students. His research interests include the areas of parallel processing, energy-aware computer architecture, and scheduling techniques. His research has resulted in numerous publications in journals and conference proceedings. His research projects have been funded by grants from industry and federal agencies. He received his PhD degree from Oregon Sate University. Dr. El-Rewini was the Principal Investigator of a number of international projects funded by the US Agency for International Development (USAID) and Higher Education for Development (HED) to establish partnerships with and offer training programs to universities in Mexico and the Middle East. Dr. El-Rewini is a registered engineer in the state of Texas.

Joseph Hartman, Ph.D. (Participant)

Dr. Joseph Hartman is Director of the School of Geology and Geological Engineering. He has been part of UND's fabric since 1986 when he joined what would become EERC. He served as a Paleontologist, Research Manager, and Senior Research Advisor, until he took an Associate Professor position with GGE in 2001. Joseph has since been promoted to Professor and received a number of awards and honors culminating in UND's higher faculty honor, the Chester Fritz Distinguished Professor. Dr. Hartman is trained as a continental invertebrate paleontologist and stratigrapher, but has broad interests in the Earth Science. His research has been global,

with field studies in China, Madagascar, and India, and Canada, and well as museum studies in a number of European countries and Canada. Joseph's students have participated in these activities, and presented papers at many national and international meetings (e.g., Antwerp, Barcelona, Perth). Joseph has been funded by a variety of national agencies and foundations to work in the Williston Basin and elsewhere in North America. He also specializes in the history of geoscience as it relates western exploration and ideas.

Steven A. Benson, Ph.D. (Participant)

Dr. Steven A. Benson is Professor and Chair of Department of Petroleum Engineering and Director Institute for Energy Studies at the School of Engineering and Mines of the University of North Dakota. Dr. Benson has a B.S. in Chemistry from Minnesota State University (Moorhead) and a Ph.D. in Fuel Science from the Pennsylvania State University. Steve's principal areas of interest and expertise include: 1) educating the next generation of petroleum engineers; and 2) performing research and developing technologies to improve the performance of oil and gas recovery/development, energy conversion, carbon product manufacturing, carbon dioxide capture, and pollution control systems. Prior to his current position, Dr. Benson was an Associate Director for Research at the Energy & Environmental Research Center where he was responsible for leading a group of over 30 highly specialized chemical, mechanical and civil engineers along with scientists whose aim was to improve the recovery of fuel resources and the performance of energy conversion systems for clients worldwide. He has authored and co-authored over 200 publications.

Lance Yarbrough, Ph.D. (Participant)

Dr. Lance Yarbrough is a Licensed Professional Engineer and a Registered Professional Geologist. He currently serves on faculty at the University of North Dakota in the College of Engineering and Mines in the School of Geology and Geological Engineering and is associated with Department of Petroleum Engineering. Dr. Yarbrough has used geospatial technologies including GIS, remote sensing and GPS for nearly 24 years. He has worked in large A&E firms and served as project engineer in numerous environmental construction projects. For the past 14 years he has conducted research in the fields of engineering geology and geospatial information science and technology. He has been the Principle Investigator for two NASA Rapid Prototyping Capability experiments using next-generation satellites. He has consulted on topics including financial, real estate and collateral management, municipal annexation and redistricting, dam safety. He has also served as a geospatial consultant for the US Department of Energy and Sandia National Laboratories for the Waste Isolation Pilot Project (WIPP) in New Mexico. Dr. Yarbrough has worked on numerous regional projects related to mining, petroleum, flood prediction and mitigation, geohazard mapping and soil stability issues. He serves as a North Dakota representative for the International Charter for Space and Major Disasters and on the Fundamentals of Engineering (FE) Examination Committee for NCEES.

MANAGEMENT

*A description of **how** the applicant will manage and oversee the project to ensure it is being carried out on schedule and in a manner that best ensures its objectives will be met, **and a description of the evaluation points to be used** during the course of the project.*

Dr. Hesham El-Rewini, the Dean of the College of Engineering and Mines, will ensure that the project is carried out and the objectives are met. The following table summarizes the different tasks, the oversight responsibilities, and the evaluation points used during the course of the project and beyond:

Activity	Oversight	Evaluation Points
Oversight of the entire project	Dr. Hesham El-Rewini	Several check points throughout the duration of the project to ensure completion of tasks.
Recruiting of the Endowed Distinguished Professors	Dr. Hesham El-Rewini	Hiring the first endowed position in Year-1. Hiring the second endowed position in Year-2.
Management of Scholarships	Dr. Joseph Hartman	Annual awarding of scholarships and assistantships to qualified students.
Establishment of Advanced Laboratories (equipment purchase, space, etc.)	Dr. Steve Benson Dr. Lance Yarbrough Dr. Kegang Ling	Annual check points during Year-1 through Year-4 to ensure that equipment are purchased and installed.
Managing Advanced Laboratories	Dr. Lance Yarbrough	Annual check points to ensure that the laboratories are utilized by students, faculty, and industry collaborators.
Establishment of the Continental Resources High Resolution Virtual Core Library (scanning, purchase of hardware, software, etc.)	Dr. Hesham El-Rewini Dr. Joseph Hartman Dr. Richard LeFever Mrs. Julie A. LeFever	Annual check points to ensure that scanning of cores, installing software tools are completed during Year-1 and Year-2 of the project.
Managing the Continental Resources High Resolution Virtual Core Library	Dr. Joseph Hartman	Annual check points to ensure that the library is utilized by students, faculty, and industry collaborators.
Management of Students Experience Funds	Dr. Joseph Hartman	Annual check points to ensure that students are utilizing the funds for professional and field activities.

TIMETABLE

Please provide a project schedule setting forth the starting and completion dates, dates for completing major project activities, and proposed dates upon which the interim reports will be submitted.

The private gift from Continental Resources, Inc. and Mr. Hamm will be made available over the next four years, and the endowment portion will continue to return funding on an ongoing basis. The funding from the Oil and Gas Research Program would be made available over the next four years in approximately \$1,000,000 disbursements each year. Semi-annual reports will be provided to the Industrial Commission and will include information on the scholarship disbursements to the students, purchase of equipment, etc.

Private Funding:

Continental Resources, Inc. and Mr. Harold Hamm will provide \$10,000,000 to enhance education and research at the Harold Hamm School of Geology and Geological Engineering. This gift will have an impact on the entire College of Engineering and Mines for many years. The gift has been designated as follows:

- \$3,750,000 – Endowed Professor of Petroleum Geology (Year-1 to Year-4).
- \$3,750,000 – Endowed Professor of Petroleum Engineering (Year-2 to Year-4).
- \$1,325,000 – Endowed Leadership Scholarships (Year-1 to Year-4).
- \$500,000 – Continental Resources High Resolution Virtual Core Library (Year-1).
- \$375,000 – Salary and benefits for the Endowed Professor of Petroleum Geology (Year-1 to Year-4).
- \$300,000 – Salary and benefits for the Endowed Professor of Petroleum Engineering (Year-2 to Year-4).

Oil and Gas Research Program Funding:

The \$4,000,000 funding being requested from the Oil and Gas Research Program will be used as follows:

- \$720,000 – Student scholarships and graduate assistantships (Year-1 to Year-4). [\$90,000 per year for undergraduate scholarships and \$90,000 per year for graduate assistantships]
- \$280,000 – Students experience fund (Year-1 to Year-4).
- \$1,500,000 – Equipment to establish Advanced Laboratories as shown in Table-1 (Year-1 to Year-4).
- \$1,500,000 – Continental Resources High Resolution Virtual Core Library (additional \$500,000 provided by the private partners). Table-2 shows an estimate provided by the vendor Petro Arc.

Table-1 – Equipment for the Advanced Laboratories (Estimated Cost)

Equipment	Use	Cost
Scanning Electron Microscope/X-ray microanalysis (SEM)	Pore sizing, pore morphology, mineral composition	\$500,000
X-ray Diffraction (XRD)	Crystalline phase measurement – mineral abundance	\$200,000
X-ray fluorescence	Bulk composition of samples of shale	\$100,000
Nuclear Magnetic Resonance	Clay bond and free water	\$500,000
Vitrinite Reflectance Microscope	Determines the maturity of the oil resource	\$200,000
Total		\$1,500,000

Table-2 – Continental Resources High Resolution Virtual Core Library (Estimated Cost)

Core Imagery				TOTALS	
TenEx High Resolution (~1360 dpi)	Unit	8,000ft	16,000 ft		
White Light	\$85.00/ft	\$680,000	\$1,360,000		
UV Light @ 340 dpi (Optional)	\$36.00/ft	\$288,000	\$576,000		
Core Prep prior to imaging (if needed)	Per hour	\$85.00			
			Total	\$1,648,000	\$1,648,000
CORSystem 2.0					
Full yearly license	Per copy	\$8,000.00	N/C		n/c
Yearly maintenance and upgrade fee	Per copy	\$3,500.00	N/C		n/c
Daily Charges:					
For first 6 months	Per day	Amount			Total
Technician Fee and Training of UND: \$250/ man x 2	\$500.00	\$91,000			\$91,000
Travel Expenses					
Shipping equipment, Rotating personnel	Cost + 15%	\$4,000			\$4,000
Other Services:					
Plug and/or Cuttings Imagery					Total
HDPlug or HD Cuttings Imagery (3,200 dpi)	Per Plug	\$75.00	1200		\$90,000
HDPlug or HD Cuttings Imagery (up to 10,880 dpi)	Per Plug	\$150.00	1066		\$159,900
Pre-existing Plug Imagery	Per hour	\$100.00	700/10/hr		\$7,000
					\$1,999,900

BUDGET

Please use the table below to provide an **itemized list** of the project's capital costs; direct operating costs, including salaries; and indirect costs; and an explanation of which of these costs will be supported by the grant and in what amount. The budget should identify all other committed and prospective funding sources and the amount of funding from each source, differentiating between cash, indirect costs, and in-kind services. Justification must be provided for operating costs not directly associated to the costs of the project. Higher priority will be given to those projects that have matching private industry investment equal to at least 50% or more of total cost. (Note ineligible activities or uses are listed under OGRP 2.02) **Please feel free to add columns and rows as needed.**

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Endowed Professor of Petroleum Geology	\$0.00	\$0.00	\$0.00	\$3,750,000 (Endowment)
Endowed Professor of Petroleum Engineering	\$0.00	\$0.00	\$0.00	\$3,750,000 (Endowment)
Student Scholarships and Assistantships	\$720,000	\$0.00	\$0.00	\$1,325,000 (Endowment)
Students Experience Fund	\$280,000	\$0.00	\$0.00	\$0.0
Advanced Laboratories Equipment	\$1,500,000	\$0.00	\$0.00	\$0.00
High Resolution Virtual Core Library	\$1,500,000	\$0.00	\$0.00	\$500,000
Salaries and Benefits	\$0.00	\$0.00	\$0.00	\$675,000
Total	\$4,000,000	\$0.00	\$0.00	\$10,000,000

Note: The College of Engineering and Mines has not included any of its costs for oversight or management of the project in the above budget.

Please use the space below to justify project associated expenses, and discuss if less funding is available than that requested, whether the project's objectives will be unattainable or delayed.

If the funding from the Oil and Gas Research Program is unattainable or delayed, there will be an impact on the number of students that will be in the programs. A delay in the establishment of the Advanced Laboratories and the Continental Resources High Resolution Virtual Core Library will delay the research needed to unlock the methods for mining the oil and gas reserves in North Dakota and for the development of these resources in a prudent and safe manner.

CONFIDENTIAL INFORMATION

Any information in the application that is entitled to confidentiality and which the applicant wants to be kept confidential should, if possible, be placed in an appendix to allow for administrative ease in protecting the information from public disclosure while allowing public access to the rest of the application. Such information must be clearly labeled as confidential and the applicant must explain why the information is entitled to confidentiality as described in North Dakota Century Code 54-17.6. Oil and gas well data that is a result of

financial support of the Council shall be governed by North Dakota Century Code 38-08-04(6). **If there is no confidential information please note that below.**

There is no confidential information in this application.

PATENTS/RIGHTS TO TECHNICAL DATA

*Any patents or rights that the applicant wishes to reserve must be identified in the application. **If this does not apply to your proposal, please note that below.***

This does not apply to this application.

STATUS OF ONGOING PROJECTS (IF ANY)

If the applicant is a recipient of previous funding from the Commission, a statement must be provided regarding the current status of the project.

The University of North Dakota has received funding from the Industrial Commission under both the Lignite Research Program and the Oil and Gas Research Program. Noted below are the two projects that currently have funding from the Oil and Gas Research Program:

- 1) Geomechanical Study of Bakken Formation in the Nesson Anticline. This project is in the process of being completed.
- 2) Enhanced Oil Recovery from the Bakken Shale Using Surfactant Imbibition Coupled with Gravity Draining. This project is underway and reports have been filed in a timely manner.

APPLICATION CHECKLIST

Use this checklist as a tool to ensure that you have all of the components of the application package. Please note, this checklist is for your use only and does not need to be included in the package.

<input type="checkbox"/>	Application
<input type="checkbox"/>	Transmittal Letter
<input type="checkbox"/>	\$100 Application Contribution
<input type="checkbox"/>	Tax Liability Statement
<input type="checkbox"/>	Letters of Support (If Applicable)
<input type="checkbox"/>	Other Appendices (If Applicable)

When the package is completed, send an electronic version to Ms. Karlene Fine at kfine@nd.gov, and 2 hard copies by mail to:

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

For more information on the application process please visit:
<http://www.nd.gov/ndic/ogrp/info/ogrcsubgrant-app.pdf>

Questions can be addressed to Ms. Fine at 701-328-3722 or Brent Brannan at 701-425-1237.