SEDIMENTOLOGY AND STRATIGRAPHY
COURSE SYLLABUS
FALL 2003

Meeting times

This class meets on Tuesday and Thursday, from 9:55-11:35 a.m., with a required lab section on Thursday from 1:30-4:30 p.m. As you will see below, I have designed this course so that it does not follow a strict "lecture/lab" format. Rather, we will do lab-like work interspersed with lecture throughout the entire schedule.

Instructor Information

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Greetings!

Pretty much all of you have had a class from me at one time or another. You are about to enter the class that I care about the most, Sedimentology and Stratigraphy. I ***am*** *a sedimentologist by training. I spent at least eight years of my life doing research in this field—as part of a PhD and as a post-doctoral researcher at the U of M—and I continue this work to today. I have taught the course twice before, in a pretty standard format. I lectured. You did labs. We went on field trips. I hoped that, in the end, you'd see how it all hung together in this great, organic whole. Unfortunately, this last step never really seemed to happen. As a result, I took a large chunk of the summer (of '03) and worked toward redesigning this course. I went to an National Science Foundation/ National Association of Geoscience Teachers workshop at Hamilton College (in New York) entitled "Designing effective and innovative courses in the geosciences" specifically to work on this course. I worked with a group of about 50 other geoscientists to brainstorm more effective ways to teach geology and I worked even more closely with five sedimentologists as we worked together to create better courses. The result is the course you're about to take. I am* ***really*** *excited about teaching this course and I hope that, in the end, you'll all feel the same way about sed/strat!*

Cheers,

Tom

Purpose of the Course

Broadly-speaking, the purpose of this course is to teach you how to think like a geologist and—somewhat more specifically—like a sedimentologist. I believe that sed/strat is the course where you really learn how to think like real geoscientists (okay, maybe field camp is tied for this honor, but you need practice in more than one course). You make careful **observations** of the sedimentary strata around you. This is followed by making well-constrained, **detailed interpretations** of the sedimentary rocks. Finally, you stitch these interpretations into an **internally consistent interpretation of the environment in which the rocks formed** (called a "depositional environment" in the lingo). Given that more than 70% of the exposed rocks on the Earth's surface are sedimentary, it would be fair to say that your ability to interpret them plays an important role in your abilities as a geologist in general.

More specifically, you will learn how to interpret sedimentary rocks. I have invested more than a quarter of my life doing this, so you should expect this to be a beginning, not an end-point. I hope you will keep this in mind throughout the course.

You might also want to note that

- Most of the world's petroleum and natural gas is found in sedimentary rocks.
- The lion's share of groundwater also resides in the seds.
- Many natural ore bodies (gold, copper, silver, mercury, iron, etc.) occupy sedimentary strata and the shapes of these ore bodies are controlled by the sediments themselves.
- Pyroclastic volcanic rocks are just sedimentary rocks deposited hot and fast.
- The record of Earth's past climate resides almost exclusively in sedimentary rocks.

So, an understanding of sedimentology and stratigraphy is not just academic….

Course Description

Sedimentology is the study of *sediment*, particularly focusing on how it is transported, and deposited. Stratigraphy emphasizes the analysis of sedimentary strata, the layers of sedimentary (and some volcanic) rocks that cover about 3/4 of the earth's surface. Sedimentary rocks illuminate many of the details of the earth's history: effects of sea level change, global climate, tectonic processes, and geochemical cycles are all recorded in the sedimentary strata of the earth. This course will cover basics of fluid flow and sediment transport, sedimentary structures and textures, and—forming the bridge between modern landforms and ancient rocks—depositional sedimentary environments.

As I mentioned above, I have re-designed the course from the ground up. In a typical course, one that might be considered "teaching-centered", I would choose the content I wanted to cover, then prepare lectures and labs that got that content across. This has been shown, through numerous studies, to be a very effective and efficient way to get a lot of information across to the student, but the student, in the end, retains very little of the content. I have re-designed this course to be "learning-centered", where I have specified three, very well-defined objectives that I want you to attain. I then created four projects that are designed to give you practice at doing the things I want you to be able to do by the end of the course (how else will you be able to do them without practice?). Finally, I decided on the content that I needed to provide you in order for you to complete the projects. In the end, whether you remember the specific content or not is not the question, but whether you can *do* what I set forth as objectives.

Course Objectives

There are three main things that I want you to be able to do at the end of this course:

1. Given an outcrop, 1D/2D section, correlation diagram, or other representation of a stratigraphic section, interpret the depositional history of the sequence and develop an internally consistent hypothesis about the relative importance of sediment supply, subsidence, and/or base level in creating the sequence.
2. Given a tectonic setting, predict what types of sedimentary processes and depositional environments would result and what their stratigraphic signature would be.
3. [Design, carry out, and] analyze an experiment that focuses on a sedimentary process.

Many of you have participated in our field camp. A couple of you have not, but follow along with this anyway. The basic idea of field camp is to teach you how to be a geologist by *doing* some of the most basic things that geologists do. I think for those of you that have been in the field, you would agree that you probably learned more in this setting than by sitting and listening to someone lecture. Ask yourself, "how much lecturing happened in field camp?" Not much. I have chosen to follow a similar philosophy for this course.

Look at the overarching goals for this course. I want you to be able to accomplish these goals and the path we take to get there will determine what I cover in class. I do not have a certain amount of material that I must cover. I also do not have a set of fixed 'labs' versus 'lectures.' What I have are a set of three (or four) projects designed to achieve the goals outlined above. If I want you to achieve the goals I've outlined, you need practice, so you will get at least four opportunities to practice. Each project will emphasize *all three goals*, not just one. Along the way, as you work on these projects, we will tackle smaller, lab-like tasks and exercises that are designed to give you the tools you'll need to complete the projects effectively.

I think you'd agree that this is not your standard course format. I have radically redesigned the course so that you will come away from it not with a brain packed with factoids, but with a set of skills that you will be able to apply not just to your future as geoscientists, but anywhere you go.

Resources

The course Blackboard site:
I will post links to web sites relevant to the course here, as well as data sets that you will need for the projects and exercises. Sometimes, I may not be as efficient at getting to you with an answer to a question as one of your colleagues, so I will also open up a "discussion board" on the site so that you can post questions/comments to each other. You may also e-mail all of the students in the course from this site.

Books on reserve:

I have placed several books on reserve that can be used to provide you with greater depth on your research projects. I would recommend perusing some of these on an "as needed" basis when you're working on your write-ups.

- *The Appalachian-Ouachita orogen in the United States* / edited by Robert D. Hatcher, Jr., William A. Thomas, George W. Viele.
- *Facies Models* / edited by Roger G. Walker and Noel P. James.
- *Sedimentary Environments: Processes, Facies, and Stratigraphy* / edited by H. G. Reading
- *Depositional sedimentary environments* / Reineck and Singh.

Readings

Every textbook has its strong and weak points. The main weak point is that every one tries to cover far too much, in order to make them attractive to all instructors. New information is created on a daily basis that adds to the girth of most textbooks and I would never expect to cover everything in any given text. I will assign readings from the required text for this course but ***do not expect to follow the textbook in a linear way.*** *Given how I've re-designed the course, there is no way I could fit a textbook to the course. Think of the text as a reference source that you can use to make your projects even more effective!*

Required text: Boggs, Sam, 2001, Principles of Sedimentology and Stratigraphy, 3rd edition, Prentice Hall, Upper Saddle River, NJ, 726 pp.

This is a good, solid reference book for sed/strat but it is expensive. I would recommend that you share costs on this book by sharing the book with a buddy.

Free, on-line text: Folk, R.L., The petrology of Sedimentary Rocks, Hemphill Publishing Co., Austin, TX.

This is an oldy but a goody! This book is meant to accompany a book like Boggs, with some really fundamental stuff in it. I may have you do a couple of readings out of it. To get to it, go to:
http://www.lib.utexas.edu/geo/FolkReady/folkprefRev.html

Course Calendar

Firm dates:

September 26-28: Sedimentology field exercise in Winona, MN (leave after class on Friday)
October 1-5: Department field exercises in the Badlands and Black Hills
November 4: No class (Geological Society of America conference)

November 27: No class (Thanksgiving break)
December 11 (last day of class): Turn in all projects with revisions for portfolio review (see below)

General dates:

Weeks 1-5 (9/4-30):	**Project 1, virtual field trip to the Jackfork Group, Arkansas** **Content:** Observation and interpretation of basic clastic lithologies, bedding geometry, and sedimentary textures (mainly grain size); sedimentary facies; sediment-gravity flow deposition; basic sedimentary petrography (rocks under the scope).
Weeks 5-11 (10/2-11/11):	**Project 2, depositional environments of the Jordan Formation (Winona, CA)** **Content:** Observation and interpretation of primary and secondary sedimentary structures; flume studies of bedforms; measuring a section; trace fossils; correlation; Walther's Law and intro to stratigraphy.
Weeks 11-13 (11/13-27):	**Project 3, basin-scale controls on sedimentary architecture, Jurassic Tank** **Content:** Autocyclic and allocyclic controls on sedimentation; tectonics, climate, and sedimentation; basin-scale sedimentary architecture; fluvial, coastal, and deltaic depositional systems.
Weeks 14-15 (12/2-11):	**Project 4, sedimentation and tectonics jigsaw** **Content:** Provenance analysis; paleocurrent analysis; sedimentary facies and plate tectonics

Course Requirements

This is a junior-level course in geoscience, with only an introductory geology course (GEOL 11x) as a prerequisite. I will not assume that you have had mineralogy, fundamentals of the lithosphere, or field camp. I will assume that you know the following:

1. The three main types of plate margins and, within this, the three types of convergent margins. You should be able to draw a reasonable cross section through these margin types and have a pretty good idea of the rock types that form in them.
2. You should know how to tell the difference between intrusive and extrusive igneous rocks and what those terms mean. You should be able to identify the major igneous intrusive and extrusive rocks in hand specimen: basalt, rhyolite, gabbro, obsidian, granite, andesite, and diorite.
3. You should know the difference between a chemical and clastic sedimentary rock.
4. You should be able to recognize a sandstone, shale, and conglomerate in hand specimen.
5. You should be able to recognize a limestone and a dolomite in hand specimen.
6. You should be able to identify quartz, feldspar (potassium and plagioclase), and micas in hand specimen.
7. You should know the difference between a rock and a mineral.
8. You should know what is meant by 'strike and dip.'
9. Given a reasonably simple geological map, you should be able to outline a geological history of the mapped region.

Evaluation

During the first week of classes, I will ask you to take a short survey/assessment to see where all of you stand in terms of your sed/strat knowledge. This will be an on-line assessment taken *via* the Blackboard website.

"The proof is in the pudding." What a stupid saying, but it applies here. I have outlined three, well-defined objectives above, essentially the three things that I want you to be able to do at the end of this course. At the end of the course, your ability to do these things will be determined as follows:

1. Most of the short, in-class assignments that we work on will require you to hand in some type of worksheet or write-up. These short assignments are designed to give you practice with the techniques you'll need to accomplish the projects, so I will look over them to make sure that you "got it", that you understood the main point of the exercise. I will also use these assignments to see where misconceptions might lie and to try to correct them. I will assess these based on the following criteria:

   - Did you put the effort in that was necessary to do the assignment?
   - Did you take some care in completing the assignment?
   - Did you get the main point?

   Don't expect me to grade these with a fine-toothed comb. I will assess these based on the following rubric:

Grade	Meaning
5	Put in more effort than required to complete the assignment; no grammatical/spelling errors (if a write-up is required); work is neat and professional; computations correctly done and answered (if calculations are necessary), work is easy to follow; clearly understands the main point; contains unusually insightful or in-depth commentary or analysis.
4	Put in sufficient effort to complete the assignment; no grammatical/spelling errors (if a write-up is required); work is neat and professional; computations correctly done and answered (if calculations are necessary), work is easy to follow; clearly understands the main point; shows a degree of insight and effort beyond the average.
3	Put in just enough effort to complete the assignment; work is neat and professional; one or two grammatical/ spelling errors (if a write-up is required); computations correctly done and answered (if calculations are necessary), but work difficult to follow; appears to have understood the main point, but some doubt remains in my mind.
2	Didn't quite complete the assignment as outlined; more than two grammatical/ spelling errors (if a write-up is required); work is somewhat sloppy and unprofessional; computations incorrectly done and answered (if calculations are necessary); evidence suggests that the main point was mostly missed.
1	Assignment essentially incomplete; many grammatical/spelling errors (if a write-up is required); work is sloppy and unprofessional; computations incorrectly done and answered; little evidence that the main point was understood.

2. Some assignments will require more effort on your part and may feel a lot like a typical lab exercise. These assignments have the same general goal as the short, in-class assignments: to give you practice with specific techniques you'll need. In many cases, I will use the same rubric outlined above, unless the assignment requires its own, custom rubric.
3. **The four projects form the core assessment tools of the course. You will do some of the work on these projects outside of class, but a lot of the work that we do in class will be directed toward completing these projects.** The final write-ups for these projects will be assessed based on the rubric above with additional feedback from me. However, perhaps more important than the individual grades on these projects will be an assessment of how you have progressed throughout the semester. As a result I offer the following:

   - You must turn in your original write-ups *for all four projects* by the last day of classes (**not the day of the final**). This is *in addition* to handing each of these in separately at the specified due dates. I will use this as a portfolio to assess your progress toward achieving the objectives I laid out above.
   - You may improve the grade on any individual project write-up by revising it and turning it in by the last day of classes as an appendix to the project portfolio above. In this revision, you may use information from the entire course to improve the write-up for an earlier project.

4. There are no midterms in this course, but there will be a final exam. This exam will be in a take-home format and you can depend on the fact that it will test whether you can perform the objectives outlined above. How else can I effectively assess whether you achieved the goals if I don't put you in a new situation and let you loose? I'm still trying to decide on the ultimate format of this exam and I may solicit your input later in the semester.

Grading Procedures

Grade component	**Weight**
In-class and homework assignments	10%
Longer, lab-like exercises	10%
Project 1: Virtual Jackfork Group	15%
Project 2: Jordan Fm. Depositional environments	20%
Project 3: Basin scale controls on stratigraphy in Jurassic Tank	20%
Project 4: Sedimentation & tectonics	10%
Portfolio review of all four projects (including revisions, if any)	5%
Final exam	10%
Total=	**100%**

Your feedback

How many times can I re-state this? I have re-designed this course and the format is quite different. I will be trying new techniques throughout the semester, as well as using some old favorites. I would very much appreciate your feedback on how the course is going, what is working, what isn't working, how it can be improved. You have several routes that you can take to give me feedback:

- I have set up a discussion board on the course Blackboard site (under the "communications" button) that is for course feedback only. You can post to this discussion board anonymously, but your anonymous comments will be read-able by the entire course. In this way, someone can post a comment and others can respond to it.
- You can e-mail me directly or talk to me. It's not anonymous, but it's very effective.
- You can slip an anonymous note under my door or put it in my mailbox in OWS153.

How to succeed in this course

I want all of you to succeed in this course. There would be nothing that would make me happier if you all came out of the class with the ability to interpret sedimentary strata in an effective and meaningful way and to be able to explain why it is important to be able to do this. I define what is meant by "effective and meaningful" as the ability to walk up to an unknown outcrop, or to be handed a graphical depiction of some sedimentary strata, and make the initial, detailed observations and process interpretations that will allow you to come up with a well-substantiated hypothesis about the environment in which the rocks were formed. I will work with you to achieve this goal. However, you have a lot of the responsibility here.

First, in my mind, to do "A" and "B" work, you have to do above average work. Merely completing the assignment in a perfunctory way is "average." For many of my assignments, there is no "right" answer, but there are some answers that are better than others. "Better" usually means greater depth, more detail, more care in crafting a response or a write-up, more organization that shows that you understand how things fit together. You may have completed an assignment and gotten the basics "right," but I want to see that you have gone that extra step and understood the material in some depth. So, you will do much better in this course if you push yourself beyond your 'comfort zone' and dig deeper into the material.

Second, it is very important that you be able to make careful observations. The operative word is "careful", not "correct." Usually, the second flows from the first, but not always. I have found that, in order to make careful observations, you need practice; you also need to be *present* and *focused*.

Third, bring your curiosity to class. You have an opportunity to learn how to read the pages of the Earth's history. I would think that this would be sufficiently interesting to spark your curiosity. Don't be afraid to be a 'geek.' Ask questions. Make sure that you 'get it.' If we're all geeks together, than no one is really a geek anymore, right?

Fourth, be willing to learn. You may feel that PCs are much better than Macs, that you'll never need to use Excel, that Adobe Illustrator is a pain in the butt, that statistics is painful. That fact is that, even if you're right, your ability to learn new things will expand your mind and will give you tools to do way more than just geology. I am obsessed with giving you tools that you can *use* in your future and learning new stuff can be challenging, but it's also great fun.

So, in addition to the more metaphysical things outlined above, here is a list of more mechanical things that will help you to succeed:

- Revise your writing. Don't ever hand me a first draft. Better yet, have someone else edit it.
- Talk to your classmates about things you don't understand. Use the course discussion board to ask questions of the whole class. It may be that your amigo in class will be better at explaining something than me.
- Be neat. Sloppy work is almost offensive to me and most certainly effects your grade.
- Bring your hand lens and grain size card to class every day.
- Use your textbook as a reference tool, not just the place to go to read assigned readings. If I asked you the question "what is seismic stratigraphy?" you could go to the book and figure it out. So, if you find yourself asking yourself a sedimentology-related question, go to the book to answer it. This will help you in terms of 'going the extra mile' to produce quality work.
- In the field, take careful notes.

I guess that's all I can think of right now. You could probably add to the list. If you do, could you share your ideas with me???