Syllabus

GEO 384T
Seismic Lithology

Unique No. 27100
Spring Term, 2010
Dept of Geological Sciences
Jackson School of Geosciences
The University of Texas at Austin

Tuesday and Thursday: 11:00 AM – 12:30 PM
Room: GEO 3.120

Lab: **Thursday**, 12:30 – 2:00 PM
Room: GEO 2.108
(Note: Lab will NOT meet every week)

Instructor:
Robert H. Tatham
Office: GEO 4.220E
Office Telephone: 471-9129
Email: Tatham@mail.utexas.edu

Office Hours: Thursday and Friday, 10:00 – 11:00 AM
Additional office hours: by appointment, or whenever available.

T/A Lab. Instructor: Ryan Lester
Office: GEO
Email: rlester@mail.utexas.edu

Objectives:

The basic objective of the course is to ensure that students, upon completion, will have an understanding of how seismic waves propagating through earth materials respond to relevant rock, reservoir and fluid properties in the subsurface and have some functional capability to use seismic data recorded on the surface to describe, discriminate and estimate these rock, reservoir and fluid properties in the subsurface.

The course will consist of two major topic areas:

I. Relating seismic (elastic) parameters to relevant rock, reservoir and infilling fluid properties.
II. Applications of surface seismic methods to estimate and track these properties.

Rock, Reservoir and Fluid properties to be addressed include:

Lithology (or rock type), Porosity, Pore Shape, Temperature, Fluid pressures, Type of fluid in pores (Natural gas, Liquid Petroleum, Water, degree of gas saturation in a liquid), fluid substitution relations, fracture orientation and density, mass density of the rocks and permeability to fluid flow.

Seismic Application techniques include: Wave propagation velocity of seismic compressional and shear waves, velocity ratio Vp/Vs, relative amplitude of reflected energy, variations in reflection amplitude with angle of incidence (AVO), polarization of particle motion associated with wave propagation, variation in velocity associated with anisotropy and comparison of computer simulated results with observed data.

Prerequisites:

Graduate standing in the Department of Geological Sciences, Petroleum and Geosystems Engineering or approval of instructor.

Note: Although no mathematics beyond that required for an entering graduate student in Geological Sciences is required, fluency in mathematical manipulations consistent with the requirements of a BS in geological sciences will be assumed. Other mathematical concepts will be introduced to address specific topics.

Required Texts:

"Offset-Dependent Reflectivity – Theory and Practice of AVO analysis"
Castagna, John P. and Backus, Milo M, editors
Society of Exploration Geophysicists, Investigations in Geophysics No. 8.
Tulsa, Ok. 1993, 348 pages

"The Rock Physics Handbook" Second Edition
Mavko, Gary; Mukerji, Tapan and Dvorkin, Jack
Cambridge Univ. Press, Cambridge, England, UK,.2009, 511p.

"Multicomponent Seismology in Petroleum Exploration,"
Tatham, R. H. and McCormack, M. D.,
Society of Exploration Geophysicists, Investigations in Geophysics No. 6
Tulsa, Ok. 1991, 248 pages. (Available as part of course packet)

Course Packed of selected publications from Jenn's copies, 2200 Guadalupe

Note: Purchase of SEG publications directly from SEG at student discounts can represent a significant discount from bookstore prices.

A reading list of relevant technical papers will be supplied, and papers will be available to students. Students will be responsible for information in the papers on the reading list. All this material should be contained in the collection of written reports submitted by the class.

Grading, Examinations and weightings.

Two midterm exams at 15% each	30%
Final (Cumulative) exam	30%
Oral Report	10%
Written Report	15%
Lab., Homework exercises and Participation	15%

Final, Cumulative exam on entire course
Lab exercises will make use of MatLab.

One written report will be submitted by each student.
The written report will be in the format of an SEG Expanded Abstract (four pages, about 2000 words, with figures, etc.) The length of the report will be limited to these four pages, and any additional pages submitted will NOT be included in the copies distributed to the class and will NOT be included in the paper evaluation. Report topics will be from a few (up to half a dozen) papers on a focused topic included in the Reading List. Copies of all submitted papers will be distributed to the class, and students will be required to evaluate (grade) all the submitted papers (other than their own). These student evaluations will be used by the instructor as a 'factor' in grading the paper.

Please write your paper to integrate the papers read into a common theme, or contrast the results of each paper. Avoid just making a list of conclusions for each paper. The point is to synthesize all the papers into a cogent, coherent unit. An "A" paper will tell the reader something he doesn't already know, even though he may have read all the individual papers. The paper topics focus on relating seismic observations and rock, reservoir and fluid parameters.

SEG Expanded Abstract format and template are available on the SEG www page at: http://meeting.seg.org/

The abstract templates are available at:
http://abstracts.seg.org/

Each student will make an oral presentation to the class, and class members will evaluate each presentation. Topics will be selected from a list (NOT the same list as the written paper) of published applications. The focus of the presentations is applications of the methods addressed in the course.

Class attendance is required and active participation in class and laboratory activities is expected.

Make-up exams will be addressed on an individual basis. Please inform instructor of any anticipated conflicts that might occur with scheduled exams.

Scholastic dishonesty: Collaboration in studying, class and lab activities is encouraged. Inappropriate collaboration on exams and individual assignments will NOT be tolerated, and will be dealt with in an appropriate manner for academic dishonesty.

Tentative Lecture Schedule

GEO 384T

Seismic Lithology

Spring Term, 2010

Lecture	Date	Topic	Reading	Lab
Week 1	----------			
1	**Tu 1/19/10**	**Introduction to Course** **Syllabus** **Information Sheet on Stud.** **Course Schedule** **Introduction:** **Review of Geophysical Methods: Focus on Seis.** **Definition of Stress** **Stress Tensor**	**T&M 26-28** **MM&D 21-23**	
2	**Th 1/21/10**	**Continue discussion of Stress** **Static Stress Fields** **Principal Stresses** **Deviatoric Stresses** **Define Strain** **Hooke's Law**	**T&M 28-30** **MM&D 17-23**	**No lab. this week.**
Week 2	----------			
3	**Tu 1/26/10**	**Review elastic constants** **Introduce discussion of wave equations** **Derivation of Wave Equations**	*Elastic Constants.* **T&M 31-35** **MM&D 17-23**	
4	**Th 1/28/10**	**Review elastic constants** **Summary of properties of P and S Waves**	**T&M 32-33** **MM&D 81-83**	**Elastic constants I. Introduction to seismic wave velocities.**
Week 3	----------			
5	**Tu 2/2/10**	**Review of basics of seismic Wave Propagation** **Reflection, Refraction and Mode Conversion** **P, SH and SV polarization**	**T&M Ch. 2** **MM&D 81-83, 93-96**	

		S1 and S2 polarization		
6	**Th 2/4/10**	**Critical Porosity** **Equivalent Media considerations**	*Nur et al. (95)* *Nur et al. (98)* **MM&D 177-183** ***Averaging Moduli*** **MM&D 347-350** ***Critical Porosity***	**No new lab this week.**
Week 4	----------			
7	**Tu 2/9/10**	**Rock Physics (Petrophysics) and relation to Seismic** **Lab Observations** **Confining Pressure** **Pore Pressure** **Differential Pressure** **Effective Pressure** **Initial intro. to Overpressure**	**Supp. Reading** **King (66)** **Gregory (77)** **Hofmann et al. (05)** **T&M Ch. 3** **C&B Ch. 2 115-120**	
8	**Th 2/11/10**	**Intro. To Rock/Reservoir properties and seismic velocities.** **Lithology** **Velocity-Density**	**T&M 43-89** **C&B 135-171** **MM&D scattered topics** **T&M 47-53** **C&B 137-139** **MM&D 263-369 347** **Appendices** **C&B 137-139** **MM&D 380-382** **Handout:** ***Nafe-Drake curve*** ***Gardner curve***	**Elastic constants II. Critical porosity and equivalent media theory**
Week 5	----------			
9	**Tu 1/16/10**	**Porosity** **Introduction to Biot-Gassman theory** **Discuss topics for written paper.**	**T&M 53-39** **C&B 39-142** **MM&D 347-363**	**No new lab this week.**
10	**Th**	**Fluid Substitution**	*Hilterman (83)*	

2/18/10 **T&M 59-60,**
90-91
C&B 146-155

Week 6				
11	**Tu 2/23/10**	**No Formal Class Meeting EDGER Forum Annual Meeting—Class is expected to attend.** Location: Thompson Conf. Center Room 3.102		**Fluid Substitution exercise**
12	**Th 2/25/10**	**Pore Shape**	**T&M 60-67**	
Week 7				
13	**Tu 3/2/10**	First Midterm Exam		
14	**Th 3/4/10**	**Compaction, depth and consolidation**	**T&M 67-71**	**No new lab this week.**
Week 8				
15	**Tu 3/9/10**	**Compaction and Depth (Continued)**		
16	**Th 3/11/10**	**Overpressure**		**Lab. exercise on compaction and overpressure.**
		Spring Break 3/15/10 → 3/19/10		
Week 9				
17	**Tu 3/23/10**	**Temperature Fluid properties Intro. to cross-well tomography**	**T&M 71-74 C&B 146-152 MM&D 339-346** *Batzle & Wang (90)*	
18	**Th 3/25/10**	Written Papers due **Anisotropy**	**T&M 36-40, 74-84 C&B 156-161 MM&D 35-54, 194-228** Tatham et al. (92)	**No new lab this week.**

Papers due Thursday, March 25, 2010
(Copies will be distributed to class on Tuesday, March 30, 2010

APPLICATIONS

Week 10				
19	**Tu 3/30/10**	Written papers distributed to class **Intro. to AVO** **"THE" seismic experiment** **Zero-offset reflectivity** **Reflections at various angles** **Shuey Approximation**	**C&B 3-29** **T&M 18-23** ***(review)***	**Synthetic Seismic and Thin Bed Effects**
20	**Th 4/1/10**	**Continue AVO**	*Rutherford & Williams (89)* *Ostrander (84)* *Smith & Gidlow (87)*	
Week 11				
21	**Tu 4/6/10**	**Synthetic Seismogram and Thin-Bed review**	*Neidell and Pogglagliolmi (77)*	
22	**Th 4/8/10**	**Inversion** **Recursive** **Sparse Spike**	**Supp. Reading** **Lindseth (79)** **Helgesen et al. ('00)**	**No new lab this week.**
Week 12				
23	**Tu 4/13/10**	Evaluation of papers due **Direct Shear Methods**	**T&M 171-185, 187-193** **C&B 317-345**	**Lab. on inversion of seismic amplitudes to acoustic impedance values.**
24	**Th 4/15/10**	Second Midterm Exam		
Week 13				
25	**Tu 4/20/10**	**Acoustic and dipole (shear-wave) logging**	*Zemanek et al. (91)*	
26	**Th 4/22/10**	**AVO Cross-plotting**	**Supp. Reading** **Castagna & Swan (97)** **Castagna et al.(98)** **Foster et al. (97)**	**No new lab this week.**

Week 14				
27	**Tu 4/27/10**	**Review of multicomponent seismic methods**		**P & S correlation and interpretation**
28	**Th 4/29/10**	**Examples of AVO and P-SV interpretations**	**C&B 333-345, 238-249**	
Week 15				
29	**Tu 5/4/10**	**Review of presentation styles and dynamics** Class Evaluation		**Lab Session may be used for student presentations.**
30	**Th 5/6/10**	**Presentations by students**		

Final Exam: Saturday, May 15, 2010 7:00 – 10:00 PM