

## PET E 365 Well Logging and Formation Evaluation

Winter 2025 - January 06 to April 09

Class time: Tuesday, Thursday 11:00-12:20      Location: GSB 2-11

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### Instructor:

Hassan Dehghanpour, PhD, P.Eng  
(780) 492 8504  
dehghanp@ualberta.ca  
6-279  
Office Hours: Wednesday 1-3 pm

### Course Description:

\*3.5 (fi) (either term, 3-1S-0) Theory and engineering applications of measurements of physical properties of the formation near the well bore; interpretation and use of the information in reservoir engineering.

**Prerequisites:** PET E 275

**Course synchronous and asynchronous content delivery schedule:**

### Land Acknowledgment:

The University of Alberta respectfully acknowledges that we are situated on Treaty 6 territory, traditional lands of First Nations and Métis people.

### TA Information:

Saman Mohammadi, smohamm2@ualberta.ca

### Seminar Sections:

Section	Day	Time	Location
SEM J21	Tuesday	13:00 - 13:50	NRE 2-020

### Course Objectives & General Content:

This is an undergraduate-level course on formation evaluation techniques by using open-hole logging. This course will discuss the basic physical phenomena and logging tools used for measuring important formation properties such as porosity and hydrocarbon saturation.

Here are the specific objectives:

- Recognize different logs and their curves
- Understand the basic principles of log interpretation
- Use quick look techniques to

- Evaluate log quality
- Identify reservoirs
- Calculate hydrocarbon content

**Learning Outcomes:**

By the end of this course, students should be able to:

1. Determine wellbore parameters such as size, temperature and electrical resistivity by using caliper and temperature logs and the information provided on log header.
2. Identify permeable/non-permeable zones using Spontaneous Potential (SP) and/or Gama Ray (GR) logs
3. Evaluate shale content (i.e. volume fraction) of reservoir rocks using SP and/or GR logs
4. Determine type of lithology using cross-plots of neutron porosity, density porosity, and photoelectric factor.
5. Determine reservoir rock porosity using sonic, density and neutron log data
6. Identify presence of natural gas in the reservoir using neutron/density log cross-plots
7. Determine formation water saturation (Sw) using resistivity log data, available petrophysical data, and formation water resistivity from SP log.
8. Identify potential hydrocarbon producing zones using quick-look techniques and porosity/resistivity cross plots (i.e. Picket Cross-plot, Hingle cross-plot)
9. Estimate original and recoverable hydrocarbon volume by combined analysis of open-hole logs.
10. Design diagnostic and predictive tools to characterize unconventional formations using laboratory and log data.
11. Design the optimum perforation intervals for hydrocarbon production, considering economical production rate, water cut, and environmental impacts such as hydrocarbon leakage.
12. Be able to interpret conventional open hole well logs to identify potential hydrocarbon zones, their porosity, water/hydrocarbon saturation and production potential

**Marking Scheme:**

Activity	(A)Synchronous	Due/Scheduled	Weight
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The Faculty recommended grade point average for a 300 level course is 3.0. Instructors have the leeway to deviate from this average and can assign grades based on their own scheme. All grades are approved by the department chair (or delegate). The office of the Dean has final oversight on all grades.

**Term Work**

All term work solutions will be posted no later than the last day of classes. All term work will be returned to students by the final day of classes, with the exception of major term work due in the last week of classes. The latter will be returned by the day of the final examination or the last day of the examination period if there is no final examination in the course as per university policy; instructors will make accommodations to

return these term work. It is the responsibility of the student to pick up all their term work at the specified time and place. Any unreturned term work, shall be retained and then shredded six months after the deadline for reappraisal and grade appeals. Final examinations will be kept for one year as required by university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

### **Calculator Policy**

There is no calculator policy in this course; students are free to use the calculator they wish for all assessments.

### **Text and References (Mandatory):**

"Theory, Measurement, and Interpretation of Well Logs," Bassiouni, Z., SPE Textbook Series, 1994.

### **Text and References (Recommended):**

To read on-line or download Schlumberger books visit: <https://www.slb.com/resource-library>  
Click on Log Interpretation Principles /Application or Charts.

You will be asked to register in order to have access to premium content. After registering you will receive by e-mail a UserID and a password. After that you can log on and have access to books.

General well logging resources

<http://www.spwla.org>

A useful source glossary of well logging terms:

<http://www.spwla.org/resources/glossary>

Schlumberger interpretation charts (Online chart books)

[https://www.slb.com/resources/publications/books/log\\_charts.aspx](https://www.slb.com/resources/publications/books/log_charts.aspx)

### **Website:**

eClass

### **Previous Examples of Evaluative Materials:**

Previous midterm questions and problems will be uploaded on eClass.

*Did you know that the University of Alberta has various low-to-no-cost services to help students succeed? Visit <http://www.deanofstudents.ualberta.ca/> for information about the academic, wellness, and various other support services available to U of A students. It's never too early or too late to seek help!*

## University and faculty policies



### Respect and professionalism



The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards.

The faculty prepares students to uphold industry standards to become a Professional Engineer (P.Eng). Therefore, respect, professionalism, and accountability must be upheld within the Faculty of Engineering and the University of Alberta.

### Academic integrity and student conduct

The University of Alberta is committed to the highest standards of academic integrity and honesty, as well as maintaining a learning environment that fosters the safety, security, and the inherent dignity of each member of the community, ensuring students conduct themselves accordingly. Students are expected to be familiar with the standards of academic honesty and appropriate student conduct, and to uphold the policies of the University in this respect.

Students are particularly urged to familiarize themselves with the provisions of the [Student Academic Integrity Policy](#) and the [Student Conduct Policy](#), and avoid any behaviour that could

potentially result in suspicions of academic misconduct (e.g., cheating, plagiarism, misrepresentation of facts, participation in an offence) and non-academic misconduct (e.g., discrimination, harassment, physical assault). Academic and non-academic misconduct are taken very seriously and can result in suspension or expulsion from the University.

All students are expected to consult the [Academic Integrity website](#) for clarification on the various academic offences. All forms of academic dishonesty are unacceptable at the University. Unfamiliarity of the rules, procrastination or personal pressures are not acceptable excuses for committing an offence. Listen to your instructor, be a good person, ask for help when you need it, and do your own work – this will lead you toward a path to success. Any academic integrity concern in this course will be reported to the College of Natural and Applied Sciences. Suspected cases of non-academic misconduct will be reported to the Dean of Students. The College, the Faculty, and the Dean of Students are committed to student rights and responsibilities, and adhere to due process and administrative fairness, as outlined in the [Student Academic Integrity Policy](#) and the [Student Conduct Policy](#). Please refer to the policy websites for details on inappropriate behaviours and possible sanctions.

The College of Natural and Applied Sciences (CNAS) has created an [Academic Integrity for CNAS Students](#) eClass site. Students can self-enroll and review the various resources provided, including the importance of academic integrity, examples of academic misconduct & possible sanctions, and the academic misconduct & appeal process. Students can also complete assessments to test their knowledge and earn a completion certificate.

*"Integrity is doing the right thing, even when no one is watching."* – C.S. Lewis

The Faculty of Engineering expects an environment free of harassment, discrimination, and bullying. We encourage you to talk to the [Office of Safe Disclosure and Human Rights](#) about experiences, questions, or concerns. Additional resources and support for students are attached below.

Engineering students studying in the province of Alberta must also follow the [Code of Ethics](#) set by the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Course outline policies, course requirements, evaluation and grading information can be found in the [University Calendar](#).



## Safety during learning activities



In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control.

Anyone found to be unable to function safely in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the [Student Academic Integrity Policy](#) and [Student Conduct Policy](#). As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of unsafe work.

## Audio and video recording



Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan.

Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. Students must not bring any unauthorized electronic device into an examination room, including cell phones or other devices.



# Student services and support

## Health & Wellness Support

### Counselling and Clinical Services

Free, short-term, appointment-based counselling and psychiatric services. Also offers drop-in workshops. Book an initial consultation. Visit [uab.ca/CCS](http://uab.ca/CCS) to learn more.

### Wellness Supports Social Workers

Free one-on-one support for students in the areas of housing, finances, academics, personal wellness, life skill development, family dynamics, system navigation, and any area of life where there is a desire to invite change. Visit [uab.ca/wellness](http://uab.ca/wellness) to learn more.

### Sexual Assault Centre

Free, anonymous, and confidential drop-in counselling. Visit [uab.ca/UASAC](http://uab.ca/UASAC) to learn more.

### The Office of Safe Disclosure & Human Rights (OSDHR)

The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy. Visit [uab.ca/OSDHR](http://uab.ca/OSDHR) to learn more.

### HIAR (Helping Individuals at Risk)

If you're worried about someone, contact HIAR, who can help assess risk and connect individuals to support. Learn more at [uab.ca/HIAR](http://uab.ca/HIAR).

### Immediate External Supports

Health Link Alberta: 811  
Suicide Crisis Helpline: 988



## Academic support



### Academic Success Centre

Access to a variety of services to maximize your academic success. Learn more at [uab.ca/ASC](http://uab.ca/ASC).



### Accessibility Resources

Connects students with disabilities to accommodations. Learn more at [uab.ca/Access](http://uab.ca/Access) under accommodations + accessibility.



### Decima Robinson Support Centre

Academic support for 100- or 200-level introductory calculus, linear algebra and statistics courses. Visit [uab.ca/DSC](http://uab.ca/DSC) to learn more.



### Engineering Student Success Centre

The Faculty of Engineering provides drop-in tutoring for first-year courses. Visit [uab.ca/ESSC](http://uab.ca/ESSC) to learn more.



### Office of the Student Ombuds

Call for complex problems and conflict mediation. Learn more at [uab.ca/ombuds](http://uab.ca/ombuds).



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## Financial support



### **Student Service Centre**

For awards and other funding support. Learn more at [uab.ca/ask](https://uab.ca/ask).



### **Campus Food Bank**

The Campus Food Bank Society is an independent charity supporting University of Alberta students, faculty, staff, and alumni for up to five years. For additional information visit their website at [campusfoodbank.com](https://campusfoodbank.com).





# Well Logging and Formation Evaluation

**PET E 365**

**Instructor:  
Dr. Hassan Dehghanpour**

**Wint**

# HELLO!



Course Name

Well Logging and Formation Evaluation



Course Code

PET E 365



Instructor

Hassan Dehghanpour



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DICE 6-279



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492-8504



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Office Hours

Wednesday: 1 pm to 3 pm



Teaching Assistant

Nima Shojaei



E-mail

[nshojaei@ualberta.ca](mailto:nshojaei@ualberta.ca)

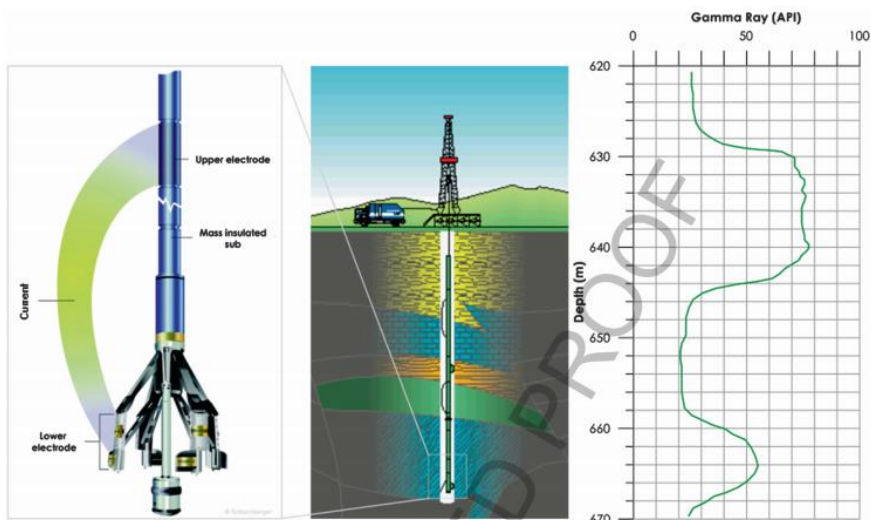


Office

NREF 7-134

# Catalog Description

Theory and engineering applications of formation physical properties measured near the wellbore.



DOI: [10.1007/978-3-642-34132-8\\_16](https://doi.org/10.1007/978-3-642-34132-8_16)

Interpretation and use of the measured parameters in reservoir engineering calculations.



[www.i2g.cloud](http://www.i2g.cloud)

# Course Description

This is an undergraduate-level course on formation evaluation techniques by using open-hole logging. This course will discuss the basic physical phenomena and logging tools used for measuring important formation properties such as porosity and hydrocarbon saturation. Several example logs will be illustrated and interpreted in class.



## Course Learning Outcomes

1. Determine wellbore parameters such as size, temperature and electrical resistivity by using caliper and temperature logs and the information provided on log header.
2. Identify permeable/non-permeable zones using Spontaneous Potential (SP) and/or Gamma Ray (GR) logs
3. Evaluate shale content (i.e. volume fraction) of reservoir rocks using SP and GR logs
4. Determine type of lithology using cross-plots of neutron porosity, density porosity, and photoelectric factor.
5. Determine reservoir rock porosity using sonic, density and neutron logs

## Course Learning Outcomes

6. Identify presence of natural gas in the reservoir using neutron/density cross-plots
7. Determine formation water saturation ( $S_w$ ) using resistivity log data, and petrophysical data, and formation water resistivity from SP log.
8. Identify potential hydrocarbon producing zones using quick-look techniques and porosity/resistivity cross plots (i.e. Picket Cross-plot, Hingle cross-plot)
9. Estimate original and recoverable hydrocarbon volume by combined analysis of open-hole logs.
10. Design diagnostic and predictive tools to characterize unconventional formations using laboratory and log data.

# Course Objectives and Expectations in Brief

At the end of  
this course,  
students will



be familiar with the physical principles used in open-hole well logging

be able to identify lithology, pay zones, and type of hydrocarbon in the producing formations by interpreting well logs

be able to identify and quantify important petrophysical properties of rock formations such as porosity and hydrocarbon saturation

be able to evaluate shaly and gas bearing formations



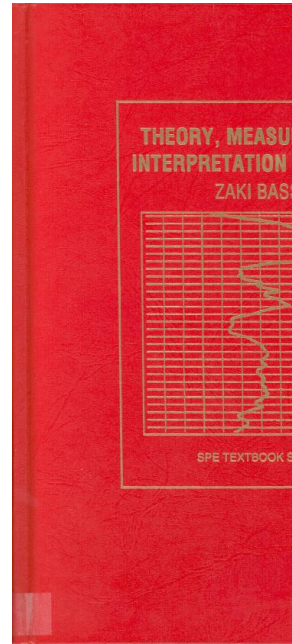
Reading Ma



## Textbook (Recommended)

**“Theory, Measurement, and Interpretation of Well Logs,”**

Bassiouni, Z., SPE Textbook Series, 1994.





## Additional Reference Books

- Schlumberger Log Interpretation - Principles and Application
- Schlumberger Log Interpretation - Charts
- Rider, M., 2004, The Geological Interpretation of Well Logs. Rider-French Consulting, Ltd.
- Western Atlas International, 1992, Introduction to Wireline Log Analysis.
- Ellis, D. V., 1987, Well Logging for Earth Scientists. Elsevier Science Publishing Company.
- Luthi, S. M., 2001, Geological Well Logs: Their use in reservoir modeling. Springer-Verlag.
- Hearst, J. R., and Nelson, P. H., and Paillet, F. L., 2000, Well Logging for Physical Properties.
- Handbook for geophysicists, geologists and engineers. John Wiley and Sons, Ltd.
- Dewan, J. T., 1983, Essentials of Modern Open-Hole Log Interpretation. PennWell Publishing Company.
- Pirson, S. J., 1983, Geologic Well Log Analysis. Gulf Publishing Company.
- Tittman, J., 1986, Geophysical Well Logging. Academic Press, Inc.

## Useful Links



- ✦ To read on-line or download Schlumberger books visit:

<https://www.slb.com/resource-library>

Click on Log Interpretation Principles /Application or Charts.

You will be asked to register in order to have access to premium content. After registering you will receive by e-mail a UserID and a password. After logging on you will have access to books.

- ✦ General well logging resources

<http://www.spwla.org>

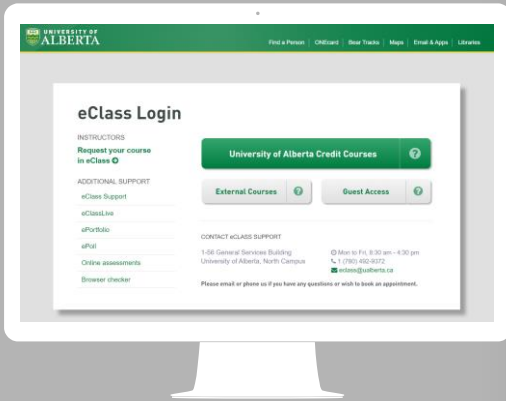
- ✦ A useful source glossary of well logging terms:

<http://www.spwla.org/resources/glossary>

- ✦ Schlumberger interpretation charts (Online chart books)

[https://www.slb.com/resources/publications/books/log\\_charts.as](https://www.slb.com/resources/publications/books/log_charts.as)

# Lecture Notes and Assignments



Lecture notes will be posted on eClass.

All assignments, class examples, and the solutions will be posted on eClass.

# Course Evaluation and Grading Criteria

<b>Evaluation Criteria</b>	<b>Weight, %</b>	<b>Date</b>
Assignments (seven)	30	During term
Midterm Exam	30	February 25, 11:00 a
Final Exam	40	TBA

All exams are open book and open notes, i.e., students are allowed to use their textbook and class notes during the exam.

# Academic Integrity



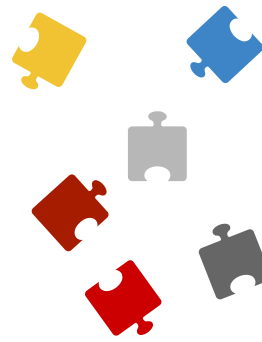
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Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect.

Students are particularly urged to familiarize themselves with the provisions of the Code of Student Behaviour at [Code of Student Behaviour | University Governance \(ualberta.ca\)](http://ualberta.ca) and avoid any behavior which potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence.

Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

# Course Outline



# Course Outline

Week of	Lecture	Content
Jan 06	1-2	Course Outline, Measurement Environment
Jan 13	2-3	Log Header, Caliper Log
Homework 1 (Due: Sunday, Jan 19)		
Jan 20	4	Gamma Ray Log
Homework 2 (Due: Sunday, Feb 02)		
Jan 27	5	Density Log
Homework 3 (Due: Sunday, Feb 16)		
Feb 03	6	Neutron Log
Feb 10	7	SP Log
Homework 4 (Due: Sunday, Mar 02)		
Midterm Exam (Feb 25) [Covers lectures 1-5 and Homework 1-3]		
Feb 24	8-9	Electrical Properties of Rocks
Homework 5 (Due: Sunday, March 09)		
Mar 03	10	Resistivity Tools and Logs

# Course Outline

<b>Week of</b>	<b>Lecture</b>	<b>Content</b>
Mar 10	11	True Formation Resistivity
Mar 17	12	Shaly, Gas-Bearing, and Shaly Gas-Bearing Formation
<b>Homework 6 (Due: Sunday, March 23)</b>		
Mar 24	13	Sonic Log
Mar 31	14	Modern Logs Analysis
April 07		Course Review for Final Exam
<b>Homework 7 (Due: Sunday, April 06)</b>		
<b>Final Exam (TBA) [Covers mainly the materials after midterm]</b>		

# LET'S REVIEW COURSE CONTENT

## 1. Introduction

## 2. Borehole Environment

Borehole Diameter

Filtrate Invasion

Formation Temperature

Mud, Mud Filtrate, and Mud Cake  
Resistivity

## 3. The Anatomy of a Log

Recording Formats

Grid Scales and Depth Scales

## 4. Caliper and Temperature Logging

## 5. Gamma Ray (GR) Log

## 6. Porosity Logs

Density Log

Neutron Log

Sonic Log

Combination Log System

# LET'S REVIEW COURSE CONTENT

## 7. Lithology-Porosity Cross-Plots

Density-Neutron Cross-Plot  
Sonic-Neutron Cross-Plot  
Density-Sonic Cross-Plot

## 10. Determination of Hydrocarbon Saturation by Resistivity Logs

The Archie Equation  
Determination of  $R_w$

## 8. Spontaneous Potential (SP) Log

## 11. Conventional Interpretation Techniques

Cut-Off Saturation and Cut-Off Porosity  
Movable Oil saturation (MOS)  
Acquiring Data from Logs

## 9. Resistivity Logs

Conventional Electrode Resistivity Logs  
Focused Current Resistivity Logs  
Induction Logs  
Micro-Resistivity Logs

## 12. Evaluation of Shaly Formations

Shale Content Evaluation  
Porosity Logs in Shaly Formations  
Water Saturation Determination in Shaly Formations

## **13. Evaluation of Gas Bearing Formations**

Gas Effect on Porosity Logs

Gas Effect on Lithology-Porosity Cross-Plots

Visual Gas Detection

Shaly Gas-Bearing Formations

## **14. Cement Bond Log (CBL) Evaluation**

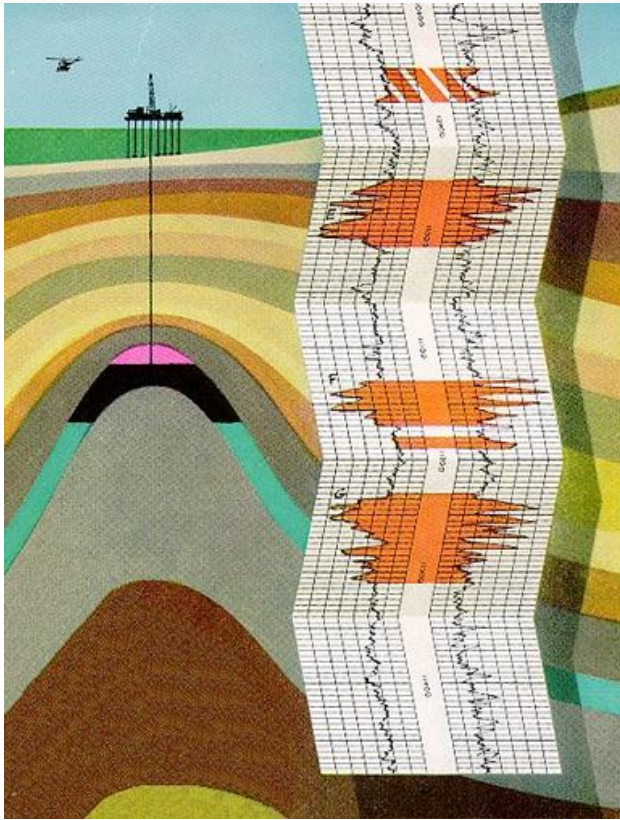


# INTRODUCTION

Let's start the journey

[www.i2g.cloud](http://www.i2g.cloud)

# Formation Evaluation



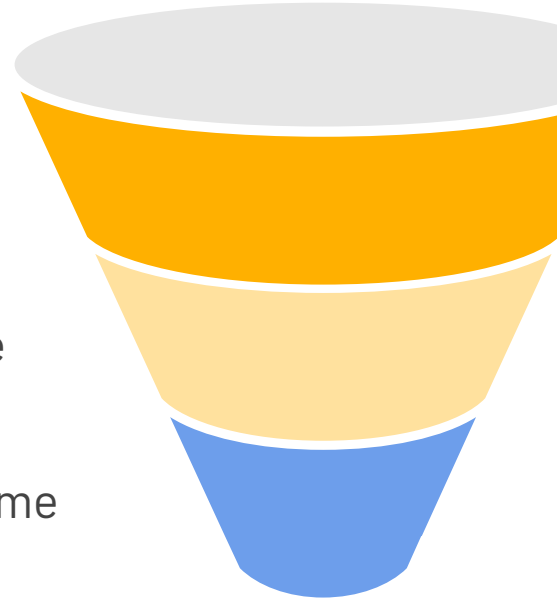
“Process of using borehole measurements to evaluate the characteristics of subsurface formations.”

# Objectives of Formation Evaluation

Identification of reservoirs

Estimation of hydrocarbon volume in place

Estimation of recoverable hydrocarbon volume



# Objectives of This Course

In this course, you will achieve the following skills:



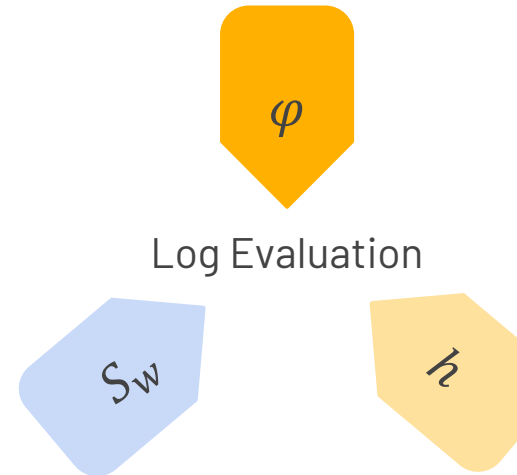
- Identify different logs, corresponding scales, and log headings
- Learn physical principles behind different logs
- Understand the basic principles of log interpretation
- Use quick look techniques to
  - ✓ control log quality
  - ✓ identify reservoirs
  - ✓ evaluate, by hand, hydrocarbon content
- Using relevant mathematical models to analyze the measured log data to calculate petrophysical parameters such as mineralogy, porosity, and fluid saturation

# Volume of Oil in Place

$$N = 7758\phi hA(1 - S_w)$$

Where

$N$	Initial oil in place, rbbl
$\phi$	Effective porosity, fraction
$h$	Productive interval thickness, ft.
$A$	Drainage area, acres
$S_w$	Initial water saturation, fraction



# Borehole Measurements

## Drilling Operation Logs

Mud Logs

Measurement While Drilling (MWD)

Logging While Drilling (LWD)

## Wireline Well Logs

Electrical

Acoustic

Radioactive

Electromagnetic

## Productivity Tests

Drill Stem Testing (DST)

Well Tests

## Core Analysis

# Mud Logging

## Mud logging includes

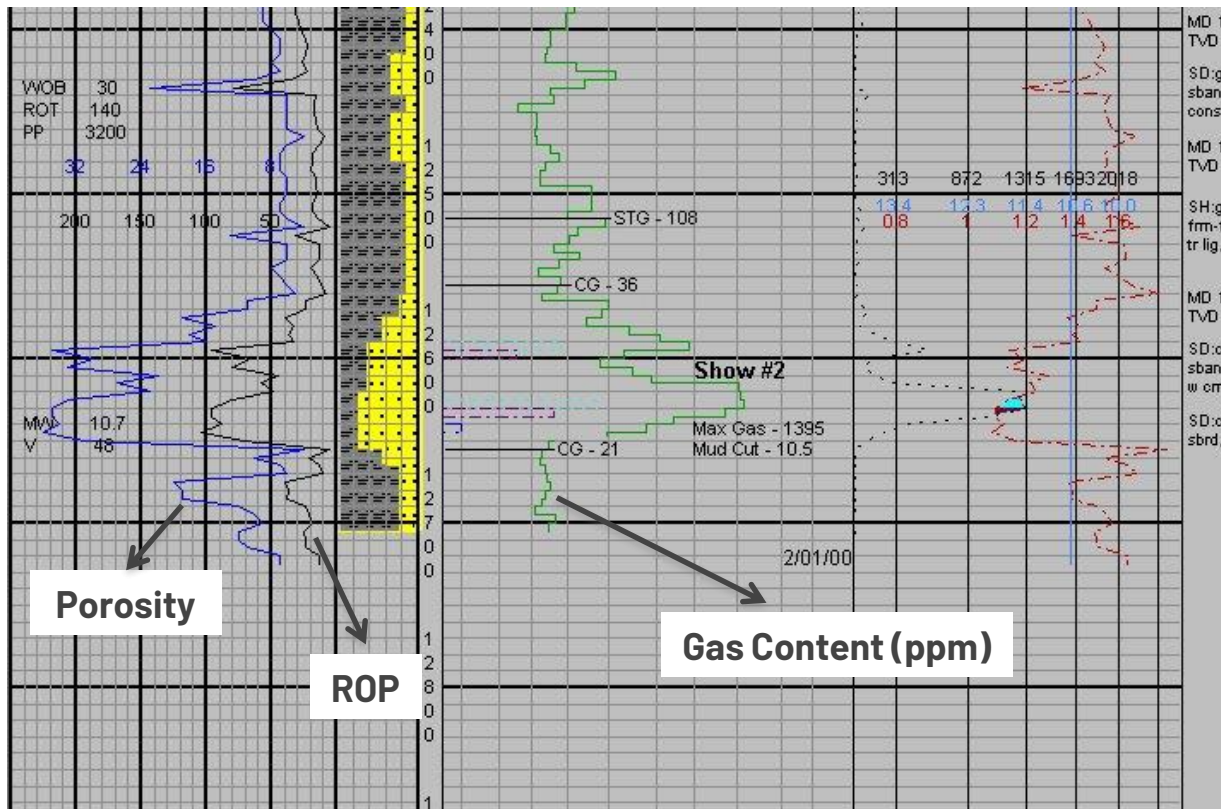
- Microscopic examination of **drill cuttings**
- Evaluating gas hydrocarbon and its constituents
- Evaluating drilling parameters such as mud pressure, viscosity, and rate of penetration (ROP)
- Data are plotted on a graphic log called a **mud log**



[www.enverus.com](http://www.enverus.com)

## Mud logging can be used for

- Determination of lithology by analyzing drilled cuttings
- Indication of hydrocarbon types
- Monitor gas levels (and types)



[www.wikiwand.com](http://www.wikiwand.com)

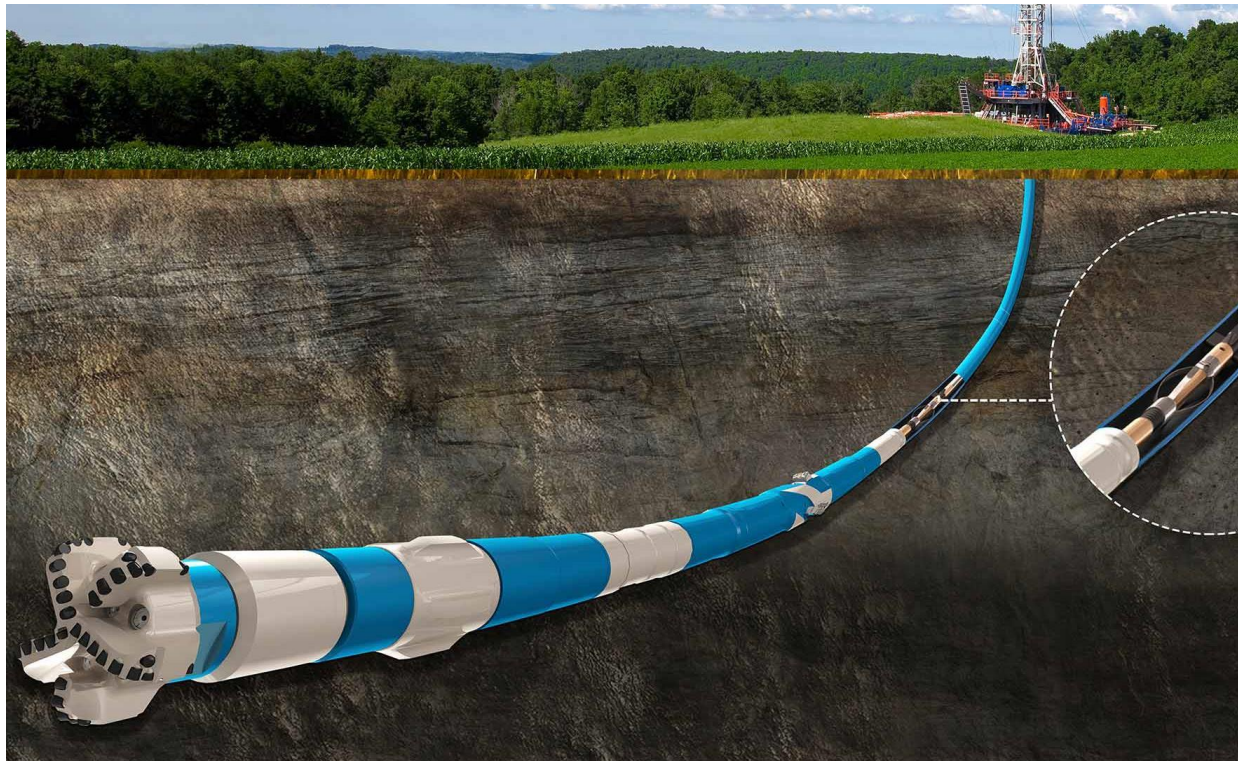
## An Example of Mud Log

# Measurement While Drilling (MWD)

- MWD system performs downhole measurements and transmit them to the surface during the drilling operation.
- MWD tools are part of the bottom hole assembly (BHA) which are usually contained or built inside the drill collar.

MWD can measure

- gamma Ray,
- compass direction (Azimuth),
- bit direction,
- borehole pressure and temperature, and
- mechanical parameters such as vibration and torque.

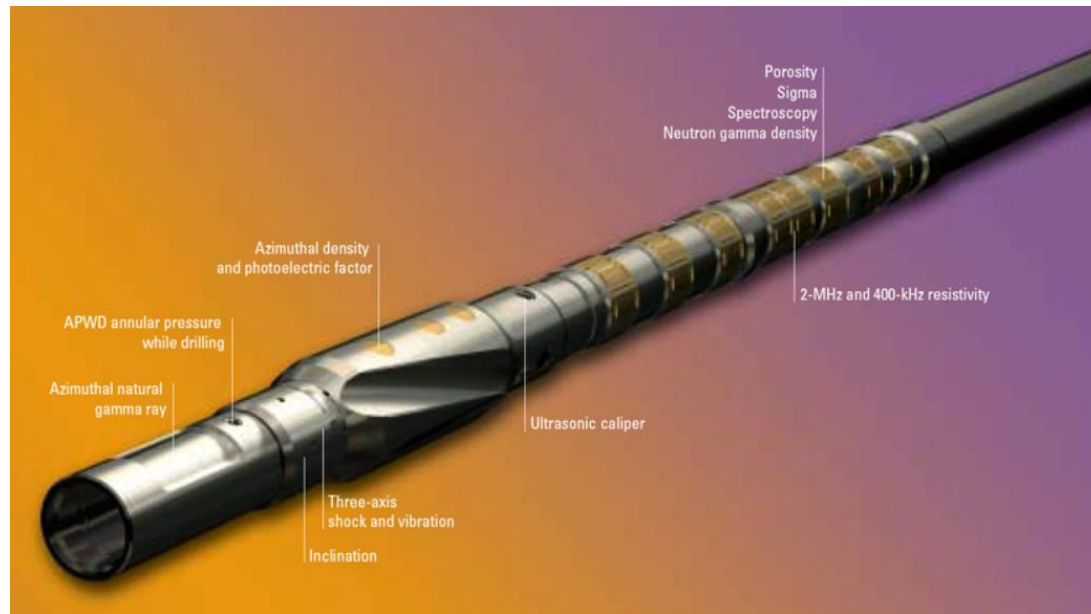


[www.nov.com](http://www.nov.com)

## MWD Device

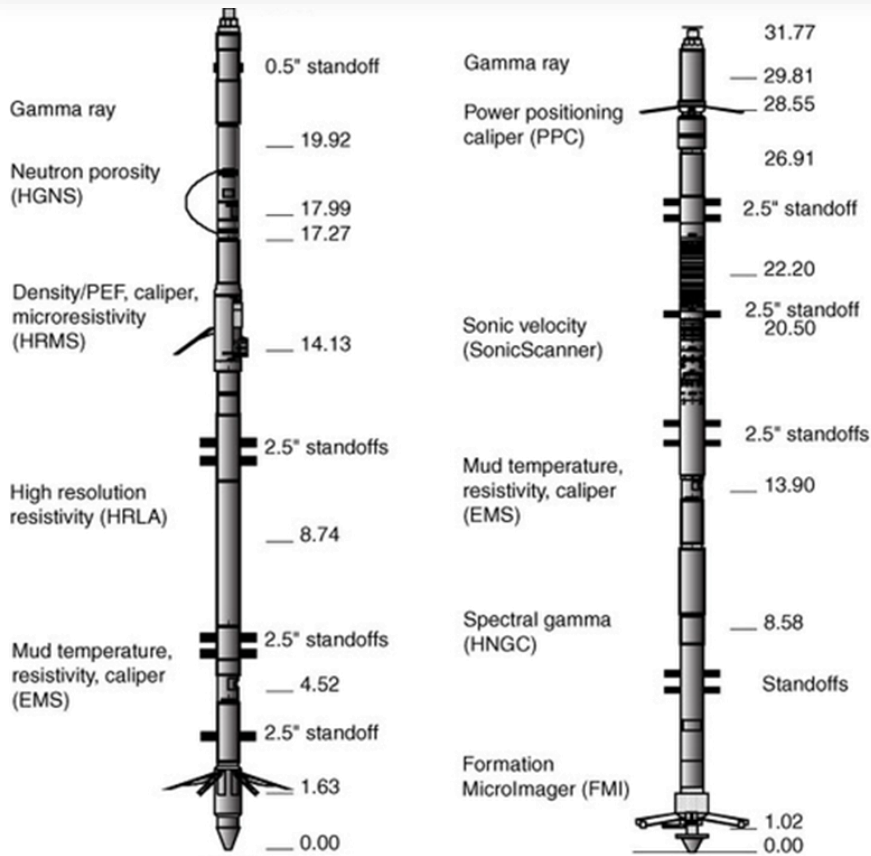
# Logging While Drilling (LWD)

LWD system conducts various logging measurements some distance away from the drill bit.



[mp.ideo.columbia.edu](http://mp.ideo.columbia.edu)

# Open-hole Logging (Wireline Logging)



Wireline logging is done by service companies after the completion of the well operation, and before running casing and cement.

## Mandrel Logging Tools

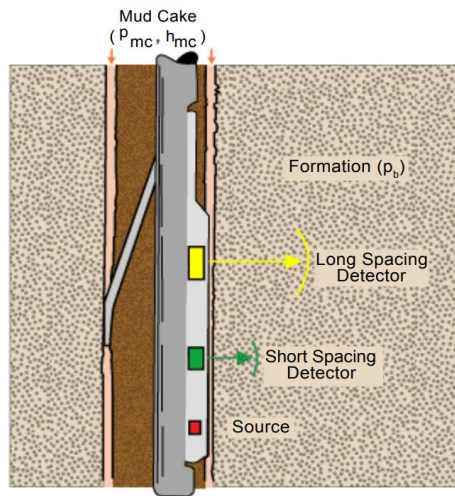
- Mandrel tools are cylindrical, and often centralized with the borehole. Sources and/or sensors are mounted inside the cylinder which are connected to other cylindrical sections in the tool string.



- Example tools include induction resistivity, laterolog, resistivity, and sonic. Some mandrel tools may be pressed against the borehole wall for measurement acquisition. This operation which reduces somewhat borehole effects is done in the gamma-ray and neutron tools.

# Pad Logging Tools

- Pad tools consist of sources and/or sensors which are mounted on a mechanical arm. During the operation, the mechanical arm extends from the center of the mandrel toward the borehole wall. Such tools minimize the effect of borehole environment since the sources and/or sensors are close to the wellbore wall. Example tools include density, electrical microlog, and dipmeter.



Density Tool: Schlumberger Well Services



Dipmeter

# Production and Cased-Hole Logging

These tools conduct measurements on produced fluids and behind-casing properties. The objective is

- to measure fluid and rock properties after the onset of production
- to characterize the types of flowing fluids inside the tubing
- to measure flow rate and water cut.



# THANKS!

**Any questions?**

You can find me at:

- [Dehghanpour@ualberta.ca](mailto:Dehghanpour@ualberta.ca)