Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: NDIC Funding to Support Research of Petroleum Engineering Program at University of North Dakota

Applicant: Vamegh Rasouli

Principal Investigator: Vamegh Rasouli

Date of Application: 10/20/2019

Amount of Request: $3,728,000

Total Amount of Proposed Project: $7,317,150

Duration of Project: 3 Years

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ABSTRACT

The department of Petroleum Engineering (DPE) at University of North Dakota (UND) received a total of $600,000 funding in support of his research activities in Sept 2018. The contract (Contract No. G-045-89) was for 18-month period with the expectation to support 9 Ph.D. students from the NDIC funding, plus 6 additional students supported by the DPE to work on project topics proposed by the NDIC and listed in the contract as the followings:

- Big Data Analytics/UAS/Data Mining
- CO2-EOR
- Sulfate Deposition
- Machine Learning/Refracking

The DPE commenced its graduate program in Fall 2016, however, now serves as the largest graduate program at the College of Engineering and Mines (CEM) with currently 32 Ph.D. students and 20 Master students. This rapid growth could not happen without the strong support of the industry. The DPE has 30 representatives serving at the Industry Advisory Council (IAC) of the department and meet twice per year in fall and spring to discuss the state of the program and provide advice on how to expand and make the program stronger. Nearly all of our undergraduate students now receive job offers with the industry as soon as they are close to graduation, thanks to the support from the IAC.

Continuation of the Ph.D. program which supports directly the undergraduate program by providing the teaching assistance and mentoring roles is not possible without financial support. This NDIC contract has enabled the department to support 9 Ph.D. students who help the undergraduate students while they are expected to work on the research topics related to the industry problems in North Dakota as defined by the NDIC. The review of the progress report of the current funding (see "Status of Ongoing Projects" section) demonstrates how it helped the department to publish over 90 conference and journal papers in 2019 so far and allowed over 60 conference and workshop travels for the students within the USA, which is a significant model to promote the program, University and the State of ND.

With the successful operation of the above funding model, this proposal is to request new funding to start from March 2020. As the graduation period of Ph.D. students is on average 3 years, the new request is for 3 years of funding for 15 Ph.D. students' tuition and stipend support. In order to provide stronger support to the students and projects, and considering the lack of adequate faculty members in the DPE, funding to support hiring an endowed faculty position at Associate Professor level with strong industry background for a 3-year period is included in this proposal. In addition, funding is requested for support of setting up the "Full-Scale Reservoir Simulated Drilling and Completions Labs" with all field scale equipment being donated to us by the former CEO of the TerraTek. This unique facility promotes the State of ND by offering the full scale testing facilities for drilling and completion operations at high pressure of up to 15,000 psi relevant for geothermal. The facility can be used for students' education purposes, advanced research and providing technical support and services to the industry in ND.

FUNDING PROPOSAL

The current NDIC funding in support of Ph.D. students' tuition and stipend, as well as faculty summer salary will end in Feb 2020. The funding promoted the department, UND and the state of ND by generating large number of quality publications in the areas of interest to ND oil and gas industry, several travels of students to different conferences and advertising for the undergraduate program in Petroleum Engineering at UND. While the Ph.D. program at UND DPE started in Fall 2016, we had our first graduate in Summer 2018, and then 7 graduates so far in 2019, and expect 8 new graduates in Spring 2020. This shows an average of less than 3-year graduation period, which is a great success. All of these student could find job within the local industry in ND, mostly working at the EERC. The 100% job placement and having over 9 of our current Ph.D. students working at the EERC during their Ph.D. program period is a strong indication of the quality of the students and how much they can support the research and projects in oil and gas industry in ND.

JUSTIFICATION

The justifications for the new funding request include:

- The progress review of the current contract demonstrates how effectively the department managed the use of the current funding to support several Ph.D. students, produce several publications and promote the Petroleum Engineering program at UND by attendance of Ph.D. students and faculty in different conferences and workshops.
- DPE has grown significantly in its teaching and research capabilities and has strong lab resources as well as industry contacts, so it is in a position to grow to its next level to be among top 5 Petroleum Eng programs across the country.
- Through my personal contact with the oil and gas companies internationally, I have been able, and will continue, to admit high quality individuals with several years of industry experiences to join our Ph.D. program. This is a significant advantage of our program over many others in the country.
- The job placement statistics of our Ph.D. students demonstrates that all of them have been able to join the industry workforce in North Dakota. The passion and interest of these international students to remain in the US after completion of their studies and the need of the oil and gas industry to hire them is a significant support to the Bakke development and its future growth.
- DPE has currently 5 full time faculty members at or above Assistant Professor level. With the available resources within the department to grow teaching and research activities, receiving funding to hire at least one additional contractual faculty would be a great support to the department. It is proposed that his endowed positon at Associate Professor level be interviewed and hired jointly with the NDIC with a highlight that the recruited faculty is expected to work on assigned projects by the NDIC and advise at least

5 Ph.D. students funded by the NDIC. The preference is to hire someone with industry background and strong contact with the industry.

- The recent donation of the "Full-Scale Reservoir Simulated Drilling and Completions Labs" to the department is a unique opportunity for the State of ND to promote the education, research and industry services using the field scale equipment that were used for many years in the industry. The support of the NDIC is critical for us to make this exciting moment to come to real and have this unique facility to set up in Grand Forks. This set up will certainly raise our ranking among other Petroleum Engineering program across the country.

NEW FUNDING REQUEST

We request funding for 3 years starting from March 2020, when the current contract will cease. The funding is requested to support 15 Ph.D. students, 6 faculty summer salaries, one NDIC Endowed faculty position and set up of the new field scale lab facilities.

DPE will commit to support additional 10 students to work on the projects assigned by NDIC, so a total of 25 Ph.D. students will be committed to work on the projects. We continue on the previous topics that was proposed by the NDIC for the current funding.

STANDARDS OF SUCCESS

The standard of success for this funding will be measurable through a number of different criteria including:

- The number of published journal and conference papers,
- The number of travels of Ph.D. students and faculty members to different oil and gas related conferences and workshops,
- For the NDIC endowed faculty hire, the number of Ph.D. students being advised by him/her, review of the quality of his/her teaching, research and industry interaction and communication with the OGRC,
- Oral and poster presentations of the projects in different events,
- Industry feedback regarding the applicability and quality of the projects, an example of this is the feedback by the Industry Advisory Council (IAC) members of the department,
- Presentation of the results to the OGRC members,
- No more than 3-year graduation period for the Ph.D. students with high quality,
- High job placement rate for the graduated students,
- For the "Full-Scale Reservoir Simulated Drilling and Completions Labs" the establishment of the lab will present a great support for students and industry in ND.

BACKGROUND/QUALIFICIATIONS

Dr. Vamegh Rasouli, the PI of this project has been involved in many research and industry projects related to lab and field scale data collection and analysis. His over 17 years of industry experiences in the oil and gas industry with focus on geomechanics projects will be an essential support to the projects related to the hydraulic fracturing, and refracturing, which is one of the main topics of study in this proposal. Dr. Rasouli will also advise Ph.D. students.

Dr. Minou Rabiei, the Co-PI of this project has the required education background and work experience in advanced data processing, AI technologies and big data analytics. She has collaborated in many research and practical projects involving technical and economic feasibility studies for improved HSE requirements. Minou began her employment with UND as an assistant professor in the Petroleum Engineering Department in March 2015. Since then, she has established her research group in advanced data mining, machine learning and big data analytics applied in petroleum industry. She has been actively participating in various research opportunities and has successfully secured several internal and external research grants acting as PI or Co-PI. Her contribution to this proposal will be on projects related to data mining, AI, UAS and data analytics.

Dr. Kegang Ling, the Co-PI of the project, who is an associate professor of DPE with expertise in reservoir and production Engineering. He will be working on projects related to the pipeline leakage detection and EOR and advise Ph.D. students.

Dr. Hui Pu, the Co-PI of the project, an assistant professor of DPE. He is conducting a separate NDIC project currently which is close to end and will work on projects related to reservoir Engineering, well logging and in particular on the new project "Economic Viability of Horizontal Open Hole Completions, Madison Group, ND" with a number of Ph.D. students who he will advise.

Dr. Hadi Jabbari, is an associate professor at the department of Petroleum Engineering with his expertise in the areas of reservoir simulations. He will be advising Ph.D. students in projects related to the CO2-EOR and communicates with relevant industries to bring their practical experiences into the projects.

MANAGEMENT

The PI will present the progress reports as requested by the OGRC with the details of how each project has moved on, a summary of the work done during each period, and the number of publications, travels to conferences and workshops and industry interactions.

The PI also proposes to have 6 or 12- months period face to face or remotely facilitated meeting with the OGRC members and other industry partners to have the Ph.D. students presenting the progress of their project.

The PI will identify an industry interaction and communication plan for the NDIC endowed faculty member to ensure a strong link with the industry is in place to benefit from practicality of the projects and continuous feedback of industry people to the projects, in addition to promote the undergrad program in Petroleum Engineering in order to attract more students to the program, which if of the priority of the department.

The PI, as it has been the case for the current grant, will establish different research groups in the department, each led by one of the faculty members, to supervise one of the project areas and have frequent meetings with the Ph.D. students. There will also be monthly presentations by students to present their project progress.

The PI is committed to work very closely on the new lab set up and make sure its establishment and operation progress as it is planned and will provide a detailed plan to the NDIC.

Comments and feedback by the OGRC will be communicated with faculty and students by the PI on a continuous basis.

In case of any potential changes to the project or unforeseen situations that may affect the progress of projects as anticipated, the PI will inform the OGRC immediately requesting their advice.

TIMETABLE

The project lasts for 3- year period, starting from beginning of March 2020.

BUDGET

1. Tuition and Stipend of Ph.D. Students

Approximate costs of a Ph.D. student per annum are listed in Table below.

Tuition	**$15,000**
Stipend	$15,000
PC & Office Supply	$1,000
Travel to Conferences, Workshops	$1,000
Lab Material, Supply, Maintenance etc for lab based projects	$2,000
Total per student per year	**$34,000**
Total for 15 students per year	**$510,000**

2. Faculty Summer Salary

Including fringes and benefits varies between $15,000 and $19,000 monthly for Assistant to Full Professor positions. Average of $16,000. We request one month of summer salary per annum for 6 faculty members, a total of **$96,000**.

3. NDIC Endowed Faculty Hiring

An Associate Professor hiring for a total annual package (salary & benefits) of **$140,000**.

4. Full-Scale Reservoir Simulated Drilling and Completions Labs

Items	Year 1	Year 2	Year 3	Total
Lab Manager Salary including benefits	150,000	150,000	150,000	450,000
Consulting Fees	50,000	10,000	10,000	70,000
Equipment Upgrade	300,000	50,000	20,000	370,000
Lab Supplies	100,000	50,000	50,000	200,000
Lab Maintenance	50,000	50,000	50,000	150,000
Initial lab set up	150,000			150,000
Subcontractors	100,000			100,000
TOTAL	900,000	310,000	280,000	**1,490,000**

Table below shows the total fund request for 3- year period:

Item	Total ($)
15 Ph.D. students tuition & stipend	1,530,000
6 faculty summer salaries	288,000
One Associate Professor Endowed Position	420,000
Full-Scale Reservoir Simulated Drilling and Completions Labs	1,490,000
TOTAL	**3,728,000**

5. Industry Cost Share

Company	Total ($)
Itasca Consulting Group: Technical advice and software license provision	1,269,150
Sid Green Four, LLC, technical advice, data sharing and donation of equipment	2,000,000
UND Petroleum Engineering (shipment of Equipment from Utah and offloading, 3 year rental payment for the building	320,000
TOTAL	**3,589,150**

CONFIDENTIAL INFORMATION

No confidential information is applicable to this proposal.

PATENTS/RIGHTS TO TECHNICAL DATA

Not applicable to this proposal.

Full-Scale Reservoir Simulated Drilling and Completions Labs

The PI of this proposal, who has been a consulting Engineer for Schlumberger for several years and since 2012, the instructor for Schlumberger's NExT (Network of Excellence in Training) program, was approached by the former CEO of the TerraTek who offered donation of full scale labs which belonged to the TerraTek several years ago.

This facility will offer drilling at 15,000 psi pressure suitable for geothermal simulations. It is a unique set up for educating hands on and practical students ready to go and work in the field upon completion of their B.S. degree, valuable resources for grad students to do research and great support for industry to do pilot projects and do proof of concept before doing any field scale operations.

The DPE with support of the College is covering the costs of the shipment and offloading of equipment from Utah which is over $150,000 and is renting a building in Grand Forks which can accommodate such heavy and massive equipment. The renting of the building is expected to be at app. $7,000 per month.

In order to bring the equipment to full operation, several accessories and new items need to be purchased, a number of modifications need to be implemented and a proper layout needs to be designed. We need to hire professional people to assist in installation of the equipment and bring it to full operational mode and a full time technician with high skills in operating such equipment to manage the facility. The support of the NDIC for the costs is of high importance as this facility can serve the entire State of ND with high level services to the oil and gas sector.

The list of equipment and their images are presented below.

Wellbore Simulator

- 23-inch inside diameter for up to 5-foot rock sample length
- 10,000 psi borehole pressure (20,000 psi simulated depth)
- 12,000 psi confining pressure / 20,000 psi vertical stress
- pressurizing intensifiers
- threaded end closure

Movable Tower on Rails

- 13 feet by 15 feet by 32 feet high structure
- motorized movement to locate at multi-workstations
- variable speed rotary 0 to 450 rpm
- 375,000 pounds axial load capacity
- polished drill shaft seal / rotary slip rings for data recording

Full-Scale Mud System

- Continental Emsco FA 1600 / pulse damper
- 1600 hp DC motors / precise variable flow rate control
- 600 volt transformer / Thyrister DC controls
- 420 gpm / 5500 psi fluid ends / 180 gpm / 15,000 psi fluid ends
- 15,000 psi swivel
- 15,000 psi vessel dual-pressure rotary seal

Mud Mixing / Building System

- 100 bbl and 60 bbl mud tanks with rotary mixing
- centrifugal circulating pumps and suction pump
- 15,000 psi piping
- Two mechanical chokes and cuttings screen containment

Operation Control and Data Recording

- Fully servo digital operating computer control
- Fully digital data recording--rpm, wt on bit, torque, penetration rate, mud strokes, temperatures, mud pressures, and other
- safety analog visual system

Miscellaneous Accessories

- For drilling, mud testing, borehole testing, and other tests
- Various couplings / specimen fixtures
- Drill pipe breaking tongs, 4.75-inch to 12.25-inch drill bit size

Fluid Ends

Drill Sample

Sand Screen Test

1600Triplex Mud Pump

Thyrister Controls for Mud Pump

Rotary Table

Mud Tanks

Mud System

Drill Tower

Electrical Controls

Test Rock Samples

Coring Samples

Pipe Transformers

Control Room

STATUS OF ONGOING PROJECTS (IF ANY)

NDIC Contract No. G-045-89

Start Date of Contract: September 1, 2018

October 2019 Status Report

Vamegh Rasouli
Chair, Department of Petroleum Engineering, UND

Introduction:

This report serves as the second status report outlining the progress of the Ph.D. projects since the conclusion of the first report, which was due on January 31, 2019. As a refresher, according to the contract, the Department of Petroleum Engineering (DPE) at UND was expected to support 9 Ph.D. students from the NDIC funding, plus 6 additional students supported by the DPE to work on project topics proposed by the NDIC and listed in the contract as the followings:

- Big Data Analytics/UAS/Data Mining
- CO2-EOR
- Sulfate Deposition
- Machine Learning/Refracking

IN Table 1, the updated titles of the projects that have been assigned to each Ph.D. student are given. Some projects have slight changes in their direction which is the nature of research work. Those are shown by (*) next to the numbers in the first column. In this Table, the title of additional 8 Ph.D. projects that are undertaken in the department is listed in the Table too in order to inform NDIC of other projects that the DPE is undertaking.

The impact of this funding in terms of the growth of the research in the Department has been significant. In 2019 to date 47 papers have been published or submitted to journals and conferences. Also, the students have attended a number of conferences within and outside the USA. The list of publications and conferences that the students attended are given at the end of the report. This has brought a great reputation for the department. We therefore appreciate the provision of this funding by the NDIC.

In the following a brief summary of each project progress since the last report is given We hope the contract can be renewed for the next term to provide financial support to the current students to complete their projects to the highest expected quality.

Attached to this report is powerpoint presentation slides which summarizes the progress of the project to date.

Industry Seminar:

As requested in the first report, in addition to the current report, as part of the requirements of the contract, we would like to organize a one-day industry seminar as soon as possible and workable for the NDIC and invite the NDIC board to listen to the presentation of the projects progress by Ph.D. students. If agreed by the NDIC, we also would like to announce the event to the industry in North Dakota to attend this seminar to provide their technical feedback about each project. This will help us to ensure that the projects will carry the industry applications and give us the opportunity to discuss the technical aspects of each project with the industry and request their support in terms of providing data. If preferred by the NDIC, the seminar can be organized via webinar or skype.

Table 1: List of current Ph.D. students' projects at the DPE

	Student	Advisor	Project Title	Project Area
1*	Karthik Balaji	Rabiei	Enhanced Financial and Regulatory Planning for Carbon Capture & Sequestration (CCS) Infrastructure using an Algorithmic Approach	Data Mining
2*	Zifu Zhou	Rabiei	Drilling Parameters optimization based on Machine Learning Models and Data Mining Techniques	Machine Learning/Block Chain
3	Matt Dunlevy	Rabiei/ Rasouli	Accelerating Pipeline Leak Detection Through Unmanned Aircraft Systems Based Routine Surveillance and Data Mining	UAS/Big Data Analytics
4	Xincheng Wan	Rasouli/ Rabiei	An integrated Data Mining and Simulation to Optimize Refracturing Design	Refracking/Dat a Mining
5	Olusegun Stanley Tomomewo	Mann	Studying the Mechanism of Barite Scales Formation & its Removal/Prevention in McKenzie and Williams Counties, Bakken Formation, ND	Barite Scales Formation
6*	Abdulaziz Ellafi	Jabbari	Experimental and Numerical Investigation of the CO2-EOR Mechanisms in Unconventional Rich Liquid Reservoirs (Bakken Fm, Williston Basin, ND)	CO2 EOR
7*	Nidhal Badrouchi	Pu	Bakken Tertiary Oil Recovery: CO2 based solvent EOR	CO2 EOR
8	Ogochukwu Ozotta	Ostadhassan	Geomechanical Impact of CO2-EOR on the Bakken Formation	CO2 EOR
9	Hao Fu	Ling	Using Pressure Distribution to Detect the Blockage and Leakage in the Pipelines	Pipeline Leakage/UAS
10*	Nejma Djabelkhir	Rasouli	Lattice simulations of lab scale hydraulic fracturing	Hydraulic Fracturing
11	Aldjia Djezzar	Rasouli/ Rabiei	Impact of Stress on the Characterization of Flow Units in the Complex Three Forks Carbonate Reservoir, Williston Basin	Machine Learning/ Petrophysics Three Forks
12	Dezhi Qiu	Rasouli/ Rabiei	Discrete Fracture Network (DFN) Modelling of Hydraulic Fracturing	DFN (Discrete Fracture Network)/Artifi cial Intelligent
13*	Omar Akash	Rasouli	Simulations of Near Wellbore Hydraulic Fracturing Through Perforations	Cased Hole HF

14	Lingyun Kong	Ostadhassan	Replicating Bakken Shale Rock for Petrophysical Experiments Using 3D Printing Technology	3D Printing Shale
15	Arash Abarghani	Ostadhassan	Multi-Scale Organic Material Characterization of the Bakken Source Rock	Organic Mat. Characterizatio n
16*	Hyeon Seok Lee	Ostadhassan	CO2 sequestration and EOR capacity of the Bakken Formation through Molecular Simulation & Characterization	Kerogen MM
17*	Seyed Alireza Khatibi	Ostadhassan	Fine scale characterization of organic matter using analytical methods: Raman and NMR spectroscopies	Spectroscopy
18	Siamak Koloushani	Rasouli	Lattice Numerical Simulations of Hydraulic Fracturing in High Permeable Formations	HF in High Permeable Formation
19*	Sofiane Djezzar	Rasouli	Fracture detection and prediction in unconventional reservoirs for finding sweet spot	Fracture Mapping
20	Yanbo Wang	Ling	Lab Experiments Using a Two-phase Flow Loop Unit and Numerical Simulations	Multiphase Flow
21	Foued Badrouchi	Rasouli	Cuttings Transportation Optimization: Lab Experiments Using a Large Scale Slurry Loop Unit and Numerical Simulations	Borehole Cleaning
22	Ahmed Ismail	Rasouli	Automated Directional Drilling: Lab Experiments and Numerical Simulation	Directional Drilling
23	Imene Bouchakour	Rasouli	Crack Geometry Prediction in Replicated Rock Samples During Triaxial Testing Using Velocity Data	Acoustic Emission

Publications:

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2. Abarghani, A., Ostadhassan, M., Bubach, B. and Zhao, P. (2019). 'Estimation of thermal maturity in the Bakken source rock from a combination of well logs, North Dakota, USA', Marine and Petroleum Geology, 105, pp.32-44.
3. Abarghani, A., Ostadhassan, M., Gentzis, T., Carvajal-Ortiz, H. and Bubach, B. (2018) 'Organofacies study of the Bakken source rock in North Dakota, USA, based on organic petrology and geochemistry', International Journal of Coal Geology, 188, pp.79-93.
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6. Abarghani, A., Ostadhassan, M., Hackley, P., Pomerantz, A. and Nejati, S. (2019) 'A chemo-mechanical snapshot of in-situ conversion of kerogen to petroleum', Geochimica et Cosmochimica Acta (Submitted).
7. Ahmadinejad, A., Rahimzadeh Kivi, I., Ameri, M. and khatibi, S. (2019) 'Experimental Study of the Hydro-Mechanical Response of Tight Sarvak Carbonates to Hydrostatic and Deviatoric Stress Changes', 53nd US Rock Mechanics/Geomechanics Symposium.
8. Akash, O., Vamegh, R., Damjanac, B., Zhang, F. and Badrouchi, F. (2019) Lattice Simulations of Hydraulic Fracture Reorientation from Perforations, 53rd US Rock Mechanics / Geomechanics Symposium edn., NewYork: American Rock Mechanics Association.
9. Alexeyev, A., Ostadhassan, M., Bubach, B., Boualam, A., Djezzar, S. 2017. Integrated Reservoir Characterization of the Middle Bakken in the Blue Buttes Field, Williston Basin, North Dakota. SPE Western Regional Meeting, Bakersfield, California.
10. Almetwally, A. and Jabbari, H., June 2019: "Development of Novel Workflow to Replicate Pore Network of Porous Core Samples Through 3D Printing Technology" American Rock Mechanics Association 53rd Symposium, New York.
11. Almetwally, A. and Jabbari, H., June 2019"CT-Scan Image Processing for Accurate Pore Network Modeling and Core Samples 3D Printing: Polynomial Interpolation & Geostatistical QC" American Rock Mechanics Association 53rd Symposium, New York.
12. Assady A., Jabbari, H, Ellafi A.M. and Goudarzi B., June 2019 "On the Characterization of Bakken Formation: Oscillating-Pulse, Pulse-Decay Permeability Measurement & Geomeachanics" American Rock Mechanics Association 53rd Symposium, New York.
13. Badrouchi, F., Bouchakour, I., Djabelkhir, N., Damjanac, B. and Rasouli, V. (2019) Lattice Simulation of Fracture Containment in Middle Bakken Formation, 53rd US Rock Mechanics / Geomechanics Symposium edn., NewYork: American Rock Mechanics Association.
14. Badrouchi, F., Rabiei, M., Badrouchi, N. and Rasouli, V. (2019) Estimation of Elastic Properties of Bakken Formation Using an Artificial Neural Network Model, 53rd US Rock

Mechanics / Geomechanics Symposium edn., NewYork: American Rock Mechanics Association.
15. Badrouchi, F., Wan, X., Bouchakour, I., Akash, O., Rasouli, V., and Damjanac, B. (2019) 'Lattice Simulation of Fracture Propagation in the Bakken Formation', Proceedings of ARMA 53rd US Rock Mechanics / Geomechanics Symposium New York City 23 - 26 June 2019
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25. Djezzar, S., Rasouli, V, Boualam, A., Rabiei, M. March 2019. Integration of Seismic Curvature and Illumination Attributes in Fracture Detection on a Digital Elevation Model: Methodology and Interpretational Implications. Joint Geological Society of America, Section Meeting South-Central, North-Central, and Rocky Mountain Sections. 25–27 March 2019, Manhattan, Kansas.
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27. Djezzar, S., Rasouli, V, Boualam, A., Rabiei, M., March 2019. Fractal Analysis of 2-D Fracture Networks of Naturally fractured Reservoirs Analog in south Algeria. Joint

Geological Society of America, Section Meeting South-Central, North-Central, and Rocky Mountain Sections. 25–27 March 2019, Manhattan, Kansas.
28. Djezzar, S., Rasouli, V, Boualam, A., Rabiei, M., March 2019. Fractography Analysis of Cambro-Ordovician Reservoirs through Surface Analog. Mouydir Basin, Algeria. Joint Geological Society of America, Section Meeting South-Central, North-Central, and Rocky Mountain Sections. 25–27 March 2019, Manhattan, Kansas.
29. Djezzar, S., Rasouli, V, Boualam, A., Rabiei, M., March 2019. Size Scaling and Spatial Clustering of Natural Fracture Networks Using Fractal Analysis. 53rd US Rock Mechanics/Geomechanics Symposium New York, NY, USA, 23–26 June 2019.
30. E. Bakhshi, V. Rasouli, A. Ghorbani, M. Fatehi Marji, B. Damjanac, and X. Wan (2019) 'Lattice Numerical Simulations of Lab-Scale Hydraulic Fracture and Natural Interface Interaction', Rock Mechanics and Rock Engineering, 52(5), pp. 1315–1337.
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33. F. Badrouchi, X. Wan, I. Bouchakour, O. Akash, V. Rasouli, and B. Damjanac (2019) 'Lattice Simulation of Fracture Propagation in the Bakken Formation', 53rd U.S. Rock Mechanics/Geomechanics Symposium, 23-24 June, New York, NY, USA
34. Fu, H., Long, Y., Wang, S., Wang, Y., Yu, P. and Ling, K. (2019) The Development of CO2 Plume in CO2 Sequestration in the Aquifer, Houston: 2019 Carbon Management Technology Conference.
35. Ge, J., Jerath, S., Ghassemi, A., & Ling, K. (2018, August 21). Sensitivity Study on the Poroelastic and Thermoelastic Effects on the Stress Reversal Nearby an Existing Hydraulic Fracture. American Rock Mechanics Association.
36. H. Liang, S. Zhang, Y. Kang, K. Ling (2018) 'Separation Performance of Supersonic Separator with a Rear-Set Helical Guide Blade', 2018 AIChE Spring Meeting, 22-26 April, Orlando, FL, USA
37. H. Liang, S. Zhang, Y. Kang, K. Ling (2019) 'Research on Natural Gas Separation Flow Laws in a New Type of Supersonic Cyclone Separator', 11th International Petroleum Technology Conference (IPTC), 26-28 March, Beijing, China
38. H. Liang, S. Zhang, Y. Kang, K. Ling, S. Wang (2017) 'Research on Separation Performance of Supersonic Separator with a Forward Helical Guide Blade', 2017 AIChE Annual Meeting, 29 October-3 November, Minneapolis, MN, USA
39. Han, G., Ma, G., Ling, K., Gao, Y., & Zhang, H. (2018, September 17). A New Transient Model to Simulate and Optimize Liquid Unloading with Coiled Tubing Conveyed Gas Lift. Society of Petroleum Engineers. doi:10.2118/191716-MS
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41. Khatibi, S., Ostadhassan, M. and Aghajanpour, A. (2018) 'Geomechanical and Geochemical Characterization of Organic Matter by Raman Spectroscopy', 52nd US Rock Mechanics/Geomechanics Symposium.

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56. Kong, L., Ostadhassan, M., Zamiran, S., Liu, B., Marino, G., Sakhaee-Pour, A., Li, C. (2019) 'Geomechanical Upscaling Methods: Comparison and Verification via 3D Printing', Energies, 12(3), pp. 382.

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61. Lee, H.; Ostadhassan M., Sep 2019: Molecular weight distribution analysis of kerogen using MALDI-TOF and FTIR. TSOP Meeting, Bloomington IN.
62. Li, C., Ostadhassan, M., Abarghani, A., Fogden, A. and Kong, L. (2019) 'Multi-scale evaluation of mechanical properties of the Bakken shale', Journal of materials science, 54(3), pp.2133-2151.
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65. N. Djabelkhir, X. Song, X. Wan, O. Akash, V. Rasouli, and B. Damjanac (2019) 'Notch Driven Hydraulic Fracturing in Open Hole Completions: Numerical Simulations of Lab Experiments', 53rd U.S. Rock Mechanics/Geomechanics Symposium, 23-24 June, New York, NY, USA
66. Ostadhassan, M., Liu, k., Li, C. and Khatibi, S. (2018) Fine Scale Characterization of Shale Reservoirs: Methods and Challenges, 1st edn.: Springer.
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68. Ozotta, O., Ostadhassan, M. and Liu, K. (2019) A Review: Impact of CO2 on Geomechanical Properties of Shale Reservoir., Journal of Petroleum Science and Engineering. (Under review)
69. S. Zhang, H. Liang, Y. Kang, K. Ling, 2018. Separation Performance of Supersonic Separator with a Rear-Set Helical Guide Blade, 2018 AIChE Annual Meeting
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74. Wang, Y., Ling, K., Fu, H., Yang, L., Wang, S. and Liang, H. (2019) Study of Pressure-Drop in Two-Phase Flow Based on Experiment and CFD Simulation, Las Vegas: 4th Thermal and Fluids Engineering Conference.
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76. X. Wan, J. Ge, W. Li, and H. Pu (2018) 'Potential Thermoelastic and Poroelastic Stresses Effects During the Fracture Propagation of Hydraulic Fracturing Treatments in Horizontal Bakken Wells', 52nd U.S. Rock Mechanics/Geomechanics Symposium, 17-20 June, Seattle, Washington, USA
77. X. Wan, V. Rasouli, B. Damjanac, H. Pu. 'Lattice Simulation of Hydraulic Fracture Containment in the North Perth Basin', Journal of Petroleum Science and Engineering. (under review)
78. X. Wan, V. Rasouli, B. Damjanac, M. Torres, and D. Qiu (2019) 'Numerical Simulation of Integrated Hydraulic Fracturing, Production and Refracturing Treatments in the Bakken Formation', 53rd U.S. Rock Mechanics/Geomechanics Symposium, 23-24 June, New York, NY, USA
79. X. Wan, V. Rasouli, B. Damjanac, W. Yu, N. Li, M. Rabiei, J. Miao, M. Liu. 'An Integrated Simulation of Multi-Stage Hydraulic Fracturing and Production Simulation for the Marcellus Shale Gas Reservoir', Fuel. (under review)
80. Yang, L., Fu, H., Liang, H., Wang, Y. and Ling, K. (2019) Analysis of Pressure Distribution along Pipeline Blockage Based on the CFD Simulation, Las Vegas: 4th Thermal and Fluids Engineering Conference.
81. Yang, L., Fu, H., Liang, H., Wang, Y., Han, G. and Ling, K. (2019) 'Detection of pipeline blockage using lab experiment and computational fluid dynamic simulation', *Journal of Petroleum Science and Engineering*, 183(0920-4105), 106421.
82. Yang, L., Ling, K., Fu, H., Liang, H. and Wang, Y. (2019) A Systematic Instruction for Selecting Methods to Detect Pipeline Leakages, Las Vegas: 4TH Thermal and Fluids Engineering Conference.
83. Z Rui, K Cui, X Wang, J Lu, G Chen, K Ling, S Patil, 2018. A quantitative framework for evaluating unconventional well development, Journal of Petroleum Science and Engineering 166, 900-905
84. Zhang, S., Li, C., Pu, H., Ling, K., Sun, & R., Zhao, J. (2019). Experimental Study of Surfactant-Assisted Oil Recovery in the Middle Bakken Cores. SPE-197080-MS. SPE Liquids-Rich Basins Conference – North America, 7 – 8 November 2019, Odessa, TX.
85. Zhang, S.; Pu, H.; Zhao, J. X. Experimental and Numerical Studies of Spontaneous Imbibition with Different Boundary Conditions: Case Studies of Middle Bakken and Berea Cores. Energy Fuels 2019, 33, 5135-5146.
86. Zhao, P., Ostadhassan, M., Shen, B., Liu, W., Abarghani, A., Liu, K., Luo, M. and Cai, J. (2019) 'Estimating thermal maturity of organic-rich shale from well logs: Case studies of two shale plays', Fuel, 235, pp.1195-1206.

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88. Zhong, X., Pu, H., Zhou, Y., Zhao, J. (2019) 'Commercial Implementation of Chemical Flooding in Daqing Oilfield, China, and Its Future', SPE International Conference on Oilfield Chemistry, 8-9 April, Galveston, Texas.
89. Zhong, X., Pu, H., Zhou, Y., Zhao, J. (2019) 'Comparative Study on the Static Adsorption Behavior of Zwitterionic Surfactants on Minerals in Middle Bakken Formation', Energy & Fuels, 33(2), pp. 1007-1015.
90. Zhong, X., Wang, Y., Pu, H., et al. (2018) 'Commercial Implementation of Chemical Flooding in Daqing Oilfield, China, and Its Future', SPE EOR Conference at Oil and Gas West Asia, 26-28 March, Muscat, Oman.
91. Zhong, X., Wang, Y., Pu, H., Li, W., Yin, S., & Ling, K. (2018, March 26). Commercial Implementation of Chemical Flooding in Daqing Oilfield, China, and Its Future. Society of Petroleum Engineers. doi:10.2118/190381-MS.

Conferences & Workshops Attended:

1. Akash, O., February 2019: Graduate Workshop: Organizing and Managing Your Research, North Dakota. Participated.
2. Akash, O., March 2019: Graduate Workshop: In-Depth Searching for a Literature Review, North Dakota. Participated.
3. Akash, O., November 2018: Panel Discussion on Sales Pitch and Negotiation, North Dakota. Participated.
4. Akash, O., October 2018: Engineering isn't easy…. managing engineers isn't any easier, North Dakota. Participated.
5. Akash, O., October 2019: Bakken Oil Product and Service Show, North Dakota. Oral Presentation.
6. Akash, O., September 2018: Geomechanics of Reservoir Stimulation by Hydraulic Fracturing, North Dakota. Participated.
7. Akash, O., September 2018: Workshop on Entrepreneurship and Leadership North Dakota. Participated.
8. Almetwally, A., June 2019: American Rock Mechanics Association 53rd Symposium, New York. Participated.
9. Badrouchi,F., June 2019: 53rd US Rock Mechanics / Geomechanics Symposium, NewYork. Oral Presentation and Poster Presentation.
10. Badrouchi,F., March 2019: 2nd International Conference on Artificial Intelligence and Information Technology, Algeria. Participated.
11. Badrouchi,F., March 2019: SEG Drilling Conference and Exhibition, Algeria. Oral Presentation and Poster Presentation.
12. Badrouchi,F., March 2019: The 9th North Africa Petroleum Exhibition & Conference NAPEC, Algeria. Participated.
13. Balaji, K., April 2019: SPE Western Regional Meeting 2019, Conference, San Jose, CA. Oral Presentation.

14. Balaji, K., July 2019: The Bakken Conference & Expo, Conference, Bismarck, ND. Oral Presentation & Panel Discussion.
15. Balaji, K., May 2018: The Midwest Big Data Hub, Workshop, Ames, Iowa. Participated.
16. Boualam, A., June 2019: 53rd US Rock Mechanics/Geomechanics Symposium, New York. Participated/Poster presentation.
17. Boualam, A., March 2019: Joint Geological Society of America, Section Meeting South-Central, North-Central, and Rocky Mountain Sections, Manhattan, Kansas. Participated/ Oral presentation.
18. Djezzar, S., June 2019: 53rd US Rock Mechanics/Geomechanics Symposium, New York. Participated/Poster presentation.
19. Djezzar, S., March 2019: Joint Geological Society of America, Section Meeting South-Central, North-Central, and Rocky Mountain Sections, Manhattan, Kansas. Participated/ Poster presentation.
20. Ellafi, A., July 2019: The Bakken Conference & Expo 2019, Bismarck, North Dakota. Oral Presentation.
21. Fu, H., April 2019: 4th Thermal and Fluids Engineering Conference, Nevada. Oral presentation.
22. Fu, H., July 2019: Carbon Management Technology Conference, Texas. Participated.
23. Khatibi, S., June 2018: 52nd US Rock Mechanics/Geomechanics Symposium, Petroleum Geomechanics, Seattle. Poster and Oral presentation.
24. Khatibi, S., June 2019: 53nd US Rock Mechanics/Geomechanics Symposium, Petroleum Geomechanics, New York. Poster and Oral presentation.
25. Kong, L., December 2018. American Geophysics Union Fall Meeting, Washington D.C. Participated.
26. Kong, L., June 2017: American Rock Mechanics Association, San Francisco. Participated.
27. Kong, L., June 2018: American Rock Mechanics Association, Seattle. Participated.
28. Kong, L., October 2017: Society of Exploration Geophysicists Annual Meeting, Houston. Participated.
29. Kong, L., October 2018: Society of Exploration Geophysicists Annual Meeting, Los Angeles. Participated.
30. Lee, H. Aug 2019: ACS National Meeting, San Diego CA. Poster presentation.
31. Lee, H. Sep 2019: TSOP Meeting, Bloomington IN. Poster presentation.
32. Li, C. July 2018: Modeling Supra-molecular Structures with LAMMPS, Philadelphia.
33. Li, C. July 2019: The Bakken Conference & Expo, Bismarck. Oral presentation.
34. Li, C. July 2019: Unconventional Resources Technology Conference, Denver. Oral presentation.
35. Li, C. May 2018: Nalco Champion Technical Training, Williston. Participated.
36. Li, C. May 2018: Williston Basin Petroleum Conference, Bismarck. Participated.
37. Liang, H., April 2018: 2018 AIChE Spring Meeting, Orlando, FL. Poster presentation.
38. Liang, H., March 2019: 11th International Petroleum Technology Conference (IPTC), Beijing, China. Poster presentation.
39. Liang, H., October 2017: 2017 AIChE Annual Meeting, Minneapolis, MN. Poster presentation.
40. Ozotta, O. July 2019: Research Experience in Carbon Sequestration, Wyoming. Participated through EERC.

41. Ozotta, O. September 2019: Geological Society of America Annual Meeting, Phoenix, Arizona. Oral presentation.
42. Ozotta, O. September 2019: National Association of Black Geoscientist Annual Conference, Fayetteville, Arkansas. Poster presentation.
43. Ozotta, O. September 2019: Society of Exploration Geophysicists Annual Conference and Exhibition, San Antonio, Texas. Student Leadership Symposium participant.
44. Patil, S., July 2019: URteC 2019. Participated. (Attended Through EERC)
45. Patil, S., May 2018: Oil Chemical Technical Training. Participated
46. Patil, S., May 2018: Williston Basin Petroleum Conference. Participated
47. Qiu, D., July 2019: Unconventional Resource Technology Conference 2019, Denver. Participated.
48. Qiu, D., June 2019: 53rd U.S. Rock Mechanics/Geomechanics Symposium, NewYork. Poster presentation.
49. Wan, X., April 2019: Refrac Well 2019, Seattle. Oral presentation.
50. Wan, X., July 2019: The Bakken Conference & Expo, Bismarck. Oral presentation.
51. Wan, X., June 2018: 52nd U.S. Rock Mechanics/Geomechanics Symposium, Seattle. Oral presentation.
52. Wan, X., June 2019: 53nd U.S. Rock Mechanics/Geomechanics Symposium, Seattle. Poster presentation.
53. Wan, X., May 2018: Williston Basin Petroleum Conference, Bismarck. Participated.
54. Wang, Y. July 2019: Unconventional Resources Technology Conference, Denver. Participated.
55. Wang, Y., April 2019: 4th Thermal and Fluids Engineering Conference, Las Vegas. Oral presentation.
56. Wang, Y., September 2018: SPE Liquids-Rich Basins Conferences, Midland. Oral presentation.
57. Zhang, S., Simultaneous Capillary Pressure and Relative Permeability Determination for Tight Bakken Cores Using Imbibition Methods. Presented at 9th Annual Bakken Oil Product & Service Show, 2 – 3 October 2019, Williston, ND. Oral presentation.
58. Zhong, X., April 2019: SPE International Conference on Oilfield Chemistry, Texas. Oral presentation.
59. Zhong, X., March 2018: SPE EOR Conference at Oil and Gas West Asia, Muscat. Oral presentation.
60. Zhou, Z., April 2019, SPE Oklahoma City Oil and Gas Symposium, Oklahoma City, Oklahoma, Oral presentation.
61. Zhou, Z., May 2018: The Midwest Big Data Hub, Workshop, Ames, Iowa. Participated.
62. Zhou, Z., October 2019, 9th Annual Bakken Oil Product and Service Show, Williston, North Dakota, Oral presentation.

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.

☒	Application
☒	Transmittal Letter
☒	$100 Application Contribution
☐	Tax Liability Statement
☒	Letters of Support (If Applicable)
☐	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.

October 30, 2019

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

Subject: Letter of Support Regarding the University of North Dakota (UND) Department of Petroleum Engineering Intent to Establish a Drilling and Completions Laboratory

Dear Ms. Fine:

This letter serves to establish the commitment by the National Energy Technology Laboratory's (NETL) Research and Innovation Center (RIC) to support the University of North Dakota Department of Petroleum Engineering in its purchase and re-deployment of Drilling and Completions Laboratory (Drilling Laboratory) equipment. NETL is a government-owned government-operated (GOGO) national laboratory, one of 17 Department of Energy (DOE) national laboratories as defined in EPAct 2005 (P.L. 109-058). As Executive Director of RIC and a direct report to the NETL Chief Technology Officer, I am responsible for authorizing and managing all NETL on-site R&D activities.

Historically, we are aware that the Drilling Laboratory was developed, fabricated and operated by Mr. Sidney Green and his team at TerraTek in Salt Lake City. The facility at TerraTek was sold and became the core of Schlumberger's Innovation Research Center. Mr. Green's group also built similar systems internationally, for example, the Schlumberger Cambridge UK drilling system and the JNOC system in Tokyo (Japan Oil, Gas and Metals National Corporation). Unfortunately, due to industry down turn all the above mentioned systems are now suspended from operations.

Mr. Green's Laboratory has a proven record in providing critical data and has an established reputation in helping to resolve key industrial problems. It has great potential to be further modified for increased capabilities. We believe the Drilling Laboratory has potential to test new bit designs, downhole electronics/sensors, and downhole motors, and to verify simulation results and other challenging tasks under elevated temperature for high pressure conditions. All these tests are unique; there is no other facility currently performing these tests with full bits and the same controlled lab conditions. The modification and re-deployment of Mr. Green's laboratory would likely make great contributions to the insights and technology development needed for drilling under more challenging conditions (e.g., harder rock, higher temperatures and pressures, bore-hole instability).

NETL looks forward to collaborating with the Department of Petroleum Engineering at UND to maximize the use of the Laboratory. It is also believed that both industry and university researchers would be very interested in teaming with UND in using the Laboratory. We have discussed with Dr. Rasouli, Chair of UND's Department of Petroleum Engineering, forming a consortium that would better address the research objectives (to meet industry needs), help to plan each year's plans for tests, and disseminate

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October 29, 2019
Subject: Letter of Support Regarding the University of North Dakota (UND) Intent to Establish a Drilling and Completions Laboratory

results to industry. The consortium could also help to address challenges in bringing this facility for full operation and to modify it specifically to address various emerging industrial needs. It is expected that with the Drilling Laboratory, UND will become a leading center in drilling technology research and development.

The capabilities of this intended Drilling Laboratory, should they come to fruition, are directly aligned with or complementary to existing research at NETL and therefore align with NETL and the DOE mission. Please do not hesitate to contact me or Michael Nowak (michael.nowak@netl.doe.gov or 412-386-6020) with any questions.

Sincerely,

Bryan D. Morreale Digitally signed by Bryan D. Morreale
Date: 2019.10.30 08:10:30 -04'00'

Bryan D. Morreale, Ph.D.
Executive Director, Research and Innovation Center