Advanced Petrophysics: Introduction to PGE381L

Instructor: Zoya Heidari, Ph.D.

Associate Professor
The University of Texas at Austin

About me and my Research Group

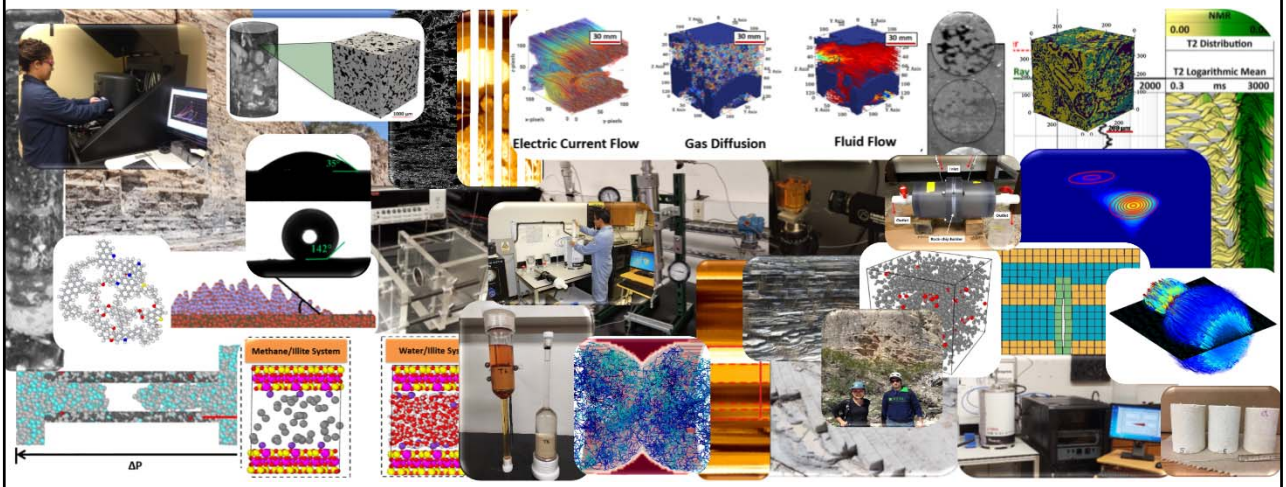
I received a Ph.D. degree in Petroleum Engineering from The University of Texas at Austin in 2011.

Then I joined the faculty of Petroleum Engineering department at ….

My Research Interests and Research Team:
Multi-Scale Petrophysics and Formation Evaluation, Completion Petrophysics, Well Logging, Rock Physics, Borehole Geophysics, Unconventional and Carbonate Reservoirs

September 2022

About me and my Research Group



Course Description

- **Measurement, interpretation, and analysis of petrophysical properties of petroleum reservoir rocks**
  - **Introduction to petrophysics of clay-free, shaly-sand, carbonate, and organic-rich mudrock formations**
- **Advanced concepts in petrophysics for assessment of static and dynamic petrophysical properties of rocks in the laboratory and in-situ condition**
- **Use of multi-scale formation data to describe the connection between pore-scale, core-scale, and reservoir-scale petrophysical properties**
  - **Quantify how these properties affect production and development of hydrocarbon reserves**

Petrophysics

What is Petrophysics?

Petrophysics is the science of describing rock properties and their interaction with fluids through an integrated analysis of multi-scale and multi-physics formation data.

Multi-Scale Sources of Formation Data

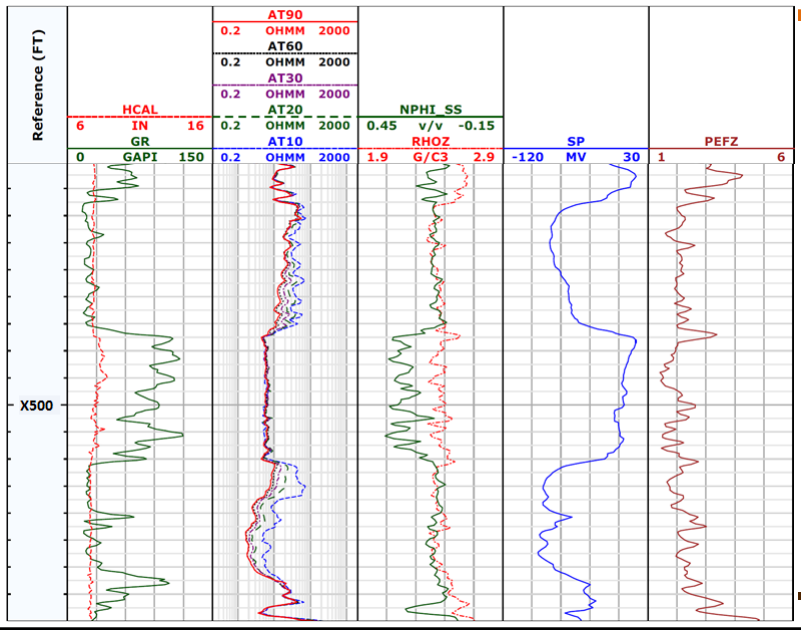
- Reservoir-scale measurements/data
- Borehole-scale measurements/data
- Core-scale measurements/data
- mm- and cm-scale measurements/data
- Micron-scale measurements/data
- Pore-scale (nano-scale) measurements/data
- Atomic-scale measurements/data

What sources of data are you familiar with?

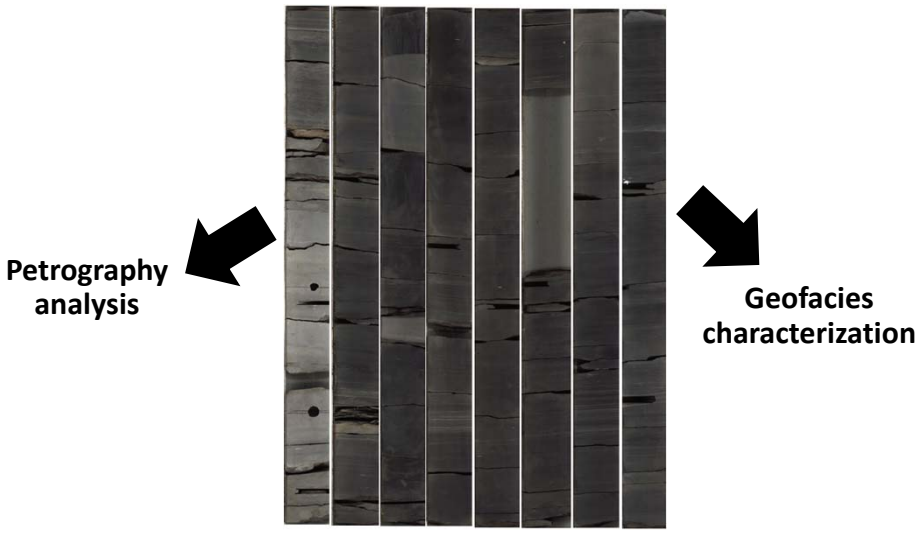
Impact of Pore Structure on Petrophysical Properties

Please watch the video during the lecture!

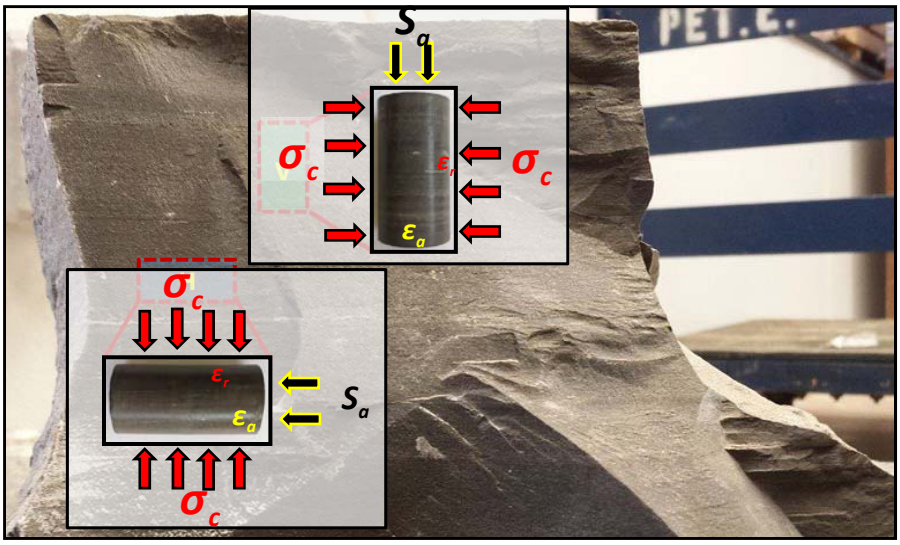
Example: Well Logs, What Do They Mean?



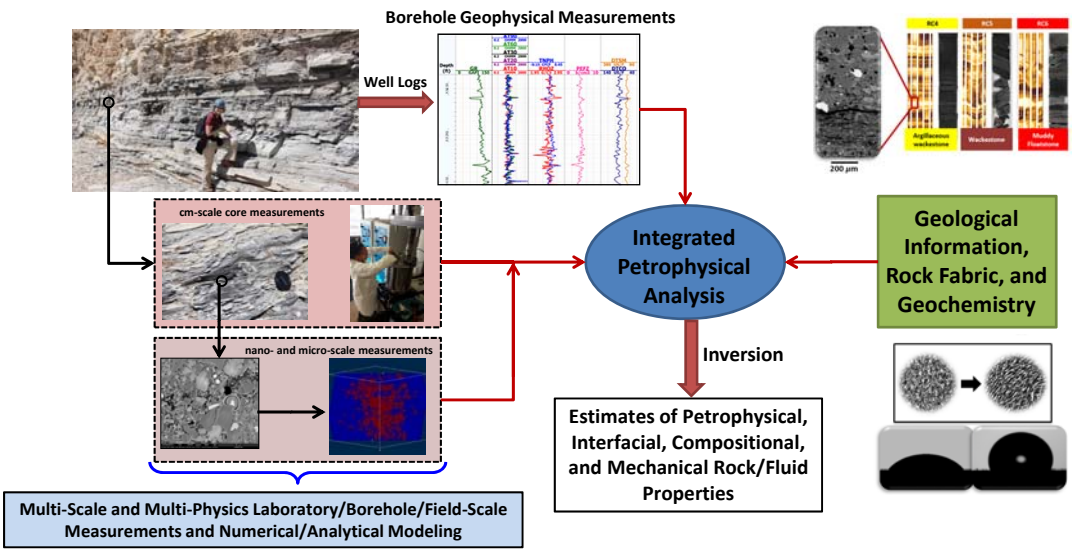
Example: Core-Scale Measurements/Data



Example: Core-Scale Measurements/Data



Multi-Scale and Multi-Physics Formation Data



Importance of PGE381L

Why do we care about Petrophysics?

Most of you will use what you learn in this course, in your future career

- **Reservoir Engineers**
- **Production Engineers**
- **Drilling Engineers**
- **Petrophysicists**
- **Geoscientists**

Course Objectives

Quantify petrophysical properties in the laboratory or in-situ condition.

Quantify the impacts of petrophysical properties on the quality of hydrocarbon reservoirs.

How does the type of formation and geology affect your response to the above questions?

How to integrate multi-scale formation data to enhance our response to the above questions?

Final Goal: Enhance Formation Evaluation, Reservoir Characterization, Production, and Recovery Factors!

What do you learn in this course?

At the end of this semester, students will be able to:

- Understand petroleum reservoir rocks and the impacts of geological environments on rock properties
- Quantify porosity in the laboratory and in-situ conditions
- Quantify water/hydrocarbon saturation in the laboratory and in-situ conditions
- Quantify hydrocarbon reserves using multi-scale and multi-physics formation data
- Quantify permeability in the laboratory and in-situ conditions
- Quantify heterogeneity of the formation
- Quantify spatial continuity in formation petrophysical properties and use that to estimate formation properties where data is not available

What do you learn in this course?

At the end of this semester, students will be able to:

- Understand the impacts of rock-fluid interfacial interactions and wettability on rock physics and fluid flow properties
- Quantify wettability in the laboratory and in-situ conditions
- Quantify capillary pressure in the laboratory and in-situ conditions
- Understand and quantify the impact of capillary pressure on spatial fluid distribution in porous media
- Evaluate the parameters affecting porosity, water saturation, permeability, capillary pressure, and relative permeability and quantify their impacts
- Quantify relative permeability in the laboratory condition
- Understand the origins of dispersion in porous media
- Quantify dispersion coefficient and dispersivity in porous media

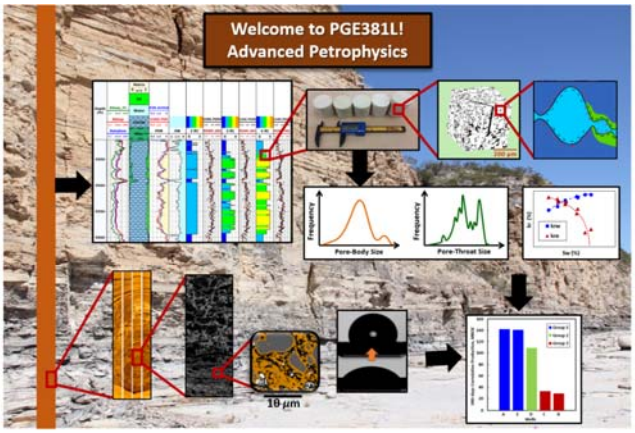
PGE381L Topical Outline/Modules

1. Introduction to petrophysics, geology, and formation data
2. Porosity
3. Fluid saturations
4. Permeability
5. Quantification of heterogeneity, spatial data analysis, and geostatistics
6. Interfacial phenomena and wettability
7. Capillary pressure
8. Relative permeability
9. Tentative: Dispersion in porous media
10. Tentative: Introduction to petrophysics of unconventional reservoirs

PGE381L Outline

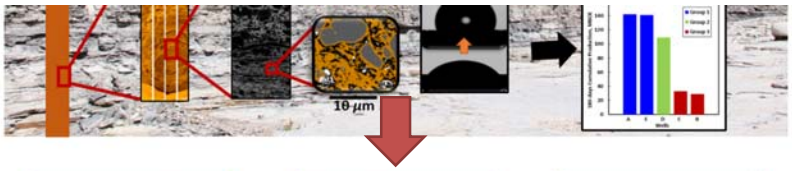
- Introduction to petrophysics, geology, and formation data
- Porosity
- Fluid saturations
- Permeability
- Quantification of heterogeneity, spatial data analysis, and geostatistics
- Interfacial phenomena and wettability
- Capillary pressure
- Relative permeability
- Dispersion in porous media
- Introduction to petrophysics of unconventional reservoirs

Course Website



Syllabus Modules Texas One Stop

How Does This Course Work?



Syllabus | Modules | Texas One Stop

Welcome to Advanced Petrophysics, PGE381L!

- MODULES: Each module is the equivalent of a topic covered in this course and will include:
  - PRE-CLASS READINGS: *Suggested chapters from your textbook, Uploaded lecture notes*
  - WATCHING: *Pre-recorded lectures (optional)*
  - MEETING: *Class will meet in-person twice a week. Pre-recorded materials will also be available to the students, to make use of class time more efficient for practicing new topics, to work in small groups, and to help you with homework/project assignments*
  - FORUMS: *You will participate in discussions about assignments, current events, lecture topics, etc.*
  - QUIZZES: *Test Your Knowledge type quizzes*

Is it difficult to get an A?

Item	Weight (%)	Due Date
Homework/Project Assignments	25	Thursdays before 11:00 PM
Class Contribution and quizzes	5	
Midterm Exam	35	Thursday, October 26, 2023, 5:00 PM-7:00 PM, GLT 1.102
Final Exam	35	Monday, December 11, 2023, 1:00 PM-3:00 PM
Total	100	

Office Hours

Zoya Heidari

Office hours:

Tuesdays **11:15 AM-12:30 PM**
Location: Zoom and GLT 4.246

Thursdays **11:15 AM-12:30 PM**
Location: Zoom and GLT 4.246

Sabyasachi Dash

Office hours:

Mondays **2:00 PM-3:30 PM**
Location: Hybrid mode

Wednesdays **2:00 PM-3:30 PM**
Location: Hybrid mode

Suggested References

PGE381L Text Book:

- **Peters, E. J., 2012, Advanced Petrophysics. Live Oak Book Company.**

More references related to Petrophysics and Rock Physics:

- **Zinszner, B. and Pellerin, F. M., 2007, A Geoscientist's Guide to Petrophysics. Editions Technip.**
- **Mavko, G., Mukerji, T., and Dvorkin, J., 2009, Rock Physics Handbook. Cambridge University Press.**
- **Gueguen, Y. and Palciauskas, V., 1994, Introduction to the Physics of Rocks. Princeton University Press.**

Additional Instructional Materials:

- **Field data and examples will be uploaded on the course website.**
- **Additional reading assignments and references will be uploaded on the website.**

PGE385L Policies

- Be collaborative, Ask questions!
- Spend enough time for homework assignments! Late or not, all assignments must be turned in.
- Start your homework assignments in advance! The deadline will not be postponed.
- Instructor and TA have office hours dedicated to you. Use them efficiently!
- Check your e-mails and course website at least once a day.
- Give me feedback during the semester!

PGE385L Policies

- Exams and quizzes
- Grading and regrading
- Homework assignments
- University regulations concerning attendance, grades, and academic dishonesty
- University code of conduct and student honor code
- Students with special needs
- Coursework copyright
- Take care of yourselves! Stay Healthy!

PGE 381L Social Rules

- **Come on time! Leave on time!**
- **Mute your microphones, when others are talking!**
- **Raise your hand when you have a question and wait for the instructor to respond.**
- **Be active, ask questions, and participate in discussions!**
- **Respect other students and the instructor!**

Prerequisites

- **Graduate standing**
- **Basic knowledge in Mathematics and Physics**
- **Enthusiasm for learning**

Final Words

- **Few words about Ph.D. Qualifying Exam**
- **Please read the syllabus carefully and let me know, if you have any questions or concerns.**
- **Would you be able to attend the office hours of the instructor or the TA? If not, please let me know.**
- **Please let me know, if you have any special needs.**

Complementary References

- **PGE381L, Fall 2023, Course Syllabus**