

Technical Reviewers' Rating Summary

Proposal Number **G-31-04** Application Title **Williston Basin Advanced** Submitted By
University of North Dakota Request For **\$1,250,000.00** Total Project Costs
\$2,500,000.00

Section A. Scoring

Statement	Weighting Factor	G-31-04A	G-31-04B	G-31-04C	Average Weighted Score
1. Objectives	9	4	4	3	27
2. Achievability	7	4	4	2	21
3. Methodology	8	4	4	3	24
4. Contribution	8	4	3	3	24
5. Awareness / Background	5	2	3	2	10
6. Project Management	3	5	3	3	9
7. Equipment / Facilities	2	5	3	4	8
8. Value / Industry - Budget	4	4	3	4	12
9. Financial Match - Budget	4	4	4	2	12
Average Weighted Score		195	178	140	171

Total: 50

250 possible points

OVERALL RECOMMENDATION

FUND	X	X	
FUNDING TO BE CONSIDERED			X
DO NOT FUND			

Section B. Ratings and Comments

- The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Oil and Gas Research Council goals are:

No comment

- Reviewer: G-31-04A

- Rating: 4

No comment

- Reviewer: G-31-04B
- Rating: 4

I believe the objectives and goals are consistent with NDIC/OGRC goals but the objective and goals statements are not consistently stated and therefore are a bit unclear. For example, under the heading Abstract, stated objectives are to use equipment to analyze cores and samples and tie them to well logs and high resolution photos, and the goal is stated to be to obtain high quality analytical data linked with photos and make the data available on the NDGS website; essentially the same thing. Under the Project Description heading Objectives, the “primary goal” become improve the understanding of the petrophysical properties of oil bearing formations using advanced methods; and five “specific objectives” are actually a list of tasks and are later acknowledged as such (but reworded) as tasks 1 through 5 under the Task Summary Structure.

- Reviewer: G-31-04C
- Rating: 3

The goal of the proposed project is to collect a uniform set of petrophysical data on the Bakken, Pronghorn Member, and the Three Forks Formation using a suite of instrumentation. There are numerous old datasets in existence, but they are variable in the instrumentation that was used and the formations that were evaluated. This project will produce a complete, uniform dataset through the current formations of interest on recently cored wells.

- Applicant

2. With the approach suggested and time and budget available, the objectives are:

No comment

- Reviewer: G-31-04A
- Rating: 4

No comment

- Reviewer: G-31-04B
- Rating: 4

Without out knowing the total number of cores and cuttings to be analyzed, the sampling interval for each type of analysis to be undertaken, the number of students involved, the type and scope of each student project, it is not possible to say if it is achievable. If only one core and set of well cuttings are examined thoroughly in the detail implied it is achievable within the time frame proposed. If the intent is to characterize the both Formations regionally and to delineate all of the proposed petrophysical traits stated in sufficient detail to detect localized variability of reservoirs, the time frame is likely too short to accomplish this objective. This is a very labor intensive project and many of the analytical techniques are time consuming and expensive. Again it gets back to sampling intensity, number of laborers, and the amount of time each will dedicate to accomplishing their tasks.

- Reviewer: G-31-04C
- Rating: 2

Student involvement is a key part of the proposed work. 4-6+ students (graduate and undergraduate) will be working on the project each year. The students will be actively working on the sample analysis and data reduction throughout the project. The graduate students will have a more rigorous level of project involvement and this project is anticipated to be the subject of multiple thesis projects. In addition, the students will be the main researchers under the Task 5 projects. These projects will be identified through the project sponsors as the proposed work and datasets emerge. These projects will likely involve 1-2 students and will involve deeper investigations into smaller datasets or additional areas. The scope for each project will be developed as the ideas and needs of industry are identified. It is anticipated that there will be approximately 10 Task 5 projects over the 5 year project period. The proposed project will analyze 15-30 cores/well cuttings as identified from the project sponsors. The variable number is due to the length of the cores. If a lot of shorter cores are analyzed, the number of cores that can be analyzed will be higher than if all long cores are analyzed. The PIs agree with the Reviewer C that this will be a very labor intensive project and utilizes expensive equipment. UND feels that the number of cores/well cuttings proposed and associated budget allow a sizable dataset to be collected in a timely duration. Table 1 displays the proposed sampling frequency for the different instrumentation in the proposed work. The frequency as stated by the reviewers determines the time and cost. Most techniques are proposed to be done on every 6-12 inches on the core samples. Shorter sampling intervals may be required for selected regions depending on the properties of the core. For the cuttings, the samples would be collected on each collected bag of cuttings, which is typically every 30 to 90 feet. Table 1. Proposed Sampling Frequency for Each Analysis Technique

Analysis Technique	Sample Type	Frequency
X-Ray Fluorescence (XRF)	Core or Cuttings	6 inches
Nuclear Magnetic Resonance (NMR)	Core or Cuttings	12 inches
Gamma Ray Logger	Core	Continuous
Vitrinite Reflectance	Core or Cuttings	12 inches
X-Ray Diffraction (XRD)	Core or Cuttings	6 inches
Scanning Electron Microscopy (SEM)	Plugs or Cuttings	12 inches
Triaxial Apparatus	Plugs	When available
Computed Tomography (CT) Scanner	Core	Continuous over interest intervals

- Applicant

3. The quality of the methodology displayed in the proposal is:

No comment

- Reviewer: G-31-04A

- Rating: 4

No comment

- Reviewer: G-31-04B

- Rating: 4

The types of tools proposed to be used are clearly above average but to evaluate the quality of the methodology one needs to know the sampling protocol to be used with each piece of equipment, specifically the distribution and number of samples. For example, sample size, frequency of sampling, and distribution of sample selection for information to be gained from SEM and back scattered XRD is substantially different than that for gamma ray spectral analysis. And, if sample frequency, size, and distribution are not tailored to each piece of

equipment the results will be less useful. The proposal did not indicate the use of statistics neither for proper sampling, nor for evaluating the quality of the results. This is necessary to address the issue of how many micrometer scale samples are required to characterize a 20 meter thick shale. The fluid injection method should also be applied to capture capillary pressure parameters as well as the proposed NMR. NMR may provide a good proxy for permeability properties, but injection, recovery of fluid volumes and pressure curves measured on core samples provides a more direct measure of reservoir rock performance than does remote sensing and modeling. It would also be good to determine the binding relationship between oil and water to various formation lithologies and specific minerals to address issues of product move-ability. The value of added by high resolution images beyond the value of current images is unclear. If their primary use is to “estimate” porosity, other, more accurate, measurements of porosity are being captured with the other tools proposed. The porosity in the shale is nanometer scale and the photo will not sufficiently resolve that, thus use of the SEM. The dark black Bakken shale members have little to show except for a few pyritized grains, and any features present are poorly resolved from blackness of the shale. The quality of the images currently being taken are of sufficient resolution to see most, if not all visible characteristics. The middle Bakken and Three Forks are more amenable to photographic characterization. More supporting documentation is needed to justify the benefits (additional information gained) of using this labor intensive technique over the current technique.

- Reviewer: G-31-04C

- Rating: 3

The number of sampling frequency was identified in Table 1. If 15 cores of 200ft were analyzed at 6 inch intervals, a total of 6000 samples will be collected for each analysis technique. It is anticipated that some of the cores will be up to 400ft in length, especially the cores with complete Bakken, Pronghorn, and Three Forks sections. The sampling frequency, size, and distribution will be tailored to each piece of equipment in order to provide the best data quality from each piece of equipment. The equipment purchased/to be purchased has been specifically target to maximize data quality from cores/cuttings. Some of the equipment being utilized as part of the project can operate in an automated mode allowing for the characterization of numerous samples. Statistics play a key role in core/cuttings analysis and there is much research to still be done in that area. How many 50 X 50 μm SEM samples does it take to characterize a thin section? This is the type of project that the PIs anticipate could be done under the Task 5 area of the project. UND agrees that fluid injection would be another excellent parameter to look at, however does not have the equipment at this time. The use of the high resolution images is of no cost to the proposed project. A set of high resolution images is currently being collected under a separately funded project. If a core selected for this study has corresponding high resolution images, the images will be correlated to the generated dataset. This provides an additional layer of data that can be used for current and future evaluations.

- Applicant

4. The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Oil and Gas Research Council goals will likely be:

No comment

- Reviewer: G-31-04A

- Rating: 4

No comment

- Reviewer: G-31-04B

- Rating: 3

From a geologic perspective, the data will be significant depending on the number, distribution, and appropriate frequency of sampling; “all areas of the basin” is rather vague. From an exploitation perspective, proper technique specific sampling has the potential to be very significant for engineering hydraulic fracturing procedures. From an exploration perspective, the data has the potential to be significant for some small and medium size companies but most of them do not have the mineral lease holdings or the computer analysis resources to utilize it. The larger companies with established lease positions might be able to use some of it to high grade drilling locations, but most of them will acquire their own data for their localized areas as needed if they do not already have it. From an education perspective, one must ask how many companies now have research laboratories doing this type of analysis? How many are currently in, or likely to be created and established in North Dakota? Much of this type and that of the geologists will be done back at their home offices and research labs. The proposal only mentioned one student project and never suggested how many students would be involved in the project.

- Reviewer: G-31-04C

- Rating: 3

UND feels that the 15-30 core/cuttings dataset combined with proper sampling techniques and statistical analyses will be a significant benefit to companies active in the Williston Basin. To the knowledge of the proposers, no labs exist in ND with the full set of analytical techniques that will be performed in proposed work. It is anticipated that few companies will open up large laboratories in the state due to instrument cost and the need for qualified people to run the equipment.

- Applicant

5. The background of the principal investigator and the awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is:

The principle investigators do not currently have an established record of research with regard to the Bakken Source System. Nevertheless significant advances often only occur when fresh ideas are brought to bear.

- Reviewer: G-31-04A

- Rating: 2

No comment

- Reviewer: G-31-04B

- Rating: 3

It is a bit disconcerting that none of the publication citations of the PI's or managers indicated work with petroleum well cores or cuttings. Most of their citations relate to work with coal and coal gasification issues. Further emphasis of their coal research background was illustrated in the management structure diagram (Figure 1) Task 3 inclusion of "Coal properties". This would probably not contribute much to the proposed objective. Dr. Lentz did not cite any publications for evaluation. The "project team" will presumably be doing the sample analysis but few of the people doing the actual sample analysis were named so the credentials for those performing the work are unknown. Little, if any, reference to work done to characterize the geology of the Bakken and Three Forks Formations or the petrophysical characteristics already known such as vitrinite reflectance, porosity, and mineralogy, hydrocarbon saturation, etc., prior to 2001 was provided. A great deal of information of this nature already exists for the Bakken but to a lesser degree for the Three Forks. Much of that work was high quality and very usable even if not as regionally distributed as that proposed.

- Reviewer: G-31-04C

- Rating: 2

Dr. Lentz has a Ph.D. in Analytical Chemistry and has over 10 years of instrumental analysis and has performed sample analysis on a wide range of samples and instrumentation. Dr. Lentz just joined the Petroleum Engineering Department in Jan. of 2012, and has been aggressively performing oil and gas related research for last year. Dr. Lentz has attended an AAPG basic well log analysis training course and has taught the well logging class at UND. In addition, he has recently completed field work utilizing XRF instrumentation. The PIs are aware of the existing datasets and will refer back to the datasets as an additional QA/QC to the proposed dataset when similar data exists. The PIs feel that much of the old data, while very sound and complete, is not regionally distributed as indicated by Reviewer C. The proposed work will also be a complete dataset that incorporates new instrumentation that did not exist when the previous datasets were collected. The existing data will also have a complete dataset on numerous core samples that were not available when the previous USGS data were collected.

- Applicant

6. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is:

No comment

- Reviewer: G-31-04A

- Rating: 5

It would be nice to see results sooner than 5 years.

- Reviewer: G-31-04B

- Rating: 3

The management structure plan Figure 1 becomes vague below the PI level but this might be expected considering this proposal is to establish a consortium and many of the workers have yet to commit or are unknown at this stage (students). The accuracy of Table 3,

Milestones and Completion Dates, is questionable given the number of sample to be taken is unknown. The plan for communications is thorough. Based on the dollars committed at the time of this review, sponsor contributions were about 73% of the matching funds required to meet the 50% stipulated by the NDIC/OGRC. The amount of time PI's and management are dedicating to this project relative to their other responsibilities is not stated. Additionally, a reasonable estimate of team member hours needs to be stated before an acceptable time budget can be assumed.

- Reviewer: G-31-04C

- Rating: 3

Project updates, data, and results will be presented by the PIs and students at each of the biannual meetings. This will facilitate communication between the project sponsors and UND and also be a key way to identify new projects for the Task 5 area. UND feels that frequent dissemination of the results is key to make sure the project is moving forward in an appropriate manner and to identify any new areas that should be examined as the results are being generated. The project has now secured the required 50% cost share. The PIs and management are dedicating a significant portion of their time to the project. The coordination between the different types of instrumental calibrations, sample preparation, analysis, data reduction, and subsequent analysis are already factored into the budget. Faculty within the Petroleum Engineering Department have a 45% research requirement in their job description.

- Applicant

7. The proposed purchase of equipment and the facilities available is:

The facilities currently available are or will be state of the art. Since there is no need for additional equipment within this proposal the use of existing equipment can only be viewed as a significant plus.

- Reviewer: G-31-04A

- Rating: 5

No comment

- Reviewer: G-31-04B

- Rating: 3

No new equipment purchases were requested. Presuming all of the "pending equipment" purchases are secured, the equipment and facilities are very appropriate for this project.

- Reviewer: G-31-04C

- Rating: 4

UND would like to thank the reviewers for their equipment comments. The current and pending equipment will lead to a state-of-the-art laboratory that can do research equivalent to the leading petroleum engineering programs in the world.

- Applicant

8. The proposed budget "value" relative to the outlined work and the commitment from other sources is of:

No comment

- Reviewer: G-31-04A
- Rating: 4

No comment

- Reviewer: G-31-04B
- Rating: 3

The notably good assessment assumes proper geographic, and core and cutting sampling protocols, and proper performance of those protocols. Given the cost of analysis by so many cutting edge methods the value of the data base will be 1) exceptionally valuable to the geologic understanding of two Formations; and has some potential to be 2) exceptionally good for hydraulic fracture design for the Bakken pool Fms., and is 3) potentially adequate for future exploration of the Bakken pool.

- Reviewer: G-31-04C
- Rating: 4

UND agrees with Reviewer C and feels that this is a very high-value project that will produce a dataset that can be used for future geologic and hydraulic fracturing designs as well as future exploration.

- Applicant

9. The “financial commitment”² from other sources in terms of “match funding” have been identified:

No comment

- Reviewer: G-31-04A
- Rating: 4

No comment

- Reviewer: G-31-04B
- Rating: 4

The number of industry sponsors is small and the commitment from each is rather small according to the numbers indicated in the supporting letters; \$75K/yr. The Alumni Foundation made a nice offer but it wasn't clear if that was an annual amount for 5 years. Together all annual commitments (assuming the Alumni contribution is annual) are only 73% of the NDIC's total annual contribution, 27% less than the minimum.

- Reviewer: G-31-04C
- Rating: 2

UND has now secured the required 50% cost share from industry sponsors. The Alumni contribution is an annual amount.

- Applicant

1 “value” – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar. A commitment of support from industry partners equates to a higher value.

2 “financial commitment” from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Support less than 50% from Industrial Commission sources should be evaluated as favorable to the application; industry partnerships equates to increased favorability.

General Comments

No comment

- Reviewer: G-31-04A

I believe the project has merit. I would like to see results and little quicker than 5 years and I would hope some intermediate progress reports would be generated from time to time. You might consider seeing if select operators in the basin would be willing to run a wireline spectral gamma ray in a vertical pilot hole to provide more data points for the project.

- Reviewer: G-31-04B

The general concept of the proposal is sound; that is, to utilize a suite of new approaches and tools on the new, larger number and wider distribution of samples from the horizontal Bakken play to increase our geologic and petrophysical knowledge of Bakken pool Formations on a regional scale. Medium and smaller sized oil companies generally do not have the resources to compile such a data set but their resources to use it is another question. Such a data set will increase geologic understanding of these Formations and has the potential to help development of the Bakken pool, but to a lesser degree, exploration. The proposal lacked specificity in many areas particularly about sampling and student participation (only one student was mentioned in Table 3). The number of samples, cores and cuttings, and their geographic distribution is known, as are the thickness of various facies and lithologies. A reasonable idea of the number of samples required to characterize the formations should be attainable. The accountability for accomplishing the wide array of analysis was diffuse except for "coordinating" activities. The “project team” will presumably be doing the sample analysis but few of the people doing the actual sample analysis were named so the credentials for those performing the work are unknown. It would be helpful to provide information about the existing Bakken data base (which is extensive including at least two thorough, lengthy USGS publications) to show sponsors what new information would be added, and so that one can evaluate the additional value of the new measurements. Without knowing this, one can only begin to speculate as to the return on investment one can expect from the project. Measurements of many of the properties they propose to acquire have been made (although not on the regional scale proposed because the sample base did not exist), and the proposal demonstrates little awareness of these. The regional scale provided by all of the new cores and cuttings available will be valuable to understanding the geology of these two Formations and potentially useful to exploitation but less so to exploration. The implication that more oil reserve estimates will be increased by studying the Three Forks Formation is unlikely because the oil produced from the Three Forks Fm. is Bakken oil. The Three Forks only serves as a reservoir for Bakken oil in localized areas. A statistical analysis of the results is appropriate for data gathered from each piece of equipment to evaluate the statistical significance and level of confidence of each data set. This analysis must be done with consideration of the sample size relative to the thickness and homogeneity of each formation and facies for meaningful use of the results. This type of information is fundamental before one can have much confidence in the numbers that are to be used for computer modeling.

- Reviewer: G-31-04C

