



UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF GEOSCIENCE
COURSE OUTLINE
WINTER 2015

1. **Course:** Geology 655, Unconventional Gas Reservoir Characterization and Evaluation

Lecture Sections:

L01: January 20, 2014-January 22, 2014, 08:00-16:00, ES 136

February 10, 2014-February 12, 2014, 08:00-16:00, ES 136

April 7, 2014- April 9, 2014, 08:00-16:00, ES 136

Instructor, Dr. C. Clarkson, Office ES 254A, Tel. No. 403-220-6445, e-mail address, clarksoc@ucalgary.ca,

Office Hours: WedFri 11:00-12:00

Geoscience Department ES 118, 403-220-5841, geoscience.ucalgary.ca, geoscience@ucalgary.ca

2. **Prerequisites:** Petroleum Engineering 523 or consent of the instructor. See section 3.5.C in the Faculty of Science section of the online Calendar (www.ucalgary.ca/pubs/calendar/current/sc-3-5.html)

Antirequisite: Credit for both Geology 655 and 699.37 will not be allowed.

3. **Grading:** The University policy on grading and related matters is described sections F.1 and F.2 of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Quizzes	40% (1 in lecture block 2, 1 in lecture block 3)
Term paper + presentation	60% (lecture block 3)
	➤ Evenly weighted between paper and presentation

Each piece of work (quiz and term paper) submitted by the student will be assigned a percentage score. The student's average percentage score for the various components listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade. The conversion between course percentage and letter grade is given below.

Letter Grade	Percent	Letter Grade	Percent
A+	95-100	C+	64-67
A	89-94	C	60-63
A-	84-88	C-	56-59
B+	78-83	D+	53-55
B	73-77	D	50-52
B-	68-72	F	0-49

4. **Missed Components of Term Work:** The regulations of the Faculty of Science pertaining to this matter are found in the Faculty of Science area of the Calendar in [Section 3.6](#). It is the student's responsibility to familiarize himself/herself with these regulations. See also [Section E.6](#) of the University Calendar

5. **Course Materials:** Students will be provided reading materials before each lecture block.

6. **Examination Policy:** Quizzes are closed book. Calculators will be allowed. Students should also read the Calendar, [Section G](#), on Examinations.

7. **OTHER IMPORTANT INFORMATION FOR STUDENTS:**

(a) **Misconduct:** Academic misconduct (cheating, plagiarism, or any other form) is a very serious offence that will be dealt with rigorously in all cases. A single offence may lead to disciplinary probation or suspension or expulsion. The Faculty of Science follows a zero tolerance policy regarding dishonesty. Please read the sections of the University Calendar under [Section K](#). Student Misconduct to inform yourself of definitions, processes and penalties.

- (b) **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on [assembly points](#).
- (c) **Academic Accommodation Policy:** Students with documentable disabilities are referred to the following links: Students with Disabilities: <http://www.ucalgary.ca/pubs/calendar/current/b-1.html> B.1 and Student Accessibility Services: <http://www.ucalgary.ca/access/>.
- (d) **Safewalk:** Campus Security will escort individuals day or night (<http://www.ucalgary.ca/security/safewalk/>). Call 220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.
- (e) **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). As one consequence, students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information see also <http://www.ucalgary.ca/secretariat/privacy>.
- (f) **Student Union Information:** VP Academic Phone: 220-3911 Email: suvpaca@ucalgary.ca.
SU Faculty Rep. Phone: 220-3913 Email: sciencerep@su.ucalgary.ca; Student Ombudsman
- (g) **Internet and Electronic Device Information:** You can assume that in all classes that you attend, your cell phone should be turned off unless instructed otherwise. Also, communication with other individuals, via laptop computers, Blackberries or other devices connectable to the Internet is not allowed in class time unless specifically permitted by the instructor. If you violate this policy you may be asked to leave the classroom. Repeated abuse may result in a charge of misconduct.
- (h) **U.S.R.I.:** At the University of Calgary, feedback provided by students through the Universal Student Ratings of Instruction (USRI) survey provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses (www.ucalgary.ca/usri). Your responses make a difference – please participate in USRI Surveys.

Department Approval: Original Signed

Date: January 7, 2015

Associate Dean's Approval for

Alternate final examination arrangements: Original Signed

Date: January 8, 2015

COURSE CONTENT, OBJECTIVES AND ORGANIZATION:

The aim of this course is to provide a review of unconventional gas and light oil reservoir characteristics and an overview of methods used to characterize and evaluate them. The first part of the course will focus on fundamentals of unconventional gas reservoirs including gas storage and transport mechanisms, volumetric and material balance reserve estimation and completion and stimulation methods. The second part of the course will focus on reservoir characterization techniques including core analysis, log analysis and pressure- and rate-transient (production data) analysis. Lastly, exploration and development concepts will be introduced. Real-world examples will be used wherever possible to demonstrate concepts and workflows.

The objectives of the course are to provide a working knowledge of advanced techniques for the evaluation of unconventional reservoirs. A detailed outline of the course is provided below (*timing is approximate):

1. Introduction (Day 1)*

- i. Unconventional Gas (UG) and Unconventional Light Oil (ULO) Reservoirs
- ii. UG and ULO Definitions
- iii. Featured Plays

2. Introduction to Tight Gas Case Study (Day 1)*

3. Fundamentals (Day 1)*

Storage and Flow Characteristics

- i. Pore structure and gas storage mechanisms
 - a. Hydrocarbons-in-Place
 - b. Volumetrics
 - c. Material balance
- ii. Flow mechanisms: matrix and fracture flow

Completions and Microseismic

Field Development Workflow

4. Unconventional Gas/Light Oil Reservoir Characterization (Day 2/3/4)*

- i. Reservoir Sample (Core, Cuttings or other) Analysis
 - a. Routine Measurements (Single-Phase Analysis)
 1. Porosity
 2. Absolute Permeability (Steady-State and Unsteady-State)
 3. Stress-Dependence of Porosity and Permeability
 4. Capillary Pressure and PSDs: Mercury Injection
 - b. Special Core Analysis
 1. Relative Permeability
 2. Other Methods for Pore Size Analysis
 3. Rock Mechanical Properties
 - c. Organic Matter Characterization (CBM and Shale)
 - d. Gas Content and Adsorption Isotherm Determination (CBM and Shale)
 - e. Inorganic Matter Characterization
 - f. Integration of Logs with Core
 - g. Tight Gas Case Study: Routine and Special Core Analysis
 - h. Tight Oil Study
- ii. Rate-Transient (Production Data) Analysis
 - a. Introduction to Concept
 - b. Example Signatures of:
 1. Vertical wells in low-k single porosity reservoirs
 2. Horizontal wells in low-k single-porosity reservoirs
 3. Multi-fractured hz wells in low-k single porosity reservoirs
 4. Multi-fractured hz wells in low-k double-porosity reservoirs
 - c. Analytical Methods for Rate-Transient Analysis
 1. Overview of Techniques
 2. Type-Curve Methods

- 3. Straight-line (flow-regime) Methods
 - 4. Simulation
 - d. Empirical Methods for Rate-Transient Analysis
 - 1. Arps Decline Curves - use with Fetkovich type-curves
 - 2. New Methods (ex. Power-Law Exponential)
 - e. Tight Gas Case Study: Application of Rate-Transient Techniques
 - 1. Integration With Surveillance data (ex. Microseismic)
 - 2. Hydraulically-Fractured Vertical Wells
 - 3. Multi-fractured Horizontal wells: commingled stages analysis
 - 4. Multi-fractured Horizontal wells: individual stage analysis
 - d. Additional Example Applications:
 - 1. Tight Gas
 - 2. Single- and Multi-Phase Shale Gas
 - 3. Tight Oil
 - 4. Shale Oil
 - 5. Flowback Analysis
- iii. Pressure Transient Analysis (Well-Testing)
 - a. Conventional PTA concepts: buildup test
 - b. Methods for tight formations/shale
 - 1. Issues with testing tight formations/shale
 - 2. Alternative methods for testing tight formations/shale (DFIT)

C. Exploration and Development Concepts (Day 5/6)*

- i. Exploration
 - a. Subsurface Considerations
 - b. Applicability of Conventional Play/Prospect Analysis
 - c. Monte Carlo Simulation
 - d. Introduction to New Unconventional Prospect Analysis Techniques
- ii. Development
 - a. Reserves Evaluation Workflow
 - b. Analyzing Field Production
 - c. Well Optimization (compression and completion optimization)
 - d. Optimal Development Considerations