Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: Artificial Intelligence and Machine Learning for Optimizing Well Selection for Re-Fracking, Case Study: State of North Dakota

Applicant: UND Petroleum Engineering

Principal Investigator: Mehdi Ostadhassan

Date of Application: Feb 15th 2018

Amount of Request: $36,427

Total Amount of Proposed Project: $90,909

Duration of Project: 1 year

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ABSTRACT

Objective: This proposal will significantly increase the added value of the huge amount of data that is stored at NDIC. We will utilize Artificial Intelligence and Machine Learning, to provide an optimized solution to select the best wells for refracking in the Bakken and Three Forks Formations through all available data at NDIC. Multiple factors that affect the decision-making process, including well locations, stress orientation, reservoir properties, original completion design, production history, costs, well repots, etc. will be analyzed to predict their performance for refracking. This process should lead to notable return of rate for operators and the state. Therefore, the following tasks will be undertaken:

1. Organize all sort of available data available in the state of North Dakota.
2. Design and program a Machine Learning algorithm for ranking each well for refracking.
3. We will validate the results by history matching and field implementation.

The procedure of collecting and managing the big data is essential for treating the long production history in the huge number of wells in the state of North Dakota. The application of Machine Learning in petroleum engineering is rare in practice. The credibility of Machine Learning algorithm can be validated by previously refracked wells, which is similar to production history matching commonly used in reservoir engineering.

Expected Results: Through this project the department of petroleum engineering will become a center in big data analytics to help increase production in the state and bring more revenue to the state and operators. The following results are expected from this proposal:

1- Develop state-of-the-art algorithm specific to ND wells and an advanced model based on Machine Learning to process the big data from production, well logs and well reports.

2- Improve the accuracy of well selection for refracking and further enhance the production recovery.

Duration: The project will start from June 2018 and will continue for 1 year.

Total Project Cost: The department of the petroleum engineering is respectfully requesting $36,427 of funding assistance from the NDIC Oil and Gas Research Program.

Participants: PI will supervise one graduate student for this project. Our industry partner, NeuDax Data Analytics is a leading big data company in petroleum industry and will also support the project by providing software, data, and consultation.

PROJECT DESCRIPTION

Background:

An effective hydraulic fracturing or refracking operation is necessary in unconventional reservoirs to enhance formation permeability and production [1]. Amid all issues confronted in refracking, selecting the best wells is the first difficulty. If this task is not done properly high economical risks as well as long-term impact on future production from the well can occur. Economic analysis and technical feasibility are the two main factors that determine the strategy of well selection [2]. Historically, multiple approaches have been taken to select the best candidate wells, including heuristic guidelines, field correlations, and neural networks. For instance, Roussel et al. (2013) proposed a dimensionless approach, similar to production type-curve matching, that can identify two promising groups (a) ineffective initial completions with a small initial production decline and (b) long initial fractures in under-depleted reservoirs as the best approach [3]. However, his method still cannot correlate with big dataset and mainly depends on production. In general, the efficiency and accuracy of previous reported results didn't generate expected outcome and impacted negatively on decision-makers.

Machine Learning (ML) has been proved to be conducive to digesting big data sets and making intelligent decisions for agile productivity and more-accurate measures [4]. Machine Learning belongs to Artificial Intelligence (AI), a branch of computer science which is inferred as the ability of a machine to perform or mimic the operations of human brain or thought, and then understand and apply thinking methodologies independently [5]. The common used ML tools include artificial neural network (ANN), logistic regression, Adaptive Neuro-Fuzzy Inference System (ANFIS), Support Vector Machine (SVM), K-Means, Naïve Bayes, Decision Tree, Random Forest, Dimensionality Reduction algorithm, Gradient Boosting algorithms and etc. [6]. Artificial Intelligent (AI) tools, especially ML, has the advantages of modelling complex or non-linear processes, generating accurate analysis based on large historical databases for cost effective algorithms [7]. ML is gradually becoming a useful tool in various areas of petroleum industry such as well-logging interpretation, microseismic signal distinction from noise, etc. [8]–[10]. Although the advantages, it is still not very common for fracturing or refracking purposes. Therefore, applying machine learning in oil and gas industry can provide substantial opportunities to gain benefits in quality, cost and schedule of exploration and development [11].

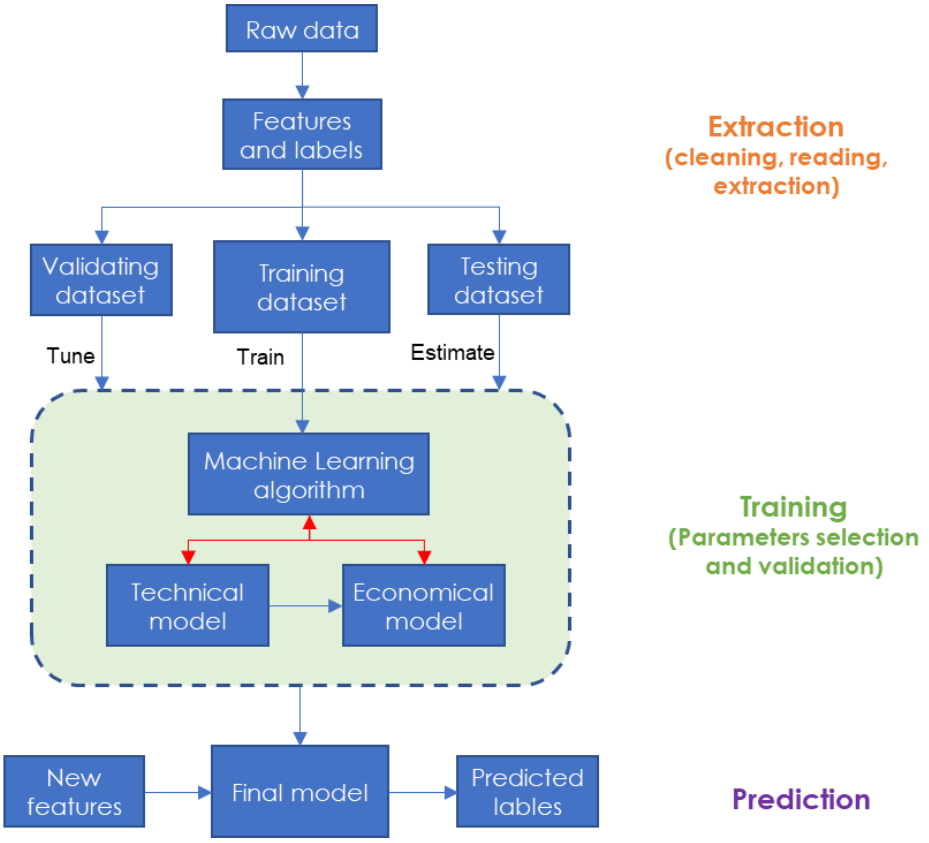
Objectives:

This project attempts to implement AI-assisted methods for refracking and aims to achieve the following objectives:

1. Understand petrophysical properties and production history of each individual well in Williston Basin producing from the Bakken and Three Forks.
2. Assess the initial completion methods that belongs to different periods in the history of the well and classify them into multiple technique types.
3. Establish an ML-based model to evaluate the technical feasibility of refracking on each well.
4. Integrate the first model into AI-assisted economic model for providing the best candidate wells for refracking that can have the highest profit and lowest risk through a probabilistic approach.

Methodology:

To achieve the objectives above, the project will be completed through the following flowchart:



First, raw data including petrophysical properties, production, stimulation and completion data will be collected from each well. Cleaning and refining the data is the most time consuming part of the project where suspicious or irrelevant data should be removed from the final dataset. After cleaning the data, we

will start to identify meaningful features in the data and extract them. Feature Engineering which means combining different information to create new attributes will be done for each well. Feature Engineering needs a deep understanding of the data and the underlying nature of it. It is the most important step that can be done precisely if a petroleum engineer is performing the task. Features and labels should be attached to each individual type of data depending on the purpose of our ML algorithm.

The processed big data will be divided into three sections, 1) training dataset, 2) validating dataset and 3) testing dataset. This step is called data extraction, and depends on the volume of historical data. The next part is training, which is the most crucial procedure. The analyst in this step should focus on the design and programming of ML algorithms. New features and data are welcome to be input into the models simultaneously to have the best predicted results for optimizing candidate wells for refracking. The prediction results from any numerical simulation done on these two formations can also be obtained from literature or available projects to match with our predictions based on our new AI approach. Thus, the tasks are divided into 3 main parts:

TASK I) Extraction and Processing Big Data

a) Data gathering and digitizing*:* petrophysical, production, stimulation, initial completion and other relevant data from well reports should be collected. In this step, some data is required to be digitized if stored in papers or images.
b) Refining the data and label them: In this step, redundant data or any data that does not have reasonable format in the entire appearance should be eliminated.
c) Grouping the data: According to the ML algorithm, majority of big data, approximately 70%, will be the training dataset for initial modelling. The rest will be considered as the validating as well as testing dataset to tune and estimate the models.

TASK II) Design and Training Machine Learning algorithm

a) Why Artificial Intelligence (feature extraction)? It should be clarified that we won't establish another complicated mathematical formula, but to improve solutions by taking advantage of the data itself. The features in the data will increase the number of inputs to the network of mathematical relations. The main advantage compared to any numerical and analytical technique is its strong capability of expanding the equation of state by incorporating more inputs without adding any complexity. This will lead to a significant increase in the degree of freedom to solve the problem more accurately and enhance solutions for optimizing the well selection for refracking.

b) Algorithm selection based on the data types: Machine Learning contains variety of algorithms for multiple purposes as illustrated above. Based on different data categories, one should understand the nature of the problem first. Logistic regression, Artificial Neural Network, K-mean method and other algorithms have different applicability and can generate dissimilar results. Thus since this project is going to be done by a petroleum engineer who understands the data nature, the most suitable algorithm will be picked.

c) Tune the technical and economic model: A mature model from ML must be tuned by validating dataset and should be assessed by the testing dataset. Moving from a technical to economic model, the process could be a one way road, but resembling tuning and estimating the models should be done multidirectional.

TASK III) Model Prediction and Verification:

a) Conclude the final model and predict the result: The final model can be trained through an ML approach while the accuracy should also be verified by the result from reservoir simulation, history matching or direct data from the field. For example, well production by refracking can be predicted by the ML model, while plenty of numerical simulation have done the work already. Simulation provide the fracture propagation, reorientation as well as future production results. If these two sources of outcome have similar results, then we can consider the machine learning satisfactory.

b) Simultaneously update ML model along with refracking operations: One of the advantages of AI technique is that the model could be updated simultaneously as the operation is ongoing. This task will enhance the results and increase the ability of the model for the next round of refracking and the wells that should be selected for the job.

Task IV- Report writing and deliverable preparation: completing the reports and submitting the results will be done mid-way through the project and at the end.

Anticipated Results: The following results are expected from this project:

i. Better understanding of big data that is available in the state of North Dakota and add more values to the unvalued/unused old dataset.

ii. Develop state-of-the-art algorithm based on an ML approach specifically for successful refracking operations in the state of North Dakota.

iii. Improve the long-term accuracy and efficiency of well selection for refracking and further enhance production recovery in the state of North Dakota.

iv. Last but not least through this proposal, we will organize the huge amount of dataset that is produced and stored for the past 50 plus years. We will give a new life and vision to this data.

Resources: The department of petroleum engineering at UND and my research team are focused on answering fundamental oil and gas research problems and put them in application. We are a group of researchers with a diverse background (geologists, geophysicists, petroleum engineers, computer scientists) who work together to make enhancements in petroleum related research by utilizing and developing advanced analytical equipment and techniques to better characterize reservoir rocks and their constituent elements in various scales.

We also collaborate with industry and have members in our team who are experienced in technology development and commercialization. Our research sponsors is NeuDax, which is one of a few pioneers in adapting Artificial Intelligence in oil and gas industry. The NeuDax team will assist applying different machine learning algorithms to unconventional reservoirs foresee the problems in this area of research. Also, their industrial understanding helps us to deliver the results that can be applied by operators in state of North Dakota.

Techniques to Be Used, Their Availability and Capability: Several computational, programming methods will be developed in the project. For our modeling we will use three packages: 1) Python (mostly Pandas, SciKitLearn, Numpy libraries which are all open source libraries), 2) MATLAB (with enough licenses available at the petroleum engineering department and CEM) and 3) TensorFlow for advanced Neural Network Analysis (also an open source library). The models will be run on the state HPC thus we do not require to put together a new computer system.

Environmental and Economic Impacts while Project is Underway: No environmental impact is expected from this study. If this project leads into successful field validation, positive economic impact may be realized either during or as a direct result.

Ultimate Technological and Economic Impacts: The ultimate technological impact will be the development of a reliable ML model which ranks all the wells in state of North Dakota based on their suitability for refracking. Also, understanding the parameters that are involved in well selection for future operations is another technological and economic impact of this project. The results will provide the state and petroleum industry to achieve a better insight into well selection for refracking by taking advantage of data. Considering that all the wells drilled through the Bakken and Three Forks should be stimulated or refracked, this proposal can have a significant economic effect on the ultimate recovery from these formations.

Why the Project is needed: Refracking is a repeatable stimulation method that can save cost and avoid public issues, compared with exploring and drilling new wells. However, how to improve the success rate and enhanced recovery of refracking would be the challenge that needs to be tackled. In addition to other operational improvements, optimizing the best wells for this job, plays a more significant role as the first step in the overall process. This project is exactly needed to focus on the demand of improving the accuracy in well selection for this purpose. Introducing the Artificial Intelligence and Machine Learning, we will apply this emerging and promising technologies for the first time on the huge amount of dataset available in the state to help organize the data and make them more meaningful. This is an advanced solution that can be verified in the fields.

STANDARD of SUCCESS

The standard of success for this research proposal can be measured by how well the team can fulfill the tasks described in the narrative in a timely manner. Consequently, by sharing results with the NDIC, our industry partners and within the team we can make sure to overcome the obstacles and assure 100% achievement of the project objectives. The success in this proposal has a direct relationship to submitting the reports and deliverables on-time to the funding agency. Also, presenting the results in peer reviewed journals and annual conferences would be a key factor to the success of the team and the project. We strongly believe the outcome of this project is in line with the mission and vision of the University of North Dakota to be the flagship university in energy related research in the region.

Finally, establishing a robust relationship with the petroleum industry and North Dakota Industrial Commission, Oil and Gas Research Council to support their growth and knowledge based operations is a major standard of success for this project. Attaining this level of success is only possible when the outcome makes to produce more energy, avoiding financial loss, and increasing revenue for the state, by abiding to the state environmental rules and regulations. If we can employ our method with success in the field, one can testify that we have been fully successful to commercialize our efforts.

BACKGROUND/QUALIFICIATIONS

Through the past few years Dr. Mehdi Ostadhassan has established a robust research team working on variety of topics. He has published number of research articles and has been involved in different projects in collaboration with other UND departments, other academic institutions and industry. These research projects include: detailed investigation of shale reservoirs (focusing in the Bakken Formation), well bore instability problems, geophysical monitoring of enhanced oil recovery, reservoir geomechanics,

microseismic monitoring, and geological-petrophysical-geomechanical modeling of number of oil fields in Williston Basin. All these past and ongoing experiences has provided him adequate knowledge to assure successful completion of this proposal and achieving its objectives.

Dr. Vamegh Rasouli as the chair of the department of petroleum engineering and a well-known researcher in the field of geomechanics, hydraulic fracturing and stimulation who has a very good relationship with industry has brought experience, knowledge and expertise in every task proposed in this project from mathematical modeling to commercialization, is a huge asset for our team, UND and the state of ND.

MANAGEMENT

This investigation will be directed by PI, Mehdi Ostadhassan at the University of North Dakota, petroleum engineering department. Ostadhassan will make sure the collaboration among the team members is effective. One PhD student with an extensive background in AI and ML will be supervised by the PI and with close collaboration and oversight by the industry partner. We will closely liaise our progress within the team through biweekly meetings and reports to ensure the efforts that are made lead to the successful completion of the project within the dedicated time frame. The expertise of the team will bring adequate time and expertise to this project and will ensure that the objectives and outcomes will be completed with the highest quality. The project tasks for this project as displayed in the following section.

TIMETABLE

	Phase I											
	2018							2019				
	6	7	8	9	10	11	12	1	2	3	4	5
Project Management and Planning	■	■	■	■	■	■	■	■	■	■	■	■
Milestones: Successful completion of project												•
TASK I) Extraction and processing of Big Data	■	■	■	■	■	■	■					
Milestones: data gathering and digitizing	•	•										
Milestones: cleaning the data and labeling			•	•	•							
Milestones: Grouping the data						•	•					
TASK II) Design and training of Machine Learning algorithm								■	■	■	■	
Milestones: understanding Artificial Intelligence model								•	•			
Milestones: choose suitable algorithm based on the data types									•	•		
Milestones: tune the technical and economic model										•	•	
TASK III) Model Prediction and Verification											■	■
Milestones: Conclude the final model and predict the result											•	•
Milestones: Simultaneously update ML model along with refracking operations												•
Task IV- Report writing and deliverable preparation	■	■	■	■	■	■	■	■	■	■	■	■
Milestones: completion of report and submission						•						•

BUDGET

The general budget is summarized in the table below, with an expected total cost for the project being $90,909. The requested budget from the NDIC OGRC totaling $36,427 over one year period.

Year	NDIC Share	Applicant's Share (In-Kind)	Other Project Sponsor's Share	Project Total Expense
Total	$ 36,427	$ 15,481	$ 39,000	$ 90,909

Budget details: University will be paying for the tuition of the PhD for the whole year equivalent to $15,481.

Other personnel: One PhD student as Graduate Research Assistants (GRA) will be working full-time on this project for the period of a year. Based on the university rates, they will be paid $2,059 monthly for the whole year thus the amount will be $24,707 per GRA for the project life.

Materials and Supplies: We asked for $3,500 to purchase all available data on NDIC website. This number was given to us through the communication we had with NDIC.

Travel: We have allocated the budget for travel based on the state rates for the three years of the project duration. The allocated money will cover lodging, air fare and ground transportation to attend conferences and workshops.

Office supplies: The amount for office supply is decided based on the past experience from previous projects.

The following tables are budget details:

	YEAR 1 NDIC SHARE			YEAR 1 UND SHARE			Industry
EXPENSES, Personnel	**Salary**	**Benefit**	**Tuition**	**Salary**	**Benefit**	**Tuition**	**Sponsor's**
Mehdi Ostadhassan, PI							
Vamegh Rasouli, Key Personnel							
One PhD srudent	24,707					15,481	
NeuDax data analytics							39,000
Total Personnel	$ 24,707					$ 15,481	
EXPENSES, Nonpersonnel	**Expense**						
Supply/Materials-Professional	3,500						
Equipment							
Lab Fees							
UND Lab Facility							
Travel, Meetings, Conferences	1,000						
Office Supplies	500						
Total Nonpersonnel	$ 1,500						
Total Direct Expenses	$ 26,207						
F&A (39%)	$ 10,221						
TOTAL EXPENSES	$ 36,427						

CONFIDENTIAL INFORMATION

There is no confidential information provided in this proposal.

PATENTS/RIGHTS TO TECHNICAL DATA

Patent rights may be preserved relative to the model development.

STATUS OF ONGOING PROJECTS (IF ANY)

The PI does not have any current projects with the North Dakota Oil and Gas Research Program.

References:

[1] G. E. King and others, “Hydraulic fracturing 101: what every representative, environmentalist, regulator, reporter, investor, university researcher, neighbor, and engineer should know about hydraulic fracturing risk,” *Journal of Petroleum Technology*, vol. 64, no. 04, pp. 34–42, 2012.

[2] T. Jacobs and others, “Changing the equation: refracturing shale oil wells,” *Journal of Petroleum Technology*, vol. 67, no. 04, pp. 44–49, 2015.

[3] N. P. Roussel, M. M. Sharma, and others, “Selecting candidate wells for refracturing using production data,” *SPE Production & Operations*, vol. 28, no. 01, pp. 36–45, 2013.

[4] A. Shadravan, M. Tarrahi, M. Amani, and others, “Intelligent Tool To Design Drilling, Spacer, Cement Slurry, and Fracturing Fluids by Use of Machine-Learning Algorithms,” *SPE Drilling & Completion*, 2017.

[5] S. J. Russell, P. Norvig, J. F. Canny, J. M. Malik, and D. D. Edwards, *Artificial intelligence: a modern approach*, vol. 2. Prentice hall Upper Saddle River, 2003.

[6] O. J. Isebor and O. Grujic, “Use of Machine Learning in Petroleum Production Optimization under Geological Uncertainty,” 2012.

[7] O. Bello, J. Holzmann, T. Yaqoob, and C. Teodoriu, “Application of artificial intelligence methods in drilling system design and operations: a review of the state of the art,” *Journal of Artificial Intelligence and Soft Computing Research*, vol. 5, no. 2, pp. 121–139, 2015.

[8] C. M. Cheung, P. Goyal, A. S. Tehrani, V. K. Prasanna, and others, “Deep Learning for Steam Job Candidate Selection,” in *SPE Annual Technical Conference and Exhibition*, 2017.

[9] Z. Zhao, L. Gross, and others, “Using supervised machine learning to distinguish microseismic from noise events,” in *2017 SEG International Exposition and Annual Meeting*, 2017.

[10] T. Hoeink, C. Zambrano, and others, “Shale Discrimination with Machine Learning Methods,” in *51st US Rock Mechanics/Geomechanics Symposium*, 2017.

[11] D. S. Fulford, B. Bowie, M. E. Berry, B. Bowen, D. W. Turk, and others, “Machine learning as a reliable technology for evaluating time/rate performance of unconventional wells,” *SPE Economics & Management*, vol. 8, no. 01, pp. 23–39, 2016.

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5/2/2018
Dear Dr. Ostadhassan,

Re: **Artificial Intelligence and Machine Learning for Optimizing Well Selection for Re-Fracking, Case Study: State of North Dakota**

It's my pleasure to inform you that NeuDax would be willing to support your proposal that is going to be submitted to the NDIC, OG Research Fund, through sharing the NeuDax AI platform, called FracDax ($15,000) as one standalone license, along with consulting from our team of petroleum engineers and AI experts ($24,000) for one year (10 hours a month) with a total in-kind support of $39,000.

NeuDax team and our proprietary AI based platform FracDax is the leading Big Data solution in the oil and gas industry. Our purpose is to help upstream decision-makers to take advantage of Artificial Intelligence and Big Data to plan for their future field developments. We strongly believe our collaboration will bring a new insight to the significant amount of data that is available at your disposal and can benefit the state as well as the companies that are operating in North Dakota.

Looking forward to our collaboration.

Regards,

Naser Tamimi, Ph.D.
Director of Business Development,
NeuDax

Naser Tamimi

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Professional Preparation:

Institute	*Major*	*Degree*	*Year*
Petroleum University of Technology, Iran	Petroleum Engineering	B.S.	2005
Petroleum University of Technology, Iran	Petroleum Engineering	M.S.	2007
IFP-School (ENSPM), France	Petroleum Geophysics	M.S.	2008
University of North Dakota, US	Petroleum Engineering	Ph.D.	2013

Appointments:

Institute	*Position*	*Duration*
University of North Dakota, Grand Forks, USA	Assistant Prof., Pet. Eng. Department	2013-Present
Energy & Environment Research Center, Grand Forks, USA	Research Scientist	2012-2013
University of North Dakota,	Graduate Research Assistant	2009-2013
Schlumberger DCS, Denver, Co	Geophysics intern/co-op	Summer 2011
Atlantic Int. Operation Ltd, Dubai, UAE	Project Manager	2008-2009
CGGVeritas , Massy, France	Geophysics Intern	Winter 2008
Khak Azma Geotechique. Lab, Tehran, Iran	Lab Assistant	2005-2006
National Iranian South Oil Company, Ahwaz, Iran	Petroleum Engineering Intern	Summer 2003
National Iranian Oil Company, Exploration Directorate, Tehran, Iran	Geophysics Intern	Summer 2004

Book and Book Chapter:

- **Ostadhassan, M**., Khatibi, S., Kouqi, L. and Li, C., (2017), Fine scale characterization of shale reservoirs, Springer International Publishing (In Press).
- **Ostadhassan, M**. (2016). Geomechanics and Elastic Anisotropy of Shale Formations, In: *New Frontiers in Oil and Gas Exploration* (pp. 165-207): Springer International Publishing.

Selected Publications:

1. Kovaleva, Y., **Ostadhassan, M.,** Tamimi, N., & Kovaleva, A., (Under review), A Preliminary Optimization of Borehole Microseismic Array Design with a Multiple Criteria Decision Analysis, Journal of Applied Geophysics.
2. Semnani, A., **Ostadhassan, M.,** Nadjar Araabi, B & Nabi Bidhendi, M., (Under review), Time-frequency decomposition of seismic signals via quantum swarm evolutionary matching pursuit, Geophysical Prospecting.
3. Rafieepour, S., Zamiran, S., & **Ostadhassan, M.,** (Under review), A cost effective chemo-thermo-poroelastic wellbore stability model for mud weight design during drilling through shale formations, Journal of Geophysics and Engineering.

4. Peiqiang, Z., Jianchao, C., Zhenhua, H, **Ostadhassan, M.** & Fuqiang, R., (Under review), Estimating permeability of shale gas reservoirs from porosity and rock compositions, Journal of Geophysics.
5. Liu, K., **Ostadhassan, M.,** Zou, J., Gentzis, T., Rezaee, R., Bubach, B., Carvajal-Ortiz, H. & Zhao, P., (Under review), Nanopore structures of isolated kerogen and bulk shale in Bakken Formation, Fuel.
6. Khatibi, A., **Ostadhassan, M.,** Tuschel, D., Gentzis, T., Carvajal-Ortiz, H., Bubach, B. & Aghajanpour, A., (Under review), Investigating Molecular Evolution of Bakken Kerogen by Raman and FT-IR spectroscopies and S/TEM Imaging: Correlation with Optical Microscopy and Rock-Eval Pyrolysis, Fuel.
7. Liu, K., **Ostadhassan, M.,** Zou, J., Gentzis, T., Rezaee, R., Bubach, B. & Carvajal-Ortiz, H., (In press), Multifractal analysis of gas adsorption isotherms for pore structure characterization of the Bakken Shale, Fuel.
8. Abarghani, A., **Ostadhassan, M.,** Gentzis, T., Carvajal-Ortiz, H., & 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*.
9. Kong, L., **Ostadhassan, M.**, Li, C., & Tamimi, N. (2018). Pore characterization of 3D-printed gypsum rocks: a comprehensive approach. *Journal of Materials Science*, *53*(7), 5063-5078.5063-5078.
10. Kong, L., **Ostadhassan, M.,** Li, C. and Tamimi, N., (In Press), Do 3-D Printed Rocks Replicate Natural Rocks? An Experimental Study, Rock Mechanics and Rock Engineering.
11. Khatibi, S., Aghajanpour, A., **Ostadhassan, M.,** & Farzay, O. (2018). Evaluating Single-Parameter parabolic failure criterion in wellbore stability analysis. *Journal of Natural Gas Science and Engineering*, *50*, 166-180.
12. Li, C., **Ostadhassan, M.;** Kong, L., Liu, K., and Bubach, B (under review), An Improved Insight to Elastic Modulus of Organic-rich Shales, Geophysics.
13. Li, C., **Ostadhassan, M.;** Gentzis, T., Carvajal-Ortiz, H., Kong, L., and Bubach, B (In Press), In-situ Nanomechanical Characterization of Organic Matter in the Bakken Shale, Williston Basin, North Dakota, Journal of Marine and Petroleum Geology.
14. Khatibi, S., **Ostadhassan, M.,** Tuschel, D., Gentzis, T., Bubach, B., & Carvajal-Ortiz, H. (2018). Raman spectroscopy to study thermal maturity and elastic modulus of kerogen. *International Journal of Coal Geology*, *185*, 103-118.
15. Liu, K., **Ostadhassan, M.,** Bubach, B., Dietrich, R., & Rasouli, V. (2018). Nano-dynamic mechanical analysis (nano-DMA) of creep behavior of shales: Bakken case study. *Journal of Materials Science*, *53*(6), 4417-4432.
16. Anderson, J., Rice, J., Said, A., Mehrer, C., **Ostadhassan, M.,** & Alexeyev, A. (2017, November). Comprehensive Study of the Charlson Oil Field, Williston Basin, ND. In SPE Annual Caspian Technical Conference and Exhibition. Society of Petroleum Engineers.
17. Liu, K., **Ostadhassan, M.**, Zhou, J., Gentzis, T., & Rezaee, R. (2017). Nanoscale pore structure characterization of the Bakken shale in the USA. Fuel, 209, 567-578.
18. Jabbari, H., Afsari, K., Rabiei, M., Monk, A., & **Ostadhassan, M.** (2017). Thermally-induced wettability alteration from hot-water imbibition in naturally fractured reservoirs—Part 2: 2D models, sensitivity study & heavy oil. Fuel, 208, 692-700.
19. Liu, K., **Ostadhassan, M.**, Gentzis, T., Carvajal-Ortiz, H., & Bubach, B. (2017). Characterization of geochemical properties and microstructures of the Bakken Shale in North Dakota. International Journal of Coal Geology.
20. Liu, K., & **Ostadhassan, M.** (2017). Microstructural and geomechanical analysis of Bakken shale at nanoscale. Journal of Petroleum Science and Engineering, 153, 133-144.
21. Liu, K., & **Ostadhassan, M.** (2017). Multi-scale fractal analysis of pores in shale rocks. Journal of Applied Geophysics, 140, 1-10.
22. Liu, K., & **Ostadhassan, M.** (2017). Quantification of the microstructures of Bakken shale reservoirs using multi-fractal and lacunarity analysis. Journal of Natural Gas Science and Engineering, 39, 62-71.
23. Kong, L., **Ostadhassan, M.**, Li., C., & Tamimi, N. (2017, August 28). Rock Physics and Geomechanics of 3-D Printed Rocks. American Rock Mechanics Association
24. Kovaleva, Y., **Ostadhassan, M.**, & Tamimi, N. (2017). Optimizing microseismic design using multiple criteria decision analysis SEG Technical Program Expanded Abstracts 2017 (pp. 2741-2745): Society of Exploration Geophysicists.
25. Li, C., **Ostadhassan**, M., & Kong, L. (2017). Nanochemo-mechanical characterization of organic shale through AFM and EDS SEG Technical Program Expanded Abstracts 2017 (pp. 3837-3840): Society of Exploration Geophysicists.
26. Liu, K., **Ostadhassan, M.**, Gentzis, T., Carvajal-Ortiz, H., & Bubach, B. (2017). Microstructures and

Geochemical Characteristics of Bakken Shale Formations. Paper presented at the Unconventional Resources Technology Conference, Austin, Texas, 24-26 July 2017.

27. Liu, K., **Ostadhassan, M.**, & Kong, L. (2017). Pore Structure Heterogeneity in Middle Bakken Formation. Paper presented at the 51st US Rock Mechanics/Geomechanics Symposium.
28. Liu, K., **Ostadhassan, M.**, & Li, C. (2017). Quantifying the nano-mechanical signature of shale oil formations by nanoindentation. Paper presented at the Unconventional Resources Technology Conference, Austin, Texas, 24-26 July 2017.
29. Liu, K., **Ostadhassan, M.**, Li, C., Alexeyev, A., & Hou, X. (2017). Fracture Toughness Measurement of Shales Using Nano-Indentation: The Bakken Case Study. Paper presented at the 51st US Rock Mechanics/Geomechanics Symposium.
30. Liu, K., & **Ostadhassan, M.** (2017). Characterize the pore microstructures of shale formation by using AFM. Paper presented at the International Geophysical Conference, Qingdao, China, 17-20 April 2017.
31. 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.* Paper presented at the SPE Western Regional Meeting.
32. Liu, K., & **Ostadhassan, M**. (2017). Microstructural and geomechanical analysis of Bakken shale at nanoscale. *Journal of Petroleum Science and Engineering, 153*, 133-144.
33. Liu, K., & **Ostadhassan, M**. (2017). Multi-scale fractal analysis of pores in shale rocks. *Journal of Applied Geophysics, 140*, 1-10.
34. Liu, K., & **Ostadhassan, M**. (2017). *Quantification of the Microstructure Heterogeneities of Bakken Shale Reservoirs from Multi-Fractal Analysis.* Paper presented at the SPE Oklahoma City Oil and Gas Symposium.
35. Liu, K., & **Ostadhassan, M**. (2017). Quantification of the microstructures of Bakken shale reservoirs using multi-fractal and lacunarity analysis. *Journal of Natural Gas Science and Engineering, 39*, 62-71.
36. Liu, K., & **Ostadhassan, M**. (2017). *Characterize the pore microstructures of shale formation by using AFM.* Paper presented at the International Geophysical Conference, Qingdao, China, 17-20 April 2017.
37. Liu, K., **Ostadhassan, M.**, & Bubach, B. (2016). Applications of nano-indentation methods to estimate nanoscale mechanical properties of shale reservoir rocks. Journal of Natural Gas Science and Engineering, 35, 1310-1319.
38. Alexeyev, A., & **Ostadhassan, M**. (2016). *Petrophysical analysis and lithology identification of a Middle Bakken member in the Blue Buttes Field, Williston Basin, North Dakota.* Paper presented at the AGU fall meeting.
39. Liu, K., & **Ostadhassan, M**. (2016). *Characterization and Quantification of the Pore Structures of the Shale Oil Reservoir Formations in Multiscale.* Paper presented at the AGU fall meeting.
40. Liu, K., **Ostadhassan, M**., & Bubach, B. (2016). Applications of nano-indentation methods to estimate nanoscale mechanical properties of shale reservoir rocks. *Journal of Natural Gas Science and Engineering, 35*, 1310-1319.
41. Liu, K., **Ostadhassan, M**., & Bubach, B. (2016). *Pore Structure Analysis by Using Atomic Force Microscopy.* Paper presented at the Unconventional Resources Technology Conference, San Antonio, Texas, 1-3 August 2016.
42. Liu, K., **Ostadhassan, M**., & Xu, X. (2016). *Multiscale characterization of pore structures of shale: quantification from SEM image analysis.* Paper presented at the 2016 Workshop: Rock Physics and Borehole Geophysics, Beijing, China, 28-30 August 2016.
43. Liu, K., **Ostadhassan, M**., Jabbari, H., & Bubach, B. (2016). *Potential Application of Atomic Force Microscopy in Characterization of Nano-pore Structures of Bakken Formation.* Paper presented at the SPE Low Perm Symposium.
44. **Ostadhassan, M**., Jabbari, H., Zamiran, S., Osouli, A., Bubach, B., & Oster, B. (2015). *Probabilistic Time-Dependent Thermo-chemo-poroelastic Borehole Stability Analysis in Shale Formations.* Paper presented at the 49th US Rock Mechanics/Geomechanics Symposium.
45. Zamiran, S., Salam, S., Osouli, A., & **Ostadhassan, M**. (2015). *Underground Disposal of Fine Coal Waste.* Paper presented at the 49th US Rock Mechanics/Geomechanics Symposium.
46. Zhang, X., & **Ostadhassan, M**. (2015). *Multipathing Via Three Parameter Common Image Gathers (CIGs) From Reverse Time Migration.* Paper presented at the AGU Fall Meeting.
47. Jabbari, H., **Ostadhassan, M**., & Rabeie, M. (2015). *Geomechanics Modeling in CO2-EOR: Case Study*. Paper presented at the SPE/CSUR Unconventional Resources Conference.

48. Jabbari, H., **Ostadhassan, M**., & Salehi, S. (2015). *Geomecanical Modeling in CO 2 Enhanced Oil Recovery.* Paper presented at the 49th US Rock Mechanics/Geomechanics Symposium.
49. Le, T., & **Ostadhassan, M**. (2015). *A Multidisciplinary Study of Stimulation Designs in the Three Forks Formation, ND.* Paper presented at the Unconventional Resources Technology Conference, San Antonio, Texas, 20-22 July 2015.
50. **Ostadhassan, M**., Bubach, B., & Oster, B. S. (2015). *Rock Physics Modeling of Salt Plugged Carbonate Reservoir Rocks—Winnipegosis Formation, North Dakota.* Paper presented at the AAPG Annual Convention and Exhibition.
51. Oster, B. S., & **Ostadhassan, M**. (2015). *Reservoir Characterization of a Carbonate Reservoir in the Williston Basin, North Dakota-Winnipegosis Formation.* Paper presented at the AAPG Annual Convention and Exhibition.
52. Zamiran, S., Salam, S., Osouli, A., & **Ostadhassan, M**. (2015). *Underground Disposal of Fine Coal Waste.* Paper presented at the 49th US Rock Mechanics/Geomechanics Symposium.
53. Jabbari, H., **Ostadhassan, M**., Khavanin, M., Lentz, N., & Johnson, S. (2014). *Uncertainty Assessment of Stimulation Design—Bakken Case Study.* Paper presented at the SPE Eastern Regional Meeting.
54. **Ostadhassan, M**. (2013). *Geomechanics and elastic anisotropy of the Bakken Formation, Williston Basin.* The University of North Dakota.
55. **Ostadhassan, M**., Jabbari, H., Zamiran, S., Osouli, A., Oster, B., & Lentz, N. (2014). *Wellbore Instability of Inclined Wells in Highly Layered Rocks—Bakken Case Study.* Paper presented at the SPE Eastern Regional Meeting.
56. **Ostadhassan, M**., & Tamimi, N. (2014). *Mechanical Behavior of Salt Rock at Elevated Temperature.* Paper presented at the 48th US Rock Mechanics/Geomechanics Symposium.
57. **Ostadhassan, M**., Zamiran, S., Jabbari, H., Osouli, A., Bubach, B., & Oster, B. (2015). *Stability Analysis of Multilateral High Density Pad Wells in the Three Forks Formation.* Paper presented at the SPE Western Regional Meeting.
58. Zamiran, S., Osouli, A., & **Ostadhassan, M**. (2014). *Geomechanical modeling of inclined wellbore in anisotropic shale layers of Bakken formation.* Paper presented at the 48th US Rock Mechanics/Geomechanics Symposium.
59. Jabbari, H., Zeng, Z., & **Ostadhassan, M**. (2011). *Impact of In-Situ Stress Change on Fracture Conductivity in Naturally Fractured Reservoirs: Bakken Case Study.* Paper presented at the 45th US Rock Mechanics/Geomechanics Symposium.
60. Jabbari, H., Zeng, Z., & **Ostadhassan, M**. (2011). *Incorporating Geomechanics into the Decline-Curve Analysis of Naturally Fractured Reservoirs.* Paper presented at the SPE Annual Technical Conference and Exhibition.
61. **Ostadhassan, M**., Benson, S., Zamiran, S., & Bubach, B. (2013). *Stress analysis and wellbore stability in unconventional reservoirs.* Paper presented at the 47th US Rock Mechanics/Geomechanics Symposium.
62. **Ostadhassan, M**., Zeng, Z., & Jabbari, H. (2011). *Using Advanced Acoustic Data to Determine Stress State Around Wellbore.* Paper presented at the 45th US Rock Mechanics/Geomechanics Symposium.
63. **Ostadhassan, M**., Zeng, Z., & Jabbari, H. (2012). *Anisotropy Analysis in Shale Using Advanced Sonic Data-Bakken Case Study.* Paper presented at the AAPG Annual Convention and Exhibition, USA.
64. **Ostadhassan, M**., Zeng, Z., & Zamiran, S. (2012). *Geomechanical modeling of an anisotropic formation-Bakken case study.* Paper presented at the 46th US Rock Mechanics/Geomechanics Symposium.
65. Kong, L., Xu, Z., **Ostadhassan, M**., & Li, C. *Geomorphology Classification and Architecture Characterization of Braided River Reservoir: A Case Study From Guantao Upper Formation of Gudong Oilfield, Bohai Bay Basin, China.* Paper presented at the AAPG Annual Convention and Exhibition.

Synergistic Activities and Awards:

- Graduate Program Director of the Petroleum Engineering Department (2015- current)
- Reviewer of Marine and Petroleum Geology Journal and Natural Gas Science and Engineering
- UND Reservoir Dogs team Director (www.undreservoirdogs.com)
- University of North Dakota Senator (2016-2018)

- The iPELAB, the remotely accessed petroleum engineering laboratories: UND OID, FIDC Grant, Summer Instructional Development Professorships (2016).
- Can Flipping the Well Logging Course Increase the Students Data Integration and Interpretation Skills? UND OID, summer mini project (2016).
- Reviewer for Elsevier Journal of Natural Gas Science and Engineering and Marine Petroleum Geology.
- Student Education Program (SEP) Scholarship (ExxonMobil Scholarship award - 2012)
- Student Leadership Symposium (SLS) Scholarship (Chevron Scholarship award - 2011)
- Iranian Ministry of Petroleum BS degree full scholarship award
- Iranian Ministry of Petroleum MS degree full scholarship award
- Faculty Adviser to the Society of Exploration Geophysicist (SEG) and Society of Petroleum Engineering (SPE) (2013- current)

Grants and Funding:

Title	Year	To	Role	Amount
Molecular mechanics of organic matter vs. thermal maturity	2018	USGS and UND	PI	$70,000/year
A Path to a Quantitative Clinical Method for Early Diagnosis of Breast Cancer Based on Cell Mechanics	2018	Research ND/Essentia Health/Lillestol Research	PI	$340,000
Mechanobiology of cancerous cells	2018	UND	PI	$28,000
Developing PE Lab I and II for Open Educational Resources	2017	UND CILT	PI	$6,000
A Comprehensive Study of UCG Viability and Field Monitoring Techniques for North Dakota Lignite	2017	UND LRC	PI	$665,708
Interplay between kerogen's chemistry, morphology and mechanical properties	2017	SSAC	PI	$4,500
iPELAB: A Technology-Based Teaching and Learning Approach for Petroleum Engineering Teaching Labs	2016	AAF foundation	PI	$10,000
Innovative Approach in Organic Rich Shale Characterization	2016	Research ND	PI	$640,000
A new framework for localizing temporal perturbation in complex media via passive image interferometry	2016	NASA EPSCOR	PI	$38,000
Agricultural Geophysics: The Key to More Efficient Farming	2016	Research ND	PI	$ 649,036
Atomic Force Microscopy- A Novel Technique for Fracture Characterization in Shale Oils	2016	SCR	PI	$4,000
Senior Undergraduates can Find the Key towards a Better Hydraulic Fracturing Job	2016	New Faculty Scholar Award	PI	$4,000

VAMEGH RASOULI Curriculum Vitae

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vrasouli@yahoo.com
Phone: 001-701-335-3601

EDUCATION

2002- PhD, Imperial College, University of London.
1997- MSc, Engineering Rock Mechanics, Tehran Polytechnic University, Iran.
1995- BSc, Mining Engineering, Yazd University, Iran.

EXPERIENCE

23 Mar 2015-Now	Department Chair, Continental Resources Distinguished Prof, Department of Petroleum Eng, University of North Dakota
Aug 2012-Now	Instructor for Schlumberger's network of excellence training (NExT) program presenting industry short courses in drilling, Geomechanics, pore pressure, hydraulic Fracturing, Sand Control.
Nov 2014-30 Jan 15	Professor of Petroleum Engineering Department, Curtin University
Jan 2013-Nov 2014	Prof & Head, Department of Petroleum Engineering, Curtin University
Jan 2012-Dec 2012	Acting Head and Associate Professor, Department of Petroleum Engineering, Curtin University

Aug 2006-Dec 2011 **CURTIN UNIVERSITY**

- Senior lecturer (till July 2010) Associate Professor (till Dec 2013), Prof (since Dec 2013) in the Department of Petroleum Engineering. Teaching undergraduate and postgraduate units including **Drilling Engineering, Advance Drilling Engineering and Petroleum Geomechanics**. Teaching **stimulation & Intervention** and **Production Eng** courses to other Universities.

Research and sponsored projects:

- Simulation of Hydraulic Fracturing and Re-frac Operations to Enhance Oil Production from Bakken and Three Forks Formations. Research ND Grant 2017 (PI, $600,000 over 3 years).
- An Integrated Software Package for Data Processing, Modeling and Simulation of Unconventional Reservoirs. Venture Grant, Research ND 2017 (Co-PI, $100,000 over one year).
- Field Demonstration of the Krauklis Seismi Wave. DE-FE0028659, 2016 (PI $167,000 over 3 years).
- Postdoctoral Research Fellow Grant, VP Res. & Econ. Dev., UND. 2016 (pi $40,000 over one year).

- National Geosequestration Labs (NGL): design and manufacture of a large scale true triaxial stress cell to study Geomechanical aspects of CO2 sequestration. $3.3M.
- Deep Exploration Technology Cooperative Research centre (DET CRC) of Australia: Next Generation Drilling Technologies. $300k pa.
- Australian Research Council linkage research project (ARC LP). Upscaling laws for hydraulic fracturing of tight reservoirs based on reproducible true tri-axial laboratory testing. ($507,000) (2012-2013). $100k of industry support.

- MERIWA Grant for 3 Years (2011-2013): $619,000.
  Rasouli & M.R. Rezaee. A study of shale gas Geomechanics in the Perth basins.
- ANLEC R&D Alternatives and Fundamentals program Grant for 3 Years (2011-2013): $653,000
  B. Evans, V. Rasouli, M. Lebedev, K. Liu, A. Saeedi. Predicting CO2 injectivity properties for application at CCS sites.
- WAERA Grant for 18 months on Tight Gas research project (completed 2011): ($70,000 for Geomechanics & $70,000 for well construction studies)
- Iranian Ministry of road Grant for one year (2003): $50,000.
  Preparing the geotechnical services manual for railway and highway tunnel design in Iran.
- University Grant for one Year (2003): $5,000
  Programming and developing a graphical computer interface to analyse roughness of discontinuous surfaces

Industry projects completed:

- 2014: Curtin Lead, consulting project, "Review and Study the Proposed Hydraulic Fractured Well for shale gas production from Canning Basin". An independent review project funded by Buru Energy, Australia. Part of a team of 4 reviewers. ($32,000).
- 2012: Estimation of state of in-situ stresses in an injection site in Australia ($25,000).
- 2011: Mud weight Design and wellbore stability analysis for Mountain Bridge Well. Norwest Energy Australia ($30,000).
- 2011: Mud weight Design, wellbore stability analysis and hydraulic fracturing studies of Arrowsmith 2 Shale Gas Well. Norwest Energy Australia ($40,000).
- 2010: Rock Mechanical Modelling and Wellbore Stability Study for Well Mondarra 1. APA Australia. ($20,000)
- 2010: Rock Mechanical Modelling and Hydraulic Fracturing Study of Well Corybas-01 in Elegans Area. AWE Australia. ($40,000)
- 2009: Geomechanical Study of Mondarra Field, Australia. Phase-1: Data review. APA Australia. ($15000)
- 2009: Rock Mechanical Modelling and Hydraulic Fracturing Studies for Woodada-5 & 6 Wells. AWE Australia. ($40000).

- 2009: Wellbore stability study and Mechanical Earth Modelling of Blacktip Field, PNG.- Consulting project to Schlumberger Australia ($55000)
- 2009: Wellbore stability study and Mechanical Earth Modelling of Blacktip filed, ENI Australia- Consulting project to Schlumberger Australia ($30000)
- 2009: Reservoir Geomechanics Study of Enfield field, Woodside Petroleum. Consulting project, Schlumberger Australia ($12000)
- 2006: Wellbore stability study in Anaran field - Consulting project through Schlumberger Iran for Norsk-Hydro ($70,000)
- 2006: Wellbore stability study in Mehr field - Consulting project through Schlumberger Iran for OMV ($70,000)

Professional Services:

- 2006-2010: Vamegh coordinated an international dual degree Master of Petroleum Eng program for 4 years in the past with Iran. That was acknowledged as a very successful program which produced 100 graduates in total.
- 2007: Established Curtin Petroleum Geomechanics Group (CPGG)
- 2007-2009: Developed and designed a unique True Triaxial Stress Cell (TTSC) for advanced Petroleum Geomechanics lab experiments.
- 2012: Developed a drilling lab for simulations of ultra-high speed drilling for applications in mineral explorations.
- 2012: Led a project to develop a large scale flow loop for simulations of cuttings transport inside the pipe and annulus space.
- 2013: Led a project to develop a bending machine lab equipment for simulations of fatigue and bending of coil tubing composite material.
- 2004-2006 and 2008-2010: Consulting Services to Schlumberger, a leader oil and gas service Company.
- 2009- Now: Carried out several short term research projects for interstate Companies to assist them with their field operations.

PhD student supervision:

- Prediction of borehole enlargement and correlation between breakout width and depth (Completed in Jan 2010)
- Numerical simulations of fluid flow through a single rough walled fracture (Completed March 2011)
- Experimental and PFC2D Numerical Study of Progressive Shear Behaviour of Single Rough Rock Fractures (Complete May 2011)
- Experimental and Numerical Study of Interaction of a Pre-Existing Natural Interface and an Induced Hydraulic Fracture (Completed 2012)
- Modelling sand production using laboratory experiment and numerical simulation (Completed 2012)

- Elasto/Visco-plastic Finite Element Simulations of Injection and Depletion in Porous Reservoirs (Completed 2013)
- Designing a downhole motor for drilling hard rocks using Coiled Tubing (Completed 2013)
- Drilling response of impregnated diamond bits: Modelling and experimental investigations (Completed Aug 2014)
- Studying the mechanical properties of shale under different saturations and stress conditions (Completed Dec 2014)
- Cutting transport modelling in Coiled Tubing drilling for mineral exploration applications (Completed Jan 2015)
- Selection of best material for coil tube drilling in hard rocks.

Undergraduate & Master students teaching and supervision:

- Vamegh's official evaluation for his teaching undergraduate and postgraduate students, which is carried out by University, indicates a satisfaction of above %90 on average. This is well above the average in University
- Supervised more than 30 Master projects and theses

July 2008-July 2010
- Consulting Geomechanics Engineer to Schlumberger, Data and Consulting Services (DCS) in Perth. Carrying out different drilling and reservoir Geomechanics related projects.
- Drilling direction optimisation and borehole stability for Woodside, 4 studied wells
- Borehole stability for ENI Australia
- Drilling optimisation for 6 wells in PNG

July 2010- Now
- Consulting Geomechanics Engineer through Curtin University conducting various Geomechanics related projects including Hydraulic fracturing studies

Feb 2003-Aug 2006 **AMIRKABIR UNIVERSITY, IRAN**

Assistant Professor, Dep. of Petroleum Engineering.
Teaching '**Advanced Rock Mechanics', 'drilling engineering', 'Petroleum Geomechanics', 'advanced underground excavation design', 'Geotechnics' and 'Geostatistics'** to both postgraduate and undergraduate students.

July 2004-Dec 2005 Deputy Education coordinator in Petroleum Engineering Department, Amirkabir University. Primary coordinator of the BSc program in Petroleum Engineering and responsible for ongoing relationships with the university over changing educational requirements.

Jan 2006-Aug 2006 Deputy research coordinator in Petroleum Engineering, Amirkabir University. Coordinating industrial research activities and joint educational and research programs with overseas universities.
Supervision of BSc projects, and, MSc / PhD theses

Industrial short courses I have taught

2011- Now
- Instructor for Schlumberger's NExT Training program. Delivering various Geomechanics related industry short courses

2002- 2005 -Rock mechanics in-situ tests: theory, application and data interpretation, Sabir Geotechnical Consulting company
-Taught geostatistics and CSMINE software for the mining industry, Rasht, Iran
-Taught underground mining methods to the mining industry, Ardabil, Iran
-Taught mining sampling to the mining industry, Qom, Iran

University research projects completed

Oct 2003- Oct 2004 'Preparing the geotechnical services manual for railway and highway tunnel design in Iran'.

Oct 2003- Oct 2004 University research grant: 'Programming and developing a graphical computer interface to analyse roughness of discontinuous surfaces'.

Consulting projects completed

2002-2004
- Economical evaluation of 11 mineral deposits in Iran. Software was developed to perform calculation of different economics to produce cash flow table
- Consulting Engineer to Bakhtiari Dam. Analysing the data obtained from in-situ test equipment (dilatometer, flatjack, plate load, shear).
- Consulting engineer to Gole-Gohar Iron ore mine, Sirjan, Iran. Feasibility study of replacing the old trucks and shovels with new systems. Studying the origin of water entering the pit.

Nov 2004- Aug 2006 **WELL SERVICES OF IRAN (SCHLUMBERGER METHOD)**
- Geomechanics consulting engineer. Geomechanics related applications in drilling and reservoir engineering (Wellbore instability, sand production prediction, pore pressure analyses, drilling practices and similar applications).
- Trained in petrophysics, log and image interpretations.
- Familiar with various software developed in drilling.

Projects carried out for the industry:
- Pore pressure estimation, wellbore stability analysis and drilling recommendations in Anaran field, Iran for Norsk Hydro: By using sensitivity analysis of deviation and azimuth, the safe and stable mud weight window determined for optimum drilling in planned trajectory (Carbonate Reservoir).
- Constructing the mechanical earth model, sensitivity analysis and drilling recommendations in Mehr Block, Iran for OMV: The most stable azimuth for drilling was determined using the mud weight window (Carbonate Reservoir).
- Geomechanics and wellbore stability analysis, South Pars Oil Layer (SPOL), Iran. The earth model constructed for three offset wells and the results used for the prediction of stable mud weight window for a deviated sidetrack planned to be drilled (Carbonate Reservoir).

- Studying the causes of Casing Collapse in wells drilled in oilfields located in the southern part of Iran.

Presentations given to industrial clients:
- Introduction to geomechanics
- Introduction to petroleum geomechanics
- Wellbore stability analysis
- Sanding prediction analysis
- Application of sonic logs in geomechanics and WBS analysis
- Prediction of stable and safe mud weight window in drilling deviated and horizontal wells

Jan 1999-Aug 2002 **IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY**
PhD research in the area of fractured rock mass characterisation.
Awarded full PhD scholarship for obtaining first prize in annual Iranian PhD examinations.

-Paper review for the International Journal of Rock Mechanics and Mining Sciences.

1996-1998 **IRAN INTERNATIONAL ENGINEERING COMPANY (IRITEC), MINING ENGINEER**
Data analyst; responsible for the control of quality and quantity of products from most of the company's mining complexes in Iran. This included both site surveys and office works.

1995-1997 **Consulting projects carried out:**
-Consulting Engineer to underground Shemshak Phosphate Mine, Iran.
-Technical and economic evaluation of Tabas coal mine, Parvadeh 1, 2 and 3, Iran.
-Feasibility study of Daralou Copper ore mine, Kerman, Iran.

1995-1997 **POST-GRADUATE STUDENT, TEHRAN POLYTECHNIC UNIVERSITY**
Awarded MSc in Rock Mechanics (First prize).

1991-1995 **UNDER-GRADUATE STUDENT, YAZD UNIVERSITY**
Awarded BSc in Mining Engineering (First prize).

COMPUTER KNOWLEDGE

-Skilled in various Petroleum Geomechanics and drilling software
-Familiar with *Phases, Examine, Plaxis, Clara, Geoslope Office* and other rock mechanics, drilling and geotechnical software.
-Skilled with geostatistical software (*GS, Gslib, Geoeas*).
-Skilled with ANSYS
-Skilled with *Fortran* programming language
-Good knowledge *of Microsoft Office, Corel Draw, Surfer* etc.

AFFILIATIONS

- Member of Engineers Australia and a Chartered Professional Status holder (CPEng)
- Registered engineer with the National Professional Engineers Register (NPER) of Australia
- Member of editorial board, Journal of Petroleum Engineering & Technology.
- Member of editorial board, Journal of Petroleum & Environmental Biotechnology.
- Interview panel member for Engineering Australia Charter Professional Engineers (CPEng)
- Member of SPE.
- Member of the ISRM.
- Was a member of directory board of the Iranian Society for Rock
- Mechanics.
- Was a member of research centre for oil, gas and petrochemistry,
- Amirkabir University of Technology and Iranian Mining Engineering Society.

AWARDS

- First prize in PhD entrance examination in mining, held in Iran.
- Awarded a full scholarship from Iranian government to carry out PhD.
- Awarded second rank in MSc entrance examination in mining, held in Iran.
- Awarded first prize among MSc students in Rock Mechanics.
- Awarded first prize among BSc students in Mining.

PUBLICATIONS

2017

- Fallahzadeh, S. H., Hossain, M. M., Cornwell, A. J., and **Rasouli, V.**, 2017. Near Wellbore Hydraulic Fracture Propagation from Perforations in Tight Rocks: The Roles of Fracturing Fluid Viscosity and Injection Rate. Energies.
- Dewhurst, D., Minaeian, V., and **Rasouli, V.**, 2017. Deformational behaviour of a clay-rich shale with variable water saturation under true triaxial stress conditions. Geomechanics for Energy and the Environment.
- Moradi, A., Tokhmechi, B., **Rasouli, V.,** and Fatehi M., 2017. comprehensive numerical study of hydraulic fracturing process and its affecting parameters. Geotechnical and Geological Engineering.

2016

- Mokhtari, M., Wood, D., Ghanizadeh, S., Kulkarni P., **Rasouli, V.,** Fathi, E., Saidian, M., and Barati, R., 2016. Virtual special issue: Advances in the petrophysical and geomechanical characterization of organic-rich shales. Journal of Natural Gas Science and Engineering. p.p. 1-4.
- Gholami, R., Rasouli, V., Sarmadivaleh, M., Minaeian, V., and Fakhari, N., 2016. Brittleness of gas shale reservoirs: a case study from the North Perth basin, Australia. **Journal of Natural Gas Science and Engineering.** 33 (2016) 1244-1259.
- Hu., P., Li., C., Elsworth, D., Xu, X., and Rasouli, V., 2016. Stress- and Adsorption-Dependent Permeability of Fractured Sorbing Media. **Journal of Natural gas science and engineering**.
- Minaeian, V., Dewhurst, D., and Rasouli, V., 2016. Triaxial and True Triaxial Testing of Preserved and Partially Saturated Shale. The 5th Fifth EAGE Shale Workshop Quantifying Risk and Potential.

2015

Book Chapter

- Rasouli, V., 2015. Book Chapter: Chapter 8: Geomechanics of Gas Shales. Fundamentals of Gas Shale Reservoirs. John Wiley & Spons. Inc. 2015. p. 169-190.
http://www.amazon.com/Fundamentals-Shale-Reservoirs-Reza-Rezaee/dp/1118645790.

Papers

- Kamyab M., and Rasouli, V., 2015. Experimental and Numerical Simulation of Cuttings Transportation in Coiled Tubing Drilling. Journal of Natural Gas Science and Engineering.
- Gholami, R., and Rasouli, V., 2015. Geomechanical and numerical studies of casing damages in a reservoir with solid production. **Journal of Rock Mechanics Rock Engineering.**
- Gholami, R., Rabiei, M., Rasouli, V., Aadnoy, B., and Fakhari, N., 2015. Application of quantitative risk assessment in wellbore stability analysis. **Journal of Petroleum Science and Engineering**. Accepted for publication.
- Sarmadivaleh, M., and Rasouli, V., 2015. Test Design and Sample Preparation Procedure for Experimental Investigation of Hydraulic Fracturing Interaction Modes. **Journal of Rock Mechanics Rock Engineering**. Vol. 48 Issue 1, p93, 13 p.
- Gholami, R., Rasouli, V., Aadnoy, B., and Mohammadi. R., 2015. Application of in-situ stress estimation methods in wellbore stability analysis under isotropic and anisotropic conditions, **Journal of Geophysics and Engineering**. Accepted for publication.
- Mishani, S., Evans, B., Rasouli, V., Rofail, R., Soe, S., and Jaensch, P., 2015. Interlaminar modelling to predict composite coiled tube failure. **APPEA Journal**.
- Raza, A., Rezaee, R., Gholami, R., Rasouli, V., Han Bing, Ch., Nagarajan, R., abd Ali H., 2015. Injectivity and quantification of capillary trapping for CO2 storage: A review of influencing parameters. **Journal of Natural gas science and engineering**. Accepted for publication.
- Fallahzadeh S.H., Cornwell, A., Rasouli, V., & Hossain, M., 2015. The Impacts of Fracturing Fluid Viscosity and Injection Rate on the Near Wellbore Hydraulic Fracture Propagation in Cased Perforated Wellbores. ARMA. The 49th US Rock Mechanics/Geomechanics Symposium. San Francisco, California, USA on 28 June-1 July 2015.

2014

-Fallahzadeh, S.H., Rasouli, V., and Sarmadivaleh, M., 2014. An Investigation of Hydraulic Fracturing Initiation and Near-Wellbore Propagation from Perforated Boreholes in Tight Formations. Rock Mech Rock Eng
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-Hamzehpour, H., Rasouli, V. and Alizadeh, N. 2008. A study on the scale effect and anisotropy on reservoir porosity and permeability. Amirkabir Journal of Science and Technology. Vol 70, 2008.
-Eskandari, S., Madani, H., Rasouli V. and Tokhmechi B. 2008. Risk determination and reserve estimation using fractal simulation, 26th Symposium on Geosciences, Geological Survey of Iran.
-Eskandari, S., and Rasouli V. 2008. Determining optimum position of drilling development boreholes in anomaly No. 3 Gole-Gohar iron ore mine, Iran using fractal simulator. Iranian Mining Engineering Magazine (paper submitted).
-Eskandari, S., and Rasouli V. 2008. Reserve estimation in anomaly No. 3 Gole-Gohar iron ore mine, Iran using fractal simulator. Tehran Science & Technology University Journal (paper submitted).
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-Askari, R., Rasouli V., Tokhmechi, B. and Rezaei, B. 2005. Comparison between Kriging and random midpoint displacement in surface morphology simulation. 23rd Symposium on Geosciences, Geological survey of Iran.
-Rafiei, Mehrabadi A., Soltani, S., Rasouli V., Tokhmechi, B., Mirabedini, H. and Avini, A. 2004. Numerical modeling of cost efficiency in mineral processing and flotation plants using combined method. 1st Mineral Processing Conferences, Tehran, Iran.

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EXPERIENCE

2014 – Present: Geophysicist and Data Scientist, Microseismic and Borehole Imaging Group, Sigma Cubed Inc. (SIGMA^3), Englewood, CO.
Duties: Seismic and Well Data QC, Seismic Data Processing, Tomography Analysis, Seismic and Well Data Clustering, Machine Learning for Automatic FB Picking, Signal Enhancement, Velocity Analysis and Inversion.

2017 – Present: Data Analyst and Director of Business Development, NeuDax, Denver, CO.
Duties: Public O&G Data Mining, Developing Models for Well Production Forecast, Optimizing Hydraulic Fracturing through Data Analysis, Back-end Programming for NeuDax AI Platform and etc.

2013 –2014: Geophysical Consultant, Microseismic and Borehole Imaging Group, Sigma Cubed Inc. (SIGMA^3), Englewood, CO.

2010: Intern, Energy and Production Technology (EPT) Group, BP America, Houston, TX.

2004: Intern, Petroleum Geosciences Group, National Iranian Oil Company, Ahwaz, Iran.

2003: Intern, Engineering Department, Abadan Oil Refining Company, Abadan, Iran.

EDUCATION

Ph.D. in Geophysics, Department of Geophysics, Colorado School of Mines, USA. Minor Degree in Petroleum Engineering.

M.Sc. in Petroleum Geosciences (Geophysics Major), IFP School, Rueil Malmaison, France.

M.Sc. in Petroleum Exploration Engineering, Petroleum University of Technology, Tehran, Iran.

B.S. in Petroleum Exploration Engineering, Petroleum University of Technology, Ahwaz, Iran.

HIGHLIGHTED SKILLS

Seismic Acquisition and Design:
OMNI 3D

Seismic and Signal Processing:
ProMax, SeisSpace and SU

Seismic Interpretation:
Seisworks 3D, Kingdom and HampsonRussel

Reservoir Modeling:
Petrel

Seismic Modeling:
Madagascar FD Elastic Modeling

Programming:
MATLAB, Python and JAVA

Data Science and Machine Learning:
Pandas, SciKit Learn, SQL and R

Time-Series Machine Learning
Deep Learning

PUBLICATIONS

Y. Kovaleva, N. Tamimi, M. Ostadhassan, Optimizing microseismic design using multiple criteria decision analysis, 87th SEG Annual Meeting, Houston, TX, 2017.
N. Tamimi, J. McGuire, R. R. Van Dok, S. Dande, Deriving anisotropic velocity models using borehole microseismic events with unknown locations, 86th SEG Annual Meeting, Dallas, TX, 2016.

R. R. Van Dok, N. Tamimi, B. N. Fuller, K. D. Mahrer, Do you truly know your geophone's orientation and should you care?, 86th SEG Annual Meeting, Dallas, TX, 2016.

T. Li, S. Mallick, N. Tamimi, T. L. Davis, Inversion of wide-azimuth multicomponent vertical seismic profile data for anisotropic subsurface properties, 86th SEG Annual Meeting, Dallas, TX, 2016.

N. Tamimi, Modifying Moveout-Based Anisotropic Spreading Correction for Borehole Seismic Data, 2015 American Geophysical Union (AGU) Annual Meeting, San Francisco, CA, 2015.

N. Tamimi, I. Tsvankin and T.L. Davis, Estimation of VTI parameters using slowness-polarization inversion of P- and SV-waves, Journal of Seismic Exploration, Vol. 24, no. 5, 2015.

N. Tamimi, Correlation between Electrical Resistivity and Anisotropic Elastic Properties of Pierre Shale, Wattenburg Field, Colorado, 2015 The Geological Society of America (GSA) Annual Meeting, Baltimore, MD, 2015.

N. Tamimi and T.L. Davis, Using P- and SV-wave VSP data δ for estimating local seismic anisotropy parameters, and η, in VTI media with lateral heterogeneity in the overburden, 84th SEG Annual Meeting, Denver, CO, 2014.

M. Ostadhassan, N. Tamimi, Mechanical Behavior of Salt Rock at Elevated Temperature, 48th US Rock Mechanics/Geomechanics Symposium, 2014.

N. Tamimi and T. L. Davis, Imaging the Morrow A Sandstone Using Shear Wave VSP Data, Postle Field, Oklahoma, International Journal of Geophysics, 2012.

N. Tamimi and P. Singh, Analysis of different well log and seismic data for estimating shear wave polarization direction, 82nd SEG Annual Meeting, Las Vegas, NV, 2012.

N. Tamimi, I. Abdolahie Fard and S. Sherkati, The effects of structural components on seismic wave velocity in incompetent units, case study: Gachsaran Formation (SW Iran), 79th SEG Annual Meeting, Houston, TX, 2009.

N. Tamimi, M. Ostadhassan, An integrated procedure for velocity analysis by using sedimentological and rock physics data in complex structures of incompetent and plastic formations, SEG Summer Research Workshop, Galway, Ireland, 2008.

N. Tamimi, I. Abdolahie Fard, S. Sherkati, M. R. Sokooti, Development of lithology- velocity model for estimating seismic velocity of incompetent Gachsaran Formation, case study: southern area of Dezful embayment, 13th Iranian Geophysics Conference, Tehran, Iran, 2008.

N. Tamimi, Design and Development of GEOMANCY, a Software for Processing, Editing and Displaying Electrical Borehole Image Logs (PART 1), Iranian Exploration and Production (Ekteshaf-Tolid) Magazine, in Persian, Vol. 32 pp. 40-42. (IN FARSI)

N. Tamimi, Design and Development of GEOMANCY, a Software for Processing, Editing and Displaying Electrical Borehole Image Logs (PART 2), Iranian Exploration and Production (Ekteshaf-Tolid) Magazine, in Persian, Vol. 33 pp. 36-39. (IN FARSI)

PROFESSIONAL WORKSHOPS AND LECTURES

2017: Introduction to Data Science, Neudax Education, Denver, Colorado
2015: Presented workshop at University of North Dakota about Seismic Anisotropy.
2015: Presented technical lecture at GE (General Electrics) Oil and Gas and Global Research about 9C Borehole Seismic Technology and Its Applications.

SCHOLARSHIPS AND AWARDS

2018 Recipient of Google Developer Challenge Scholarship

Full scholarship from National Iranian Oil Company during MSc degree at Petroleum University of Technology and IFP School at France.

Full scholarship from National Iranian Oil Company during BS degree at Petroleum University of Technology and IFP School at France.

PEER REVIEW

Technical Program Session Chair for VSP Case Histories session at the SEG 87th Annual Meeting, 2017
Reviewer for NEAR SURFACE GEOPHYICS journal.
Technical Program Session Chair for the SEG 86th Annual Meeting, 2016
Reviewer for JOURNAL OF NATURAL GAS SCIENCE & ENGINEERING.
Reviewer for FIRST BREAK.
Reviewer for GEOPHYSICS Journal (a Society of Exploration Geophysicists journal).

CERTIFICATES

2017: Certificates from Vertabelo for SQL Basics and Operating on Data in SQL
2017: Certificate from Michigan University for Data Science in Python
2017: Certificate from Michigan University for Using Database in Python
2017: Certificate from Michigan University for Using Python for Access Web Data
2017: Certificate from Michigan University for Python Data Structure
2015: Statement of completion from Stanford University for Reservoir Geomechanics.
2015: Certificate of completion from John Hopkins University for The Data Scientist's Toolbox.
2015: Certificate of completion from John Hopkins University for R Programming.
2006: Certificate of completion from CGGVeritas Company for Land Seismic Acquisition & Data Processing with Geocluster.

PROFESSIONAL ACTIVITIES

2017: Member of SEG Big Data Analytics Subcommittee
2017: Co-founder of Neudax Data Analytics