

James Madison University

Department of Geology And
Environmental Science

SYLLABUS
GEOLOGY 364

<http://csmres.jmu.edu/geollab/Fichter/Geol364/Geol364.html>

STRATIGRAPHY AND BASIN ANALYSIS

FALL, 2002

CREDIT HOURS:	04
BUILDING/ROOM: TIME:	Room 209 Miller Hall MWF 9:05 - 9:55
LABORATORY: LAB TIME:	Seven Saturday field trips See enclosed schedule
INSTRUCTOR: OFFICE: OFFICE PHONE: E-MAIL: HOME PHONE: OFFICE HOURS:	Lynn S. Fichter, Professor Miller Hall, Room No. 233 568-6531 Fichtels@jmu.edu 434-3781 M 8:00 - 9:00; T/Th 8:00 - 9:00; By Appointment, but any time I am in my office, most of the time, you may come by to see me
FINAL EXAM:	Monday, Dec 9, 8:00-10:00
TEXTS:	& Copy Center: Notebooks (2) of Lecture/Laboratory Illustrations & Plus a diversified reading list

LABORATORY VOUCHERS: This semester the university is assessing a charge for chemicals and other consumable items used in laboratory courses. Consequently, during the first two weeks of classes, each student in this course must obtain a paid "laboratory voucher" from the bookstore. Failure to obtain a voucher will lead to administrative withdrawal.

INTRODUCTION

Today, even more than in the past, the subject of stratigraphy is too large, diversified, and rich to be summarized in one semester. Both in the breadth of the discipline, and the depth of each subdiscipline, as well as the interdisciplinary nature of most of it, the subject has become increasingly more complex and diverse. Most of these advances have been the direct result of research by the exploration (gas and oil) industry which has developed progressively more powerful and sophisticated geological, geophysical, geochemical, and mathematical tools for exploring the earth, and hired armies of some of the best geologists in the world to do the research. These advances continue apace across a broad front. As a result, basic stratigraphic subject matter which 20 years ago took an entire leisurely 17 week semester to cover must now be condensed into a few weeks in order to have time for the numerous new concepts which have developed, and which must now be taught in only 15 weeks.

Distinctive trends in the evolution of "soft rock" geology are recognizable. In the late 1960's and early 1970's geology was emerging from the geosynclinal phase of its theoretical history, and synthesizing geosynclinal concepts with plate tectonic theory was a major project. It was known there was a relationship between the sediments which filled a depositional basin and the tectonics which formed the basin, but an accurate general theory did not exist to explain the relationship. Since the 1960's much progress has been made toward this synthesis.

In the 1960's soft rock geology was in a phase of description and classification, working out the petrology (description and classification) of sedimentary rocks and classifying sedimentary structures. We pretty much knew what the structures were, but had little understanding of how they formed. It was during this time the study of carbonate and clastics became so specialized, since the techniques required to explore each are distinctive.

The next phase focused on sedimentation when the basic physics of how sediments are transported and deposited was worked out. General theories of fluid dynamics and flow regime allowed us to interpret the processes under which individual sedimentary structures formed. This work is not complete, however, and future developments will almost surely need to incorporate some of the new concepts of chaos and complexity theory. That task has barely begun.

The sedimentation phase evolved into a phase when the recognition and identification of sequences of sedimentary structures (e.g. Bouma, point bar, etc.) and their meaning was dominant. This evolved into the study of depositional environments (depositional systems) and how they are recognized in outcrop.

Simultaneously with all these developments were almost unimaginable advances in exploration tools related to geophysics, such as advanced well logging techniques and seismic stratigraphy, which gave

us ways of looking at the earth as revolutionary as the invention of the telescope for astronomy and X-ray for medicine¹.

Today research is actively focused on basin analysis and sequence stratigraphy. Basin analysis is the newest synthesis of tectonics and the study of sedimentary rocks and by far the most interdisciplinary. It is epitomized by the publication in the past several years of at least a half dozen books on the subject. Basin analysis begins with the geophysical lithospheric mechanics of how tectonic basins form, explores the controls on basin stratigraphy, and the depositional styles of various basin fills.

Simultaneously today with basin analysis is active theoretical development in sequence stratigraphy which explores the results and implications of cyclical eustatic sea level changes on the patterns in the stratigraphic record (old concepts of transgression and regression revisited).

The message of this brief history is that all the knowledge gained in the past two decades must be brought together into one integrated series of theoretical models which apply and explain how all the knowledge fits together. It is the basic and essential knowledge now needed to be a professional geologist. The educational implications of this are just as profound. Twenty years ago a good course in soft rock geology taught you the facts and techniques necessary to do the basic observation and descriptive work required of a geologist.

Today, however, these basic facts and competencies are but a small part of the preliminary information necessary to master where the discipline is right now. We can now observe and study rocks in the field with such sophistication that the beginning student of the earth can be hopelessly out of touch without an introduction to all the theories which lie behind our understanding. At the same time our theories are numerous and sophisticated enough that it can be difficult to integrate and place them all in perspective. Bodies of information, such as principles of sedimentation, depositional models, regional studies, etc. which not too long ago seemed to be the be-all and end-all of most introductory courses in soft rock geology have now become just essential tools in the study of the overarching tectonic, eustatic, and basin analysis models now under active research.

Therefore, it will not be easy to accomplish everything necessary to give you a balanced introduction in one semester to this so very diversified subject. It requires work, discipline, and dedication on both your part and mine. And because of the short amount of time available there are subjects we will not even touch on, such as biostratigraphy and its essential role in basin analysis, carbonate depositional systems and their evolution through time, seismic stratigraphy, and well logging techniques.

The descriptions below outline the procedures, requirements, and rules for the course; refer to them frequently. They will be your guide to the labyrinth of learning we are about to enter.

¹ Describing this history in phases does not mean that research in each area came to an end with the new phase. Refinements and extensions continue in all areas up to the present day. For example, the study of fluid dynamics and flow regime have been based on classical principles in physics, but the turbulence which accompanies moving fluids is a chaos phenomena. The lesson is, no knowledge is writ in stone forever. Even "basic" concepts need to be rethought and relearned in new contexts.

REQUIRED FIELD EQUIPMENT

You need the first 6 items in the table below for the first Saturday of the semester for the first field trip. The rest of the field equipment (7 - 9) is necessary by the third field trip of the semester.

In addition to the items in the table below you should have a hat, sun screen, and a water bottle. In the early fall outcrops can be very uncomfortable places to work. On a clear hot day the high 80° temperatures are bad enough, but the rocks are also radiating a lot of heat and the temperature can be very uncomfortable.

1. Rock hammer	5. Field boots and field clothes	7. Drafting equipment; ruler, drawing triangle, protractor, trig calculator
2. Hand lens - 10 X	6. Field notebook (ideally a surveyors book with hard back, sewn binding, and waterproof paper, but any book which will fit into your back pocket and take a beating will do).	8. Jacobs Staff (purchase, borrow, or make one; ask for instructions to make a Jacobs Staff)
3. Texture scale (buy one from bookstore, or make: ask for instructions)		9. Clipboard
4. Acid bottle (a plastic eyedropper bottle from a pharmacy works fine)		

WHAT IS REALLY IMPORTANT IN THIS CLASS *Or, What You must Learn to Do Well*

We are going to do many things this semester. Most of them will probably seem technical and nit-picking to you. You may or may not discern a pattern in all of it. But every part of this class has been planned and included because it enhances the achievement of three goals - three goals which reach to the center and the whole of stratigraphy, and of science. I cannot teach you these goals, but I can help you in your struggle to achieve them.

You can learn all that's technical and nit-picking in this class but if you don't improve in these three goals your time has not been well spent.

GOAL # 1

To look at rocks ... and see processes, see sequences of processes, see environments, see tectonics (all in your mind's eye, of course.)

- (It is the activation and development of the creative imagination.
- (It is the creative and intuitive synthesis of numerous individual experiences into a model which logically makes sense.
- (It is to see in the mind's eye the weaving together of the spatial and temporal which constitutes earth history.

GOAL # 2

To understand the difference between theory and fact, and observation and interpretation, to be able to move back and forth between them with accuracy and precision, and to be able to creatively dance with and extend them into the unknown.

GOAL # 3

To take what exists in your creative imagination and convince others you're right. That is:

- (To clearly describe in writing what is in your imagination.
- (To logically demonstrate in writing the validity of your imaginative model.
- (To create images (striplogs, drawings, charts, graphs, etc.) which accurately and unambiguously illustrate and embody your models.
- (To convincingly present your ideas in a scientific paper.

Along the way, while learning these things, you will develop other traits characteristic of an educated scientist, such as the importance of historical context, scientific and intellectual integrity, critical observation, logical analysis, hypothesis formulation and testing, abstraction, persistence, synthesis, and evaluation.

It is my firm belief that all this learning is a cooperative venture between you and me, and between you and your working partners. Learning how to become a scientist, how to creatively interact with other scientists, is not a zero-sum game (a zero-sum game is one where the goodies are strictly limited, and if you don't grab yours first there won't be any left). The world is too diverse and rich; there are more than enough rewards for everyone. And through cooperation (biologically this is called reciprocal altruism) we can increase the total pile of goodies in the world. But also, some of the best rewards are intrinsic, what you gain not because you need to beat someone else but because of your own curiosity and internal satisfaction with doing something well. You are not competing for my interest and attention. I take great pleasure in helping and watching other people make discoveries, about nature and about themselves. I hope you will too.

***Strive to Maximize the
Non-Zero-Sumness of the World***

GRADING

The grading scale is:

LAB: 43% total

- " 5% - Reproducing the Shenandoah Valley Stratigraphic Section ²
- " 8% - Rock Specimen I.D. and Interpretation of Valley Formations ³
- " 30% - Final draft of research paper

LECTURE: 57% total

- " 15% - Test Number 1 - Philosophy and Facies Elements
- 15% - Test Number 2 - Sequence Theory
- 15% - Final Exam - Depositional System

Scheduling depends on how quickly material is covered and a date convenient to the majority of the class. Each test is scheduled over a 2-3 day period and you may take the test any mutually convenient time in that period (discussed in more detail as the exam approaches). You should bring a clean copy of the questions with you to take the exam.

- " 12% - Exercises in scientific reasoning (see description below). Because of the size of the class the critical reasoning problems may be reduced or eliminated this semester. If so the 12% will be spread among the three tests.

TESTS

The two tests and the final exam are all the same. Final exam is not comprehensive. Tests are computer graded, multiple choice and true/false. Sample tests are on the course web site so that you have a good idea what they are like, and how to prepare.

EVALUATING AND GRADING TESTS

- e Each question is read anonymously and assigned a separate grade. Test and research paper grades are based on the 12 point scale. Grades of all questions **from each test** are averaged, and weighed by the appropriate percentage value of each test.

- e The 12 point grading scale is as follows:

12 - 11 = A+	8.9 - 8 = B+	5.9 - 5 = C+	2.9 - 2 = D+
10.9 - 10 = A	7.9 - 7 = B	4.9 - 4 = C	1.9 - 1 = D
9.9 - 9 = A-	6.9 - 6 = B-	3.9 - 3 = C-	No D- grades

- e The following procedures apply to the 12 point scale.
 - L No rounding of test scores or final averages is done (although fractional scores are possible).

² This test will be taken Saturday morning before we leave for the first field trip. See Lab schedule.

³ This test will be taken Friday afternoon before the third field trip. It will consist of two parts: (1) identifying Valley formations from hand specimens, (2) answering several critical reasoning problems dealing with the geologic history of Virginia.

- L Test or assignment grades can be in the negative range (e.g., -2)
- L Grades for each exam are calculated by adding together all question grades, finding the average, and multiplying that times the percentage. Thus, the more questions that are answered, the less each one is worth in the total (that is, the less damage one bad answer can do, and the less good one superb answer will do.)
- e Failure to take any test or complete any assignment results in the loss of one final grade for each test/assignment not completed. In addition, an "0" will be averaged into the final grade for each missed test/assignment before the final grade is lowered for missed assignments.

AVOID PLAGIARISM

Plagiarism is using someone else's work as if it were your own. You are expressly forbidden to read, refer to, or use in any way any critical reasoning solutions, papers written, or any other work done by past students. I know past papers are floating around on disk or in hard copy. Avoid the temptation to look at them.

On the other hand, in doing your research you are allowed to use any of the published papers provided in the laboratory. And, of course, you will properly reference any of these papers you use for any ideas you got from them (instructions later).

The object here is for you to learn as much as you can about the process of doing science. The less the work is yours the less you will learn, and the worse off you will be in the long run.

EXERCISES IN SCIENTIFIC REASONING

NOTE that because of the size of the class this semester these problems may be reduced or eliminated.

To be a scientist one of the things you must learn is to examine evidence critically, establish a line of reasoning, and reach a conclusion or interpretation. What's more, you need to be able to do this in writing so that it stands up to critical review.

There is only one way to learn this - practice, practice, practice. This semester you will get lots of practice. Several different sets of critical reasoning problems will be assigned during the semester, some dealing with field trip material, some with lecture material, and some dealing with sedimentary structures. The organization and format are similar to those in Geology 230, although for those unfamiliar with these problems detailed instructions are provided with the first set of problems handed out.

STRATIGRAPHY LABORATORY

Fieldwork is an essential and integral part of virtually all studies of stratigraphy. To be successful in stratigraphy one must be proficient and knowledgeable in the field. These practical skills are not quickly or easily gained. They require hard work, persistence, concentration, frustration, and practice.

Proficiency in the field involves learning how to observe, which means you must not only know what to look for (i.e., the application of knowledge from lecture to what you see in the outcrop) but must also see what you are not looking for (a skill called serendipity).

If you did not learn how to draw using Betty Edwards book Drawing on the Right Side of the Brain, as I asked you to in the pre-registration information, you are now handicapped and at a disadvantage. Get the book and do the exercises! Learn how to observe.

The lab requires living with and becoming absorbed in the continuous struggle to understand, a probing curiosity, question asking, work under uncomfortable or obnoxious conditions, and the ability to continue to make detailed observations and take accurate notes even when you are too hot, cold, tired, thirsty or hungry to care any more. All of this requires practice. The laboratory is designed to give you this practice while developing your skills in field note taking, section measuring, section interpretation and report writing.

- (1) ALL FIELD TRIPS ARE REQUIRED. **NO EXCEPTIONS**. See schedule on next several pages. Even if you do miss a trip for whatever reason, you will be responsible for the work. If you cannot make the trips you should withdraw from the class.
- (2) ALL FIELD TRIPS ARE RUN RAIN OR SHINE. Be sure to provide yourself with proper clothing and a waterproof parka should conditions necessitate. Some alternate dates exist during the semester to allow postponing of some trips if the weather is particularly lousy.
- (3) ON ALL FIELD TRIPS BRING YOUR: rock hammer, hand lens, texture scale, acid bottle, field notebook, pencils, felt tip marker, concentration, and serendipity. Other special equipment for some trips are listed in the Descriptions and Objectives of Field Trips at the back.
- (4) For those of you who normally eat in the D-Hall, make arrangements to prepare a bag lunch on those days we are out all day (which is every trip but the third). You may also want to bring snacks and drinks for the first two field trips; eating is very irregular, and the days are long.

CONFERENCES AND PAPER READING

One major project of this course is the writing of a scientific paper based on field research. If the class size is small each person writes their own research paper. If the class size is larger then the papers are jointly written by each team doing the field work.

Scientific papers are very sophisticated pieces of work. In one semester you cannot become expert. Expert requires much experience and practice, which you begin to learn here. Some of you may come into the class better writers than others. I cannot change that, and the best each of you can do is begin where you are and struggle to perfect your skills. One of the ways I can help you, however, is to provide you with frequent feedback on your work. We will do this two ways.

CONFERENCES: About one week after (in the summer, a few days after) each section measuring field trip, you and your partner will have a conference with me where you explain your strip log while I ask

you questions to probe your field techniques, knowledge of the literature, knowledge of things learned in lecture, and in general probe your understanding (more information later).

PAPER READINGS: I am not going to read and edit in writing the early drafts of your papers. Rather, you are going to read them to me.

You (and your partner) are to make an appointment with me on or around the appropriate date (see Conference dates under Quick Field Trip Summary at end.) Each of you are to have written some parts of the paper by yourself. When you come to the Reading bring a photocopies for me and for your partner. Each of you will then read to me the portions you have written. Along the way we (you, me and your partner) will discuss your writing for its geological perspicacity, clarity, organization, grammar, etc. You will be expected to take extensive notes for changes to be made. I will take notes and compare your later drafts for the suggested changes and improvements.

For the final draft of the major paper I will collect the completed papers and accompanying figures and read them critically in light of all our previous discussions and finally assign a grade.

QUICK FIELD TRIP SUMMARY, WITH READING AND CONFERENCE DATES

(all dates are Saturdays, except where noted; every week
is listed so the calendar is sequential and complete)

WEEK 1. Aug. 31: **TRIP #1** - Shenandoah Valley Stratigraphy and the Geologic Evolution of Virginia

K (**TEST** on Valley Stratigraphic Section before we leave)

WEEK 2. Sept. 7: **TRIP #2** - Shenandoah Valley Stratigraphy and the Geologic Evolution of Virginia

WEEK 3. Sept. 14: **TRIP #3** - (On campus 3/4 day) Methods of Section Measuring
K (**TEST** on Recognition, Description and Interpretation of Valley Formations before we begin; may be done the Friday before; more information later)

WEEK 4. Sept. 21: **TRIP #4** - Section Measuring, Fulks Run

WEEK 5. Sept 28: NO TRIP - (Alternate trip date)

CLASS CONFERENCE: FRIDAY, OCT 4, 3:30 PM. Due date final version of Fulks Run strip log, list of lithofacies, etc. Strip logs will be posted, compared, and contrasted. Judging of best strip logs. (If there are class conflicts we may do this in the evening.)

WEEK 6. Oct. 5: **TRIP #5** - First section measuring, Major Project.⁴ (*Parents Weekend*)

CONFERENCES: THURSDAY, OCT 10 Signup list on door; first come first served. See Instruction Sheet for preparation and what to bring.

WEEK 7. Oct. 12: **TRIP #6** - Second section measuring, Major project.

⁴ I try to not schedule field trips on Parents and Homecoming weekends, but we have to schedule with sufficient time to complete projects before the end of the semester. Typically trips have to be scheduled on one or both of these weekends. This year, unfortunately, we have to be out for Parent's Weekend

WEEK 8. Oct. 19: Fall Break NO TRIP

CLASS CONFERENCE: FRIDAY, OCT 25, 3:30 During this meeting I will, with slides and diagrams, summarize the big picture paleogeography of your research project, including environmental and depositional processes occurring in the basin, and comment on some of the literature you will need to use in writing your paper.

WEEK 9. Oct. 26: NO TRIP - Homecoming

WEEK 10. Nov. 2: NO TRIP

CONFERENCES: THURSDAY, NOV 7 Signup list on door; first come first served. See Instruction Sheet for preparation and what to bring.

WEEK 11. Nov. 9: **TRIP #7** - Section measuring cleanup. A last look at the section to gather missing data, get questions answered, etc.

WEEK 12. Nov. 16: NO TRIP -

CONFERENCES: THURSDAY, NOV 21 Signup list on door; first come first served. See Instruction Sheet for preparation and what to bring.

WEEK 13. Nov. 23: NO TRIP -

WEEK 14. Nov. 30: NO TRIP - THANKSGIVING

WEEK 15. Dec 6 - FRIDAY - SEMESTER IS OVER

LAST DUE DATE: Friday, Dec. 6 6:00 P.M.

You may turn your paper in any time before this. But, paper must be turned in by the end of the day on the day above. Final grade of paper will lose 2 points (on 12 point scale) for every 12 hour time span, or part thereof, it is turned in after this time.

DESCRIPTIONS AND OBJECTIVES OF FIELD TRIPS

TRIP 1 AUG 31 SAT: SHENANDOAH VALLEY STRATIGRAPHY

LEARN SHENANDOAH VALLEY STRATIGRAPHIC SECTION.

- (You will be expected to reproduce the section from memory the morning of Trip 1 before leaving for the field. Getting the section correct the first time constitutes an A grade. If the section is not reproduced satisfactorily the test must be repeated until it is learned; each time the test must be taken the grade drops one letter. This test is worth 5% of your lab grade.
- (The objectives of these first two trips are many, and for that reason quite demanding.
 - Learn how to observe critically, and accurately record your observations as field notes.
 - Learn to recognize a large number of sedimentary structures, as well as other sedimentary facies elements (so you have some memory to draw on during lectures on these.)
 - Learn to distinguish noise from data.
 - Learn to distinguish between observation and interpretation.
 - Learn to distinguish between theoretical (Top-Down) and empirical (Bottom-Up) thinking.
 - Learn to recognize valley formations and their depositional environments.
 - Review geologic history of Appalachians.
- (Depart 8:00 a.m. (or right after everyone finishes the strat section test) Miller Hall parking lot. If section test is to be taken arrive by 7:30 in Miller 209. Return 7:00 p.m., plus or minus, depending on weather, size of the class, and other unforeseen events (one year we lost a transmission - that was a long day.) The bigger the class, the later we finish. Bring snacks and lots to drink. Lunch is late. We will stop at "Burger Biggie" for lunch, or pack your own. There are few places for pit stops; use the bushes.
- (Bring **Field Trip Notebook** plus your field notebook and field equipment.
- (No reports are due, but on the Friday before Trip 3 you will be tested on this material. Test will consist of: (1) identification of valley formations from hand samples (see test format in notebook of lecture/lab illustrations), (2) several critical reasoning problems requiring solution based on your field trip experiences and any other knowledge you have garnered. 8 % of lab grade.
- ; There will, of course, be a set of **Critical Reasoning** problems handed out at the last stop dealing with the geology seen. Due in Monday at class time.

TRIP 2 SEPT 7 SAT: SHENANDOAH VALLEY STRATIGRAPHY

- (See description under Trip 1. During this trip we will visit many of the formations missed on the first trip.

TRIP 3 SEPT 14 SAT: METHOD OF SECTION MEASURING

- (Work will be done on campus; report to Miller 208, 8:00 a.m. for test, and introduction to section measuring techniques. Will finish by mid-to-late afternoon.
- (Bring notebook, pencils, Jacobs Staff, calculator with trig functions, drafting equipment. Have assigned a Brunton compass.
- (See outline of the lab sequence in the notebook of lecture/lab illustrations

- (Each person will work with a field partner. Partners will be assigned.

TRIP 4 SEPT 21 SAT: SECTION MEASURING, FULKS FUN

- (Objectives are to introduce you to the art of measuring a stratigraphic section and to some characteristics of tidal-near shore carbonate environments.
- (See handout for further guidelines on work to be turned in.
- (Depart 8 a.m. Miller Hall parking lot. Return sometime in the late afternoon. Bring your lunch.
- (Each person will work with a field partner. Partners will be assigned.
- (See Summary Field Trip Schedule for CONFERENCE dates; Be prepared to explain your strip log and interpretations to date, including all lithofacies (with possible interpretations), formation contacts associations, sequences, and cycles.

TRIP 5 OCT 5 SAT: MAJOR PROJECT: FIRST SECTION MEASURING

- (Objectives are to further your practice of section measuring and interpretation, but also to become familiar with shelf/slope, near shore marine and terrestrial systems. You will not be expected to finish measuring the entire section so you will not be as rushed and cramped as at Fulks Run.
- (Depart 8 a.m. Miller Hall parking lot. Return by 6 p.m. Bring your lunch, we are out in the middle of nowhere.
- (Work in pairs. Choose your own field partner and give me a list of your team before leaving for the field.
- (See Summary Field Trip Schedule for CONFERENCE date.

TRIP 6 OCT 12 SAT: MAJOR PROJECT: 2ND SECTION MEASURING

- (You are expected to finish measuring the whole section on this day with enough data to draft a detailed, high quality publication quality strip log.
- (Depart 8 a.m. Miller Hall parking lot. Return by 6 p.m. Bring your lunch, we are out in the middle of no where.

TRIP 7 NOV 9 SAT: MAJOR PROJECT: FINAL VISIT

- (Questions frequently come up while drafting your strip logs, or during conferences, or while you are reading the literature, making interpretations, or writing sections of your paper. This trip is to get all those questions answered and gather what ever last minute data you need.
- (Depart 8 a.m. Return when we are done; usually late afternoon.
- (See Summary Field Trip Schedule for CONFERENCE dates and paper due date. This paper is worth 30% of your final grade.