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
Tulsa, Ok. 1993, 348 pages

Mavko, Gary; Mukerji, Tapan and Dvorkin, Jack

“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

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
<th>Lab</th>
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| 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 | No lab. this week. |
|         | 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 | |
| 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 | Elastic constants I. Introduction to seismic wave velocities. |
|         | 4       | **Th** 1/28/10 Review elastic constants  
Summary of properties of P and S Waves | T&M 32-33  
MM&D 81-83 | |
| 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 | |
<table>
<thead>
<tr>
<th>Week 4</th>
<th>Tu</th>
<th>2/9/10</th>
<th>Rock Physics (Petrophysics) and relation to Seismic Lab Observations</th>
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<td>Confining Pressure</td>
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<td>Pore Pressure</td>
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<td>Initial intro. to Overpressure</td>
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<td>Supp. Reading</td>
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<td>King (66)</td>
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<td>Gregory (77)</td>
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<td>Hofmann et al. (05)</td>
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<td>T&amp;M Ch. 3</td>
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<td>115-120</td>
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<td>Elastic constants II.</td>
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<td>Critical porosity and equivalent media theory</td>
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<td>8</td>
<td>Th</td>
<td>2/11/10</td>
<td>Intro. To Rock/Reservoir properties and seismic velocities.</td>
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<td>Lithology</td>
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<td>Velocity-Density</td>
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<td>T&amp;M 43-89</td>
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<td>C&amp;B 135-171</td>
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<td>MM&amp;D scattered topics</td>
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<td>MM&amp;D 347</td>
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<td>Appendices</td>
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<td>C&amp;B 137-139</td>
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<td>MM&amp;D 380-382</td>
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<td>Handout: Nafe-Drake curve</td>
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<td>Gardner curve</td>
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<td>9</td>
<td>Tu</td>
<td>1/16/10</td>
<td>Porosity</td>
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<td>Introduction to Biot-Gassman theory</td>
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<td>Discuss topics for written paper.</td>
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<td>T&amp;M 53-39</td>
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<td>C&amp;B 39-142</td>
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<td>MM&amp;D 347-363</td>
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<td>No new lab this week.</td>
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<td>Th</td>
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<td>Fluid Substitution</td>
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<td>Hilterman (83)</td>
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2/18/10

T&M 59-60,
90-91
C&B 146-155
| Week 6 | Tu 2/23/10 | No Formal Class Meeting  
       |        | EDGER Forum Annual  
       |        | Meeting—Class is expected  
       |        | to attend.  
|       | Location:  
       |        | Thompson Conf. Center  
       |        | Room 3.102  
|       | Th 2/25/10 | Pore Shape  
       |        | T&M 60-67  
| Week 7 | Tu 3/2/10 | First Midterm Exam  
|       | Th 3/4/10 | Compaction, depth and consolidation  
|       |        | T&M 67-71  
|       |        | No new lab this week.  
| Week 8 | Tu 3/9/10 | Compaction and Depth  
|       |        | (Continued)  
|       | Th 3/11/10 | Overpressure  
|       |        | Lab. exercise on compaction and overpressure.  
| Week 9 | 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)  
|       | 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)  
|       | Spring Break 3/15/10 → 3/19/10 |  

### 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)  

**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)  

**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.
<table>
<thead>
<tr>
<th>Week 14</th>
<th>Tu 4/27/10</th>
<th>Review of multicomponent seismic methods</th>
<th>P &amp; S correlation and interpretation</th>
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<tbody>
<tr>
<td></td>
<td>Th 4/29/10</td>
<td>Examples of AVO and P-SV interpretations</td>
<td>C&amp;B 333-345, 238-249</td>
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<thead>
<tr>
<th>Week 15</th>
<th>Tu 5/4/10</th>
<th>Review of presentation styles and dynamics</th>
<th>Lab Session may be used for student presentations</th>
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<tbody>
<tr>
<td></td>
<td>Th 5/6/10</td>
<td>Presentations by students</td>
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Final Exam: Saturday, May 15, 2010 7:00 – 10:00 PM