A QUANTITATIVE ANALYSIS OF THE EFFECTIVENESS OF DIRECTED-
DISCOVERY TEACHING METHODS AND WEEKLY QUIZZES
IN A STANDARDIZED INTRODUCTORY EARTH SCIENCE
LABORATORY COURSE

By

Julia Gail Johnston

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in the Department of Geosciences

Mississippi State University

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A study was conducted to determine the effects of directed discovery-based teaching methods and weekly quizzes on learning in an introductory geosciences laboratory course. Assessment was accomplished using percentages of correct responses to questions on two tests, using percentages from the first semester of the study as a baseline to which data from each subsequent semester were compared to determine the effects of each introduced study variable. Student evaluations of value, meaning, and enjoyment of the course were investigated through the use of an essay question at the end of the second test. The study revealed that directed discovery-based methods were successful for teaching some subject material, but not for all, and that the method did not necessarily enhance learning of scientific vocabulary. Weekly quizzes resulted in improved learning in all subject areas. Simultaneous use of traditional and directed-discovery teaching methods as well as weekly quizzes is recommended.
DEDICATION

I would like to dedicate this paper to Dr. Hulon Madely, who is my daily inspiration. I will always remember to aspire to be the kind of geologist, the kind of teacher, and the kind of friend that he is.
ACKNOWLEDGEMENTS

The author wishes to express her sincere appreciation to many people without whose help this study would never have been accomplished. First, my thanks to my committee chair, Dr. Brenda Kirkland, for her endless patience and understanding through the whole process of creating this work. Thanks is also due to rest of my committee members, Dr. Chris Dewey, Dr. Jamie Dyer, and Dr. Leo Lynch for working within the compressed time frame for pulling this paper together, and for their help with the frustrations of the research and the writing process. Thanks to my fellow graduate students, who cooperated, mostly without complaint, with the constant changing of their teaching methods and for supplying me with the classroom time and the data necessary for the study. Thanks to all of the Earth Science I lab students who agreed to be my subjects for the study and allow me to use their grades and their images for this paper. Lastly, I’d like to thank my family, and especially my husband, Rick, who have allowed me the freedom from responsibilities at home to dedicate the time I needed to this degree.
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CHAPTER I

INTRODUCTION

The objective of this study was to conduct a quantitative analysis to determine the most effective teaching methods for an introductory college-level laboratory course in geosciences. Different methods of teaching the course to a group of students that consisted mainly of non-science majors were compared. The research hypothesis was that the use of directed discovery-based teaching methods would be more effective than PowerPoint-driven lectures given by teaching assistants followed by completion of lab manual or pre-lab exercises for teaching basic introductory earth sciences concepts. It was expected that the directed discovery-based method would result in more effective learning of the course material. In addition, the effect of weekly quizzes on learning was investigated.

The methodology used in this study was to quantitatively assess test material in an introductory earth sciences lab course. The development of the methodology, choices of subject matter for the labs, production of PowerPoint-based lectures, creation of directed discovery-based experiments, writing of pre-lab exercises, lab exercises, quizzes and tests, and interpretation of the data required that the researcher have a graduate-level understanding of geologic concepts and processes. In addition, it was necessary for the
researcher to have experience in the classroom and leadership abilities to obtain the cooperation of the laboratory teaching assistants who act as instructors in the course.

Research into the demographic distribution of the students in geosciences courses has been the focus of a minority enrichment program (Kirkland, 2006; Milliken and Kirkland, 2006). A profile of the student enrollment in this lab indicates that the sample set is representative of the university as a whole in gender, ethnicity, class standing, overall grade point average, and major field of study, with the sole exception that engineering majors are underrepresented. The sample size of 200-300 students who take the Earth Science I Lab each semester represents 1.5-2% of the entire undergraduate student body at Mississippi State. The size of this data set is sufficiently large that it could be assumed to be statistically representative of the student body as a whole (Burt and Barber, 1996).

The most effective methods for teaching science have been a matter of considerable debate among American educators for many years (For reviews of literature, see McDonald, et. al., 2005; Libarkin and Anderson, 2005). While most teachers would agree that a basic education in science is essential to a well-rounded education, exactly what that basic education should entail and how it should be taught has been the subject of articles in education journals throughout the last 100+ years.

Traditional education in science usually consists of teacher-directed learning in which the material covered, as well as the methods by which that material will be presented and the students’ learning assessed, are determined by the educator. For the past 60 years or so, federally-funded programs have driven the prevailing methods in
America’s science classrooms to include laboratory experiments designed to enhance the students’ understanding of science through hands-on experience (Carin and Bass, 2001). Most modern high schools are equipped with laboratories in order to facilitate these experiments, which have been considered vital to the scientific educational experience (Hofsteina and Lunetta, 2004).

In the 1960’s, an innovation in the education of science was introduced with the concept of discovery-based learning (Kuslan, 1968; Wittrock, 1966). The basic concept is for the learning to be student-directed rather than teacher-directed, with the students drawing on their past experiences and natural curiosity to drive them to ask questions leading to the scientific investigation of new problems. In the modern American classroom with 25 or more students and only one teacher, it is usually impractical to allow students to follow their own curiosity on subject matter. In addition, the main ideas of discovery-based learning are that the process of developing the method of study and experimenting to find the questions as well as the answers is as important to the students’ education as the mastery of the subject matter. A basic tenet of the process is that by allowing the students to fail they will be led to further questions and eventual arrival at creative answers. The goal, therefore, is the experience of the process, and not necessarily the eventual learning of the accepted answers (Hendrix, 1961). All of these concepts, while theoretically appealing, prove to be impractical in the modern classroom setting, nor do they allow a student to develop a deep content base. While development of problem-solving and group dynamic skills may be important goals for primary and secondary students, they may still be left unprepared for the right-or-wrong approach of
standardized college entrance exams and most college curricula. Scientific study at the collegiate level focuses more upon the mastery of information than the exploration of scientific methodologies and use of the failure-to-success paradigm. One of the important outcomes of this study was to determine whether discovery-based methods can be utilized effectively to promote mastery of course material. The design of the discovery-based exercises themselves must be more focused on the goal of what Chiappetta and Adams (2004) call “content”, rather than emphasizing “process” or some combination of the two.

So much discussion has filled the professional journals over the past 40 years or so about the benefits and drawbacks of discovery-based learning, that an exhaustive literature review of the entire question is impractical. It appears that the mainstream of the educational community advocates the use of the system in theory, while recognizing the impracticality of its implementation on a large scale (Button, 1971; Carin and Bass, 2001; Harris, 2003; Leech, et. al., 2004; Libarkin, et. al., 2005; MacDonald, et. al., 2005; McConnell, et. al., 2003). As part of the acceptance of the idea, however, comes the prevailing belief that hands-on laboratory experiences enhance the students’ understanding of the subject matter taught by the less-involved methods of reading, listening to lectures, and note-taking. Some educators who advocate the more give-and-take approach of Socratic debate-based lecturing recognize directed discovery-based laboratory exercises as the next logical step (Paul, 1995; SERC, 2006; UNC-CH, 2001).

While many studies have been completed for the use of discovery-based methodologies at elementary and secondary levels (Castronova, 2002; Chiapetta and
Adams, 2004; Hofstein and Lunetta, 2004; NRC 2005), very few studies investigate this issue at the college level (Harris, 2002). Almost exclusively, the published studies deal with the way children learn, as opposed to the learning methods that will be effective for college students, who experience a transition through levels of cognitive development during the course of their studies. While many publications have contributed novel ideas for active participation in geosciences labs (Baker, et. al., 2004; Calderone, et. al., 2003; Guertin, 2005; Harpp, et. al., 2005; Mylroie, 1978), only one study was found that investigated what is being done by teachers in the college classroom (MacDonald, et. al., 2005). No studies were found that made a quantitative assessment of the effectiveness of hands-on experiments in a college introductory geology lab course.

The elimination of a requirement for Earth Science from many grade school and high school curricula has left a void in the education of American children. It is hoped that the interest generated through this hands-on learning experience in students who have not yet declared a major might provide a pool of otherwise-undiscovered geologists. While the study was conducted using students at Mississippi State University, the course and methods will have broad-based applications to many other, similar courses taught elsewhere. Only the final lab, which relates all of the concepts studied throughout the semester to the geology of Mississippi, would have to be revised for use in other institutions.

The results of this study should give insight into possible improvements in the way introductory science courses are taught in colleges. The information gained from this study will benefit educators in understanding the adult learning process and the
teaching methods that might best be employed to enhance learning of scientific course materials.
CHAPTER II

METHODS

IRB Permission Slips

Given that this study involved the use of human subjects, it was necessary to obtain approval by the Institutional Review Board (IRB) before the project could begin. IRB approval was granted on Nov. 10, 2004 (Appendix A). To comply with IRB standards, human subjects must be informed that their participation is entirely voluntary, and any information obtained or their permission or refusal to participate will have no effect on them or their grade in the course. A standard permission slip form was constructed and approved through the IRB office on campus as part of the application for IRB approval (Appendix A).

At the beginning of each semester, the researcher visited each section of the lab. The researcher introduced herself, explained the purpose and overall methodology of the study, and asked each student to give permission to participate in the study. It was reiterated that participation or refusal would not affect them or their grades in any way, and that participation was entirely voluntary. It was explained that answers from the Mineral and Rock Test and the Final Exam would be used as the data set for a study with the purpose of evaluating the teaching methods used in the lab course and how changes in
the teaching methods will affect learning of the course material. The students were assured that neither their names nor identifying numbers would be attached to their individual grades or performance on the tests or on the follow-up study, and that the data would be analyzed simply as percentages. It was explained that this is part of a Master’s thesis, and as such would be presented to the faculty and students of the department, retained in the MSU library, and possibly published in a professional journal and/or presented at professional conferences. Subjects were then asked to sign the front of the permission form if they gave permission for use of their test answers and grades for the study.

Next, the students were told that a follow-up study would be conducted three to four months after they take the Final Exam. It was explained that by providing their contact information, they were not promising to participate in the follow-up study, merely giving permission for the researcher to contact them and ask them to participate. It was explained that there would be a reward for participation in the follow-up study in the form of $6.00 in gift certificates to Wendy’s (which could be used in town or at the Student Union). Funding for the incentives would be from personal funds provided by the researcher. Subjects were then asked to complete the contact information and sign the back of the permission form if they gave permission to contact them for the follow-up study.

Finally, the students were asked to sign image waivers if they gave permission for photos taken by the researcher in lab to be used for the thesis, the thesis presentation, publication, or for presentation at professional meetings.
In total for the four semesters, 548 of 870, or 63% of students enrolled in the course, gave permission for the use of their grades and contact information for the follow-up study. The permission slips were locked in a secure location to protect the privacy of the students.

**Selection of Target Questions**

A review of all of the subject material for the course was conducted to identify a set of 25 target questions for this study. The questions were chosen to function as an overview of the course material, emphasize key concepts that are essential to understanding the Earth and its processes, and represent a basic knowledge base that the students might apply to the situations they encounter in their daily lives by simple observation of the world around them. Concepts from each lab were included in the target set, with particular attention paid to knowledge that might have further practical application outside the university. The list of target questions was edited by the professor who oversees the lab and all of the graduate students who teach the lab. The final list of target questions included 24 subject questions and one final essay question asking which was the student’s favorite lab and why. The target question set included seven questions from the Mineral and Rock test and 18 questions from the Final Exam (Table 1).
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<th>Q #</th>
<th>Question</th>
<th>Answer</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>The only difference between a conglomerate and a breccia is that conglomerates have rounded gravel-sized sediments and breccias have angular</td>
<td>The sediments in the conglomerate traveled much farther than the sediments in the breccia.</td>
</tr>
<tr>
<td></td>
<td>gravel-sized sediments. What does the shape of the sediments reveal about these two sedimentary rocks?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Where does the sediment that forms sandstone come from?</td>
<td>Mechanical/chemical weathering of pre-existing rock.</td>
</tr>
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<td>3</td>
<td>In Metamorphic rocks, what does the parent rock refer to?</td>
<td>The original rock before it underwent a metamorphic change.</td>
</tr>
<tr>
<td>4</td>
<td>What type of rock can be changed by a metamorphic event?</td>
<td>Igneous, sedimentary, and metamorphic rock</td>
</tr>
<tr>
<td>5</td>
<td>Forms from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation</td>
<td>Sedimentary rock</td>
</tr>
<tr>
<td>6</td>
<td>Forms from molten rock (magma or lava).</td>
<td>Igneous rock</td>
</tr>
<tr>
<td>7</td>
<td>An inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline</td>
<td>Mineral</td>
</tr>
<tr>
<td></td>
<td>structure.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Forms by changing from one form to another by intense heat, intense pressure, or the action of watery hot fluids.</td>
<td>Metamorphic rock</td>
</tr>
<tr>
<td>9</td>
<td>Which stress creates folds such as anticlines and synclines?</td>
<td>Compressional stress</td>
</tr>
<tr>
<td>10</td>
<td>Which stress causes reverse or thrust faults to occur?</td>
<td>Compressional stress</td>
</tr>
<tr>
<td>11</td>
<td>Which stress causes left or right lateral faults?</td>
<td>Shear stress</td>
</tr>
<tr>
<td>12</td>
<td>Which stress causes normal faults?</td>
<td>Tensional stress</td>
</tr>
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<td>13</td>
<td>You have just won the lottery and your friends tell you, “California is the place you ought to be” so you load up the truck and move to</td>
<td>Granite rock</td>
</tr>
<tr>
<td></td>
<td>Beverly (as in Los Angeles). You must decided on which property to build your mansion. Which land would you choose to make your home as safe</td>
<td></td>
</tr>
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<td></td>
<td>as possible from the devastating effects of an earthquake?</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>From the scenario in question #13, which of these choices would be the worst location to build on?</td>
<td>An old landfill now covered with dirt and grass</td>
</tr>
<tr>
<td>15</td>
<td>What is another name for 0° latitude?</td>
<td>Equator</td>
</tr>
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<td>16</td>
<td>The North and South poles are</td>
<td>Maximum latitude</td>
</tr>
<tr>
<td>17</td>
<td>What direction does the stream flow in Diagram L (labeled Question 64)?</td>
<td>Northwest to southeast</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>What feature is Berlson Lake (labeled Z) on Diagram O (labeled Question 67)?</td>
<td>Oxbow lake</td>
</tr>
<tr>
<td>19</td>
<td>What type of valley is characteristic of a straight stream channel?</td>
<td>V-shaped</td>
</tr>
<tr>
<td>20</td>
<td>What is the biggest problem associated with building jetties and groins?</td>
<td>They disturb the natural sediment transport and cause erosion</td>
</tr>
<tr>
<td>21</td>
<td>Exposed marine terraces, wide beaches, and salt marshes are features of what type of coastline?</td>
<td>Emergent coast</td>
</tr>
<tr>
<td>22</td>
<td>A submergent coastline can be caused by:</td>
<td>Sea level rising or the land sinking (subsiding)</td>
</tr>
<tr>
<td>23</td>
<td>What natural coastline feature can be used to determine the direction of the longshore current?</td>
<td>Spit</td>
</tr>
<tr>
<td>24</td>
<td>Where in the world today are ice sheets still present?</td>
<td>Antarctica and Greenland</td>
</tr>
<tr>
<td>25</td>
<td>Which was your favorite lab? Why?</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER III

TEACHING METHODS

Incremental Changes in Each Semester

The Earth Science I Lab (GG1111) is a stand-alone course and not part of the Introduction to Earth Science course (GG1113). There is a degree of autonomy, allowing the graduate teaching assistants (TAs) to develop the course and change the teaching methods for the benefit of the students. While many students take the lecture and lab courses concurrently, many have taken the lecture in previous semesters, and some have not had the lecture course at all. In a discussion with members of the faculty, the “ideal lab” was defined as a setting in which the students would be interested in the subject matter, motivated to learn and ask questions, and feel that the lab enhanced their understanding and learning of the subject matter for the lecture section if they were currently enrolled in GG1113. Students should consider the science learned in the lab to be valuable to their daily lives to enhance their motivation to learn (Dewey, 2005). Finally, we would like the students and TAs to enjoy the learning process.

The lab as it was being taught was a long way from our concept of the ideal. Comments from and attitudes of students in the classroom indicated that they were not recognizing the value, meaning, and benefits of their time spent in the lab, nor were they
having much fun. Instead, the majority of students expressed the opinion that the subject matter was boring and useless, the lab was too difficult, the lab was not helping them to do better in the lecture section, they saw no relevance to the information in their lives outside the lab, and it was their least favorite class. Those students who enjoyed the lab attributed this to the TA, who was trying her/his best to make the lab an enjoyable learning experience.

A plan of action was constructed using the “ideal lab” as a model. Incremental changes would be made at the rate of one per semester as the test variables for this study. Each semester’s variable was implemented with the intention of moving the lab closer to the ideal, while allowing tracking of the effects of the variable on learning of the lab material. Additionally, anecdotal information was sought from the TAs that indicated the effects of the changes on the perception of the value, meaning, and benefits of the course, as well as the enjoyment of the lab by the students and the TAs.

**Baseline: Spring 2005: Hand-in Labs and Two Tests**

The format for the baseline semester was “hand-in labs and two tests”. Each week covered a different subject, and students worked in pairs, but each turned in an individual lab assignment before leaving the lab. There were eleven lab exercises during the semester. At the end of the semester, the lowest lab grade was dropped for each student. In-class lab assignments counted as 25% of the final grade for the course.

The first test was the Mineral and Rock Exam (Appendix B), given during the fifth lab meeting of the semester. Each student received an individual box of minerals and rocks in front of him/her along with the test and an answer sheet. The questions on the
test were designed so that there were at least three questions that tested understanding of the concepts emphasized in the lab leading to each rock or mineral identification (ex. What is the streak of mineral J?). Each sample was identified in the question as being a mineral, an igneous rock, a sedimentary rock, or a metamorphic rock, because the goal was for students to understand the classification procedures for each type of rock and how to apply them, rather than simply how to tell a sedimentary rock from an igneous one. Most geologic concepts are understandable without specialized vocabulary and, because it was the goal of the course for the students to learn and retain concepts, the use of technical terminology was minimized in the questions. Understanding of the processes that create rocks, such as the types of volcanoes and magmas or depositional environments of sediments, was also tested. All questions were multiple-choice format to emphasize recognition of the correct information and eliminate ambiguity in grading, as well as spelling and grammar issues. There were two versions of the test (A and B) so that each pair of students who were lab partners and shared a table had a different version and different rocks and minerals, to prevent cheating. If questions were duplicated on the two versions, they were numbered differently. The Mineral and Rock Test consisted of 50 multiple-choice questions and counted as 25% of the final grade for the course.

The second test was the Final Exam (Appendix B) given at the end of the semester. Again, technical terminology was kept to a minimum and concept questions outnumbered memorization questions. Emphasis on understanding of concepts over memorization required the use during testing of the geologic tools to which the students were introduced during the lab meetings. Sets of full-sized topographic maps were
provided to each pair of students. Each student also received an individual folder that contained his/her test, answer sheet, diagrams, color photographs, and small maps that related to the test, as well as a ruler and a simple calculator. All questions were multiple-choice format, for the same reasons as on the first test. Again, there were two versions of the test (A and B) to prevent cheating. The two people who sat at the same lab table did not have the same version of the test or diagrams. If questions were duplicated on the two versions, they were numbered differently. Space restrictions necessitated sharing of the maps during the test, but the benefits to the students of utilizing the tools with which they were familiar and were expected to understand greatly outweighed the inconvenience. Mastery of all of the geologic tools and processes included in the labs following the first test was evaluated by 100 questions. In this baseline semester, the Final Exam score counted as 50% of the total grade for the course.

**Standardization**

To ensure that the target questions (and any other material contained on the two tests) were covered adequately in all sections, it was necessary to standardize the lectures given by the teaching assistant in each section, the lab exercises, and the tests. The researcher had the responsibility in her position as Lab Coordinator to construct the PowerPoint presentation (Appendix C) that was used each week for an opening lecture by each TA and for clarification during lab exercises. The Microsoft® PowerPoint presentation program allows projection of photographs and diagrams to be paired with or interspersed with text for use by the lecturer. Other responsibilities of the Lab Coordinator included choice of the lab exercises (Appendix C), procurement of the
proper materials, and provision of a key that each TA used to correct the labs. The responsibilities provided some degree of experimental control. A mandatory TA meeting was conducted every Friday afternoon, at which the current week’s lab was reviewed for problems and the following week’s PowerPoint and lab exercises were demonstrated. The researcher led the meetings, fielded questions and concerns, and facilitated resolution of any conflicts that arose.

**Introduction of the Mississippi Lab**

The last regular lab period before the Final Exam has traditionally been used to review the material the students need to study for the Final Exam. For this semester, the last lab period was redesigned as a discovery-based exercise (Appendix C). The exercise served the threefold function of giving the students new information about their home state, showing them how the information they learned in the course could be relevant to their day-to-day lives, and helping them to discover what part of the course material they needed to review in more depth before the Final Exam. The students left this lab period with a Final Exam Study Guide (Appendix C).

**Summer 2005: Introduction of Pre-Lab Exercises**

For this first experimental semester, the standard PowerPoint presentations and lectures, the “Hand-In Labs and Two Tests” format, and the identical Mineral and Rock Tests and Final Exams from the spring semester were retained.

Pre-lab exercises (Appendix C) were introduced for this term, and the effects that this first variable had on student learning and retention were tracked as part of the data
for the thesis. Pre-lab exercises were given to the students at the end of the lab period
each session to be completed as homework and returned at the beginning of the following
week’s lab session. Pre-lab exercises consisted mainly of vocabulary, definitions, and
delineation of the observations that would be required of the students during the
following lab. The answers were obtained from the student’s lab manual, mostly
covering defined key words. The pre-lab exercises should have been completed by the
students in 20 minutes or less each week. One hypothesis of this study was that a cursory
introduction to the vocabulary and other material before arriving in the lab would
improve understanding, learning, and retention.

Grading for the course required adjustment. It was decided the Final Exam had
been too heavily weighted in previous semesters, and that more emphasis should be
placed on completion of the hand-in lab exercises. The two tests together constituted
one-half of the points for the course, and each was weighted proportionally to the number
of lab meetings and the amount of information it tested. Completion of the pre-lab
exercise was weekly and its purpose was to enhance understanding of the subsequent lab
exercise. Pre-labs and lab exercises together comprised the remaining half of the points
for the course. It was necessary to choose a point value for the pre-labs that was heavy
enough to ensure that most students would take the time to complete the exercise, while
at the same time recognizing that participation in, and completion of, lab exercises
required more time and effort than pre-labs. The percentages then became 10% Pre-lab
exercises, 40 % Lab exercises, 20 % Mineral and Rock Test, 30% Final Exam.
Fall 2005: Directed Discovery-Based Instruction

In this semester, the directed discovery-based learning was implemented in all lab sessions. Pre-lab exercises, the “Hand-In Labs and Two Tests” format, and the grading scale from the summer semester were retained. Adjustments to both tests (Appendix B) were necessary to reflect the changes in the instruction methods, but care was taken to retain the target questions for this study without alteration.

Directed discovery-based lab activities (Appendix C) were introduced into the lesson plan of each lab session. The activities were self-directed by the students whenever possible, with the understanding that some instruction by the TAs might be necessary, depending upon the subject material being covered. Most lab exercises consisted of a series of leading questions that directed the student toward discovery of understanding of the subject material. When possible, PowerPoint lectures were eliminated altogether. If necessary, standardized lecture materials in PowerPoint were used, but broken into shorter segments, with students completing activities between segments as was appropriate.

A small number of extra-credit exercises (Appendix C) was added to the curriculum. The exercises were completely self-directed, as they were completed by the students outside of the lab and returned to the TA at the following lab meeting. The subject matter of the exercises was related to but not directly addressed in the lab meetings. The points for the extra-credit exercises were added to the lab exercise grade, allowing for some recovery in case of a low lab exercise grade.
Spring 2006: Weekly Quizzes

For this semester, pre-lab exercises, directed discovery-based lab exercises, extra credit assignments, and PowerPoint presentations from the previous semester were continued. Adjustments to both tests were necessary to reflect the changes in the instruction methods (Appendix B), but care was taken to retain the target questions for this study without alteration.

A change in the format from the “Hand-In Labs and Two Tests” format to “Weekly Quizzes and Two Tests” format was made. The students completed the same lab exercises as in the fall semester, which were checked for accuracy before the student left the lab, to ensure that the students had the correct answers from which to study for the following week’s quiz. The first task in lab each week was a multiple-choice quiz (Appendix C) on the previous week’s lab material. Quizzes were substituted in the grading scale for the hand-in lab exercises from previous semesters, and no lab exercises were turned in by the students. Each TA wrote his/her own quizzes, emphasizing the material in the manner that he/she taught it the previous week. All TAs were asked to include the target questions from this thesis on their weekly quizzes. The emphasis for the quizzes was intended to be on understanding of the concepts rather than memorization. Questions were derived from either lab exercises or pre-lab exercises. Quizzes replaced the lab exercises in the grading scale and constituted 40% of the total grade for the course.
Follow-up Study

Approximately four months after the completion of the spring, 2005 and fall, 2005 semesters, the students who gave prior permission were contacted by e-mail or telephone and asked to participate in the follow-up study (Appendix D). The follow-up study was held each time in the lab early on a weekday evening. The students were reminded that they had given permission for the contact, that the study would require about half an hour of their time, and they would be compensated with $6.00 in Wendy’s gift certificates for their participation.

The study consisted of the target questions for this thesis (Appendix D). The students were given no prior notice that the study would be a “quiz”, so it was assumed that they had no contact with the course materials for the previous four months since completing the Final Exam for the course. It was implicit that long-term retention of the target question materials was being tested by the follow-up study.

According to standard marketing response patterns, it was expected that 5-10% of students would participate. Unfortunately, the expectation was not realized, and a total of only 26 students participated in the study for the two semesters it was conducted. It is suspected that the incentive was not large enough to elicit the amount of effort required by the students to come to the follow-up study. The small number of participants necessitated elimination of the follow-up study from the thesis results because the numbers were not adequate for appropriate statistical analysis.
Evaluations by Teaching Assistants and Professors

At the end of each semester, the Teaching Assistants were asked to provide a short written evaluation of the semester. Feedback about lab materials, teaching methods, and general attitude of the TAs and the students was the goal of the evaluations. The same feedback was requested from the professors who hold oversight authority for the lab and the study.
CHAPTER IV

STATISTICAL METHODS

Collection of Test Answer Sheets

After the students completed the Mineral and Rock Tests and the Final Exams each semester, the answer sheets (Appendix B) were collected from the TA for each section. Each answer sheet was then stapled to the corresponding permission slip obtained from the student at the beginning of the semester, filed according to section number, and sorted alphabetically within each section. Answer sheets from the students who did not give permission for their inclusion in the study were filed separately and not used.

Spreadsheet

Each student’s responses from the Mineral and Rock Test answer sheet were entered into a spreadsheet by using a 1 if the student answered the question correctly and a 0 if the student answered incorrectly (Appendix E). The total at the end of the row was then calculated and doubled (because there were 50 questions on the test) to obtain a percentage score for the student’s test, which was double-checked against the TA’s grade on the sheet, to ensure accuracy. Columns were added to obtain the number of correct responses to each question, which was used to calculate percentages for analysis.
The same method of data entry was used for the Final Exams, with an entry of 1 if the student correctly answered the questions and a 0 if s/he did not. Questions 98 and 99 on the Final Exam asked the student which was his/her favorite lab and why and which was his/her least favorite lab and why. The answers to questions 98 and 99 were short answer or essay in nature, so codes of several letters were entered into these two columns to indicate each student’s answers.

After an alphabetical worksheet was generated for each semester, subsequent worksheets were obtained by a simple copy-and-paste procedure to separate the Mineral and Rock Test data from the Final Exam data, to separate the A and B versions of the tests, and to create worksheets that line up corresponding questions and eliminate names or any other identifying data from the data set. Only data from the final set of worksheets were used for summary, analysis, and graphing.

**Correlation of Questions**

Each test was generated as two versions, A and B, to reduce the possibility of cheating during testing. Most of the questions were identical, but numbered differently on the two versions. Sometimes, the questions were testing the same concept, but made use of different diagrams or photographs. Entire questions were sometimes eliminated from one semester and new ones inserted to reflect the changes made in the teaching methods and content material in the lab.

The same question had different numbers on the different versions and during different semesters, so each question was assigned a reference number which was used to
correlate student response. Care was taken to include the target questions every semester, and questions not used in all four semesters were eliminated from the data set.

**Learning-Level Analysis**

A system was developed by the researcher to distinguish the questions according to the skills required to answer them to determine whether the teaching method might have more impact on the learning of a particular type of question. Each question was assigned a learning-level value. The levels were defined as follows:

- **Level 1** – questions that require memorization of facts
- **Level 2** – questions that require students to use the tools learned in lab to recognize properties of minerals and rocks or derive information from maps or diagrams
- **Level 3** – questions that require students to interpret Level 1 or Level 2 information to draw conclusions, or that require mathematical calculations

The number of correct responses at each of these levels was evaluated to determine whether the study variables had more effect on learning and/or retention of the material for particular levels of questions.

**Statistical Analysis**

Summation of the columns on the correlated pages produced the total number of students who responded correctly to each reference question. The sum was then divided by the total number of students in the study for each semester to obtain a percentage of correct responses. The number of possible answer choices for each question was
determined (it varied from 2 to 5) and a percentage of correct responses that would occur randomly was calculated for comparison to the actual percentage of correct responses.

Comparison of data from all semesters was conducted by calculating the deviation of the percentage of correct responses on each question to the percentage of correct responses in the baseline semester. Analysis to determine the statistical significance of each question was conducted using a two-tailed, paired sample t-test, comparing Spring 2005 to Fall 2005, Fall 2005 to Spring 2006, and Spring 2005 to Spring 2006. The data from Summer 2005 was eliminated from the t-test analysis because the small sample size (15 students) made it statistically incomparable to the other semesters. Only those questions for which changes from one semester to another were found to be statistically significant (p<0.05) were examined and discussed in detail (Tables 2 and 3). Conclusions were drawn only from this subset of significant data.

Qualitative assessment of the effects of the changes in the teaching methods was also conducted to determine whether the goals identified as part of the “ideal lab” of increasing motivation to learn and enjoyment of the lab were met. Answers to questions #98 and #99 on the Final Exams for each semester asked the students which were their favorite and least favorite labs respectively. Totals and percentages of the categorical responses were calculated for each semester. (Appendix E).

**Graphing Techniques**

Data for each semester and each test were grouped by learning level, and bar charts were created showing percentages of correct responses for all semesters compared to number of correct responses that would occur randomly (Fig. 1-7). Bar charts were
generated showing deviations from the baseline using the same groupings. Finally, bar charts were generated including only the questions found to show statistically significant (p<0.05) changes from one semester to another.
Figure 1: Level 1 (Memorization) Questions from Mineral and Rock Tests

Figure 2: Level 2 (Recognition) Questions from Mineral and Rock Tests
Figure 3: Level 3 (Interpretation) Questions from Mineral and Rock Tests

Figure 4: Level 1 (Memorization) Questions from Final Exams – Questions 1-50
Figure 5: Level 1 (Memorization) Questions from Final Exams – Questions 51 – 100

Figure 6: Level 2 (Recognition) Questions from Final Exams
Figure 7: Level 3 (Interpretation) Questions from Final Exams
CHAPTER V

RESULTS

Correct Responses to All Questions

The data for this study consist of percentages of correct responses to questions on the Mineral and Rock Tests and Final Exams for each semester (Appendix B). Data from the Mineral and Rock Tests and the Final Exams are shown in Figures 1 - 7, grouped by learning level for ease of analysis. The number of correct responses to each test question is shown in Appendix E. The pink bars on the graphs represent the probability of a correct response to each question by random guessing, based on the number of answer choices available. The green bars represent the Spring 2005 semester, in which standardization of all lab materials was implemented to form a baseline with which all experimental variables would be compared in subsequent semesters. The yellow bars represent the Summer 2005 semester, in which the variable introduced was the inclusion of pre-lab exercises. The orange bars represent the Fall 2005 semester, in which the variable introduced was replacement of lectures by directed discovery-based exercises for each lab. The blue bars represent the Spring 2006 semester, in which the variable introduced was the replacement of hand-in lab exercises by weekly quizzes.

Data for Summer 2005 are included here for completeness, but are eliminated from further analysis because the small number of participants and the shortened schedule during summer courses precludes the data from being statistically comparable.
The percentages of correct responses expected from random probability is also included here for completeness, but is omitted from further analysis because it was determined that percentages in all semesters and on all questions was significantly \((p<0.01)\) above random probability.

**Correct Responses to Target Questions**

Data from the target questions (see Table 1) are shown in Figure 8. The follow-up study data are included here for completeness, but are eliminated from further analysis because the small number of participants in the follow-up study precludes the data from being statistically comparable.
Figure 8: Target Question Percentages for All Semesters and Follow-up Study

Key for Figure 8
- Spring 05 Baseline
- Spring 06 Follow-up
- Fall 05 Students
- Spring 05 Students
- Fall 05 Follow-up
- Weekly Quizzes
- Directed Discovery
Comparison of Statistically Significant Questions

Standardization occurred during the Spring 2005 semester to enable the use of its data as the experimental “control” or baseline to which all subsequent semesters would be compared following introduction of study variables. Tables 2 and 3 show questions that differed significantly (p<0.05) from the baseline in at least one semester of the study or in the cumulative totals.

Table 2: Statistically Significant Questions from the Mineral and Rock Tests.

<table>
<thead>
<tr>
<th>Q #</th>
<th>Question</th>
<th>Answer</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>M7</td>
<td>Which tool(s) is/are used to identify mineral hardness?</td>
<td>Glass plate, iron nail, penny, fingernail (all of the above)</td>
<td>Mem</td>
</tr>
<tr>
<td>M16</td>
<td>What texture below indicates an igneous rock is INTRUSIVE in origin?</td>
<td>Phaneritic</td>
<td>Mem</td>
</tr>
<tr>
<td>M21</td>
<td>Vesicles form from:</td>
<td>Gasses escaping from the lava</td>
<td>Mem</td>
</tr>
<tr>
<td>M23</td>
<td>Which type of volcano is the largest?</td>
<td>Sheild volcano</td>
<td>Mem</td>
</tr>
<tr>
<td>M46</td>
<td>An inorganic, naturally occurring substance that has a characteristic</td>
<td>Mineral</td>
<td>Mem</td>
</tr>
<tr>
<td></td>
<td>chemical composition, distinctive physical properties, and crystalline</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>structure.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M48</td>
<td>Forms from weathered (chemical or mechanical) fragments of rock,</td>
<td>Sedimentary rock</td>
<td>Mem</td>
</tr>
<tr>
<td></td>
<td>consisting of remains or secretions of plants/animals, or precipitation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M49</td>
<td>The basic building-block of all rocks.</td>
<td>Mineral</td>
<td>Mem</td>
</tr>
<tr>
<td>M01</td>
<td>What color is the streak for mineral J? (Sulfur)</td>
<td>Yellow</td>
<td>Rec</td>
</tr>
<tr>
<td>M33</td>
<td>What is the grain arrangement of sedimentary rock S? (Breccia)</td>
<td>Poorly sorted</td>
<td>Rec</td>
</tr>
<tr>
<td>M28</td>
<td>What is the compositional category of sedimentary rock R? (Coquina)</td>
<td>Biochemical</td>
<td>Inter</td>
</tr>
<tr>
<td>M30</td>
<td>Identify sedimentary rock R.</td>
<td>Coquina</td>
<td>Inter</td>
</tr>
<tr>
<td>M34</td>
<td>Identify sedimentary rock S.</td>
<td>Breccia</td>
<td>Inter</td>
</tr>
<tr>
<td>M35</td>
<td>The only difference between conglomerates and breccias is that</td>
<td>The sediments in the breccia traveled much farther than the sediments</td>
<td>Inter</td>
</tr>
<tr>
<td></td>
<td>conglomerates have rounded gravel-sized sediments and breccias have</td>
<td>in the conglomerate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>angular gravel-sized sediments. What does the shape of the sediments</td>
<td>reveal about these two sedimentary rocks?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>reveal about these two sedimentary rocks?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M40</td>
<td>Identify metamorphic rock U.</td>
<td>Schist</td>
<td>Inter</td>
</tr>
</tbody>
</table>
Table 3: Statistically Significant Questions from the Final Exams

<table>
<thead>
<tr>
<th>Q #</th>
<th>Question</th>
<th>Answer</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>F02</td>
<td>Sedimentary strata and lava flows are laid down horizontally. Any variation happened after they were initially deposited.</td>
<td>Law of Original Horizontality</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F03</td>
<td>The oldest layer is at the bottom, younger layers on top.</td>
<td>Law of Superposition</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F05</td>
<td>Strata and lava flows extend laterally in all directions until they pinch out or reach the edge of their depositional basins.</td>
<td>Law of Lateral Continuity</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F12</td>
<td>Which stress causes folds such as anticlines and synclines?</td>
<td>Compressional stress</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F13</td>
<td>Which stress causes right and left lateral faults?</td>
<td>Shear stress</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F27</td>
<td>The North and South Poles are:</td>
<td>Maximum latitude</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F29</td>
<td>Where is elevation assumed to be 0 feet or meters?</td>
<td>Sea level</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F43</td>
<td>Flows year-round. Represented by a solid blue line on a topo map.</td>
<td>Perennial stream</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F44</td>
<td>Does NOT flow year-round. Represented by a dashed or dotted line on a topo map.</td>
<td>Intermittent stream</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F45</td>
<td>The entire area of land that is drained by one stream or one system.</td>
<td>Drainage basin</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F61</td>
<td>Built perpendicular to the shoreline to trap sand or build up a beach.</td>
<td>Groin</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F62</td>
<td>Built perpendicular to the shoreline, usually in pairs, to keep a harbor open.</td>
<td>Jetty</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F66</td>
<td>Exposed marine terraces, wide beaches, and salt marshes are features of what type of coastline?</td>
<td>Emergent coast</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F73</td>
<td>The bottom end or nose of the glacier.</td>
<td>Terminus</td>
<td>1-Mem</td>
</tr>
<tr>
<td>F74</td>
<td>Addition of snow and ice to the glacier.</td>
<td>Accumulation</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F75</td>
<td>Loss of snow and ice from the glacier.</td>
<td>Ablation</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F76</td>
<td>The glacier is melting and the terminus is moving up the valley.</td>
<td>Retreat</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F77</td>
<td>The dividing line between the zone of accumulation and the zone of ablation.</td>
<td>Snowline</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F93</td>
<td>Where does the city water in Starkville come from?</td>
<td>Wells that draw from the Gordo aquifer</td>
<td>1 Mem</td>
</tr>
<tr>
<td>F15</td>
<td>What is the geologic structure depicted in Diagram C?</td>
<td>Syncline</td>
<td>2 Rec</td>
</tr>
</tbody>
</table>
Table 3 (continued)

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>F23 How do you determine the age of a particular rock formation on the map?</td>
<td>They are color-coded in the legend – oldest on the bottom</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F26 What are the latitude and longitude of Letter Y?</td>
<td>80°S, 15°E</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F32 The fractional scale of this map is 1/25000. This means:</td>
<td>1 inch on the map = 25,000 inches on the earth’s surface</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F33 The contour interval of this map is:</td>
<td>20 feet</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F35 What is the closest index contour to the top of Kerr Hill?</td>
<td>600 feet</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F40 What named feature is located at T7N, R9E, Sec. 10?</td>
<td>Pleasant Hill Church</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F41 What feature is located at T5N, R10W, Sec. 9, SW ¼?</td>
<td>Swan Lake</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F42 In what Township, Range, and Section do you find White Chapel School?</td>
<td>T5N, R9W, Sec. 2</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F64 In Diagram F, what natural coastal feature is Letter U?</td>
<td>Spit</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F67 A submergent coastline can be caused by:</td>
<td>Both B (sea level rising) and C (the land sinking (subsidence))</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F68 What feature below cannot reveal the direction of the longshore current?</td>
<td>Sea wall</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F69 What natural coastline feature can be used to determine the direction of the longshore current?</td>
<td>Spit</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F88 What three rock units underlie the soils in Oktibbeha County?</td>
<td>Selma Group, Midway Group, and Wilcox Group</td>
<td>2 Rec</td>
</tr>
<tr>
<td>F06 List the events in order from oldest to youngest.</td>
<td>X,B,H,S,M,F,U,C,P,I</td>
<td>3 Inter</td>
</tr>
<tr>
<td>F36 What is the change in elevation (relief) from the top of Kerr Hill to the main intersection in Knoxlyn?</td>
<td>360 feet</td>
<td>3 Inter</td>
</tr>
<tr>
<td>F63 What is the biggest problem associated with building jetties and groins?</td>
<td>They disturb the natural sediment transport and cause erosion</td>
<td>3 Inter</td>
</tr>
<tr>
<td>F65 In Diagram F, which direction is the longshore current flowing?</td>
<td>Southeast</td>
<td>3 Inter</td>
</tr>
</tbody>
</table>
Table 3 (continued)

| F78 | What is (are) the reason(s) we study glaciers? | All of the above (They can be good indicators of global warming, they are responsible for a lot of North American topography, they are the reason we have good farm land in America, they covered large areas of America in the past) | 3 Inter |
| F96 | Which direction is the longshore current flowing in this section of the Gulf of Mexico? | Northwest | 3 Inter |
| F97 | Bayou is another name for estuary. What does the abundance of bayous in this area indicate? | Sea level is rising the Gulf, flooding river valleys | 3 Inter |
| FB  | Which of these choices would be the worst location to build on in an earthquake-prone area? | An old landfill now covered with dirt and grass | 3 Inter |

The variable introduced in the Fall 2005 semester was the replacement of lectures by directed discovery-based exercises in each lab. Deviations from the baseline are shown in Figures 9 and 10. The Mineral and Rock Test data show that directed discovery-based exercises increased the percentage of correct responses on only one of seven questions. The Final Exam data show an increase on seven of nine Level 1 (memorization) questions, an increase on only one of seven Level 2 (recognition) questions, and an increase in one of three Level 3 (interpretation) questions.
Figure 9: Deviations from Baseline from Mineral and Rock Tests – Fall 2005 – Addition of Directed Discovery-Based Exercises.

Figure 10: Deviations from Baseline from Final Exams – Fall 2005 – Addition of Directed Discovery-Based Exercises.
The variable introduced in the Spring 2006 semester was the replacement of hand-in lab assignments with weekly quizzes. The baseline was changed to the percent of correct responses to each question in the Fall 2005 semester to determine the effect of the quizzes. Deviations from the baseline are shown in Figures 11-13. The Mineral and Rock Test data show that weekly quizzes increased the percentage of correct responses on all five Level 1 (memorization) questions, but decreased the percentage of correct responses on all three Level 2 (recognition) questions. Two of three Level 3 (interpretation) questions showed an increase. The Final Exam data show an increase on 13 of 14 Level 1 (memorization) questions, an increase on 8 of 10 Level 2 (recognition) questions, and an increase on 6 of 7 Level 3 (interpretation) questions.

Figure 11: Deviations from Baseline from Mineral and Rock Tests – Spring 2006 – Addition of Weekly Quizzes.
Figure 12: Deviations from Baseline of Level 1 (Memorization) Questions from Final Exams – Spring 2006 – Addition of Weekly Quizzes.

Figure 13: Deviations from Baseline of Level 2 (Recognition) and Level 3 (Interpretation) Questions from Final Exams – Spring 2006 – Addition of Weekly Quizzes.
The cumulative effects of all of the changes made during the course of the study are shown in Figures 14-16. Percentages from the Spring 2005 semester are used as the baseline and compared to Spring 2006 percentages to determine overall effects. The Mineral and Rock Test data show an increase in 5 of 9 questions. The Final Exam data show an increase in 14 out of 15 Level 1 (memorization) questions, an increase in 4 of 8 Level 2 (recognition) questions, and an increase in 4 of 5 Level 3 (interpretation) questions.

![Spring 06 Cumulative Effects - Mineral and Rock Test](image)

Figure 14: Cumulative Effects of All Variables from the Mineral and Rock Tests
Figure 15: Cumulative Effects of All Variables on Level 1 (Memorization) Questions from the Final Exams

Figure 16: Cumulative Effects of All Variables on Level 2 (Recognition) and Level 3 (Interpretation) Questions from the Final Exams
Most and Least Favorite Labs

Because there was a large group of students available as subjects, the decision was made to make a qualitative analysis of the laboratory teaching methods to accompany the quantitative analysis. It was hypothesized that addition of discovery-based exercises would improve morale in the lab classroom and render some traditionally disliked labs more agreeable to the students. It was further hypothesized that the improved morale would result in improved learning and greater interest in the subject matter, possibly recruiting some future geoscientists.

Answers to questions #98 and #99 on the Final Exams each semester asked the students which were their favorite and least favorite labs respectively. Figures 17-22 show the percentage of students who chose each lab as their favorite or least favorite.

The graph of favorite labs in the Spring 2005 semester (Fig.17) shows that four labs were favored by approximately equal percentages of students: Rock Identification (13%), Mississippi (15%), Earthquakes (14%), and Topographic Maps and Public Land Survey (14%), with Glaciers (10%) and Coastal Processes (7%) just slightly behind. Each of the other labs was favored by only a small percentage (5% or fewer) of students.

The graph of favorite labs in the Fall 2005 semester (Fig. 18) shows that three labs were favored by approximately the same percentage of students: Mississippi (19%), Streams and Groundwater (16%), and Topographic Maps and Public Land Survey (21%). Four other labs were favored by smaller percentages, but still more than most: Rock Identification (8%), Earthquakes (7%), Relative Age Dating (7%) and Structure (9%). Each of the other labs was favored by only a small percentage (5% or fewer) of students.
Spring 05 Favorites

Figure 17: Favorite Labs in Spring 2005

Fall 05 Favorites

Figure 18: Favorite Labs in Fall 2005
Figure 19: Favorite Labs in Spring 2006

Spring 06 Favorites

Figure 20: Least Favorite Labs in Spring 2005

Spring 05 Least Favorites
Figure 21: Least Favorite Labs in Fall 2005

Figure 22: Least Favorite Labs of Spring 06
The graph of favorite labs in the Spring 2006 semester (Fig. 19) shows that three labs were favored by approximately the same percentage of students: Glaciers (19%), Mississippi (15%), and Streams and Groundwater (22%). Four other labs were favored by smaller percentages, but still more than most: Rock Identification (6%), Earthquakes (8%), Structure (7%) and Topographic Maps and Public Land Survey (11%). Each of the other labs was favored by only a small percentage (2% or fewer) of students.

The graph of least favorite labs in the Spring 2005 semester (Fig. 20) shows that the Topographic Maps and Public Land Survey lab was overwhelmingly disliked by 45% of the students. Two labs were disliked by approximately equal percentages of students: Rock Identification (15%) and Gradient (14%). Each of the other labs was disliked by only a small percentage (5% or fewer) of students.

The graph of least favorite labs in the Fall 2005 semester (Fig. 21) shows that two labs were most disliked by approximately the same percentage of students: Rock Identification (25%) and Topographic Maps and Public Land Survey (23%). The Coastal Processes lab was also most disliked by a rather large percentage of students (17%). Each of the other labs was most disliked by only a small percentage (5% or fewer) of students.

The graph of least favorite labs in the Spring 2006 semester (Fig. 22) shows that two labs were most disliked: Rock Identification (25%) and Topographic Maps and Public Land Survey (23%). Three labs were most disliked by a slightly elevated percentage of students: Mississippi (7%), Relative Age Dating (6%) and Streams and
Groundwater (8%), while 6% of students said they did not have a least favorite lab. Each of the other labs was most disliked by only a small percentage (5% or fewer) of students.
CHAPTER VI
DISCUSSION

Standardization

As many as 10 different TAs function as instructors and assistants in the Earth Science I lab course each semester. Quantitative analysis of the effects of different teaching methods required that all TAs implemented the study methods and that the test questions used as a proxy for student learning would be the same in all sections. In her function as Lab Coordinator, and with the approval of the professors overseeing the course, the researcher chose the subject matter of the lessons, constructed the PowerPoint presentations that each TA would use, wrote the pre-lab and lab exercises, and constructed the Mineral and Rock Tests and the Final Exams, so that everything in so far as possible would be standardized across all lab sections each semester (see Appendices B and C). Weekly TA meetings in which the standardized material was demonstrated for the TAs were essential in the process, as was the outline that was placed on the lectern for use by each TA during the lab period.

Mineral and Rock Tests

Quantitative analysis of the Mineral and Rock Test questions revealed several effects of changes in teaching methods on learning. Standardization was implemented during
the Spring 2005 semester to enable the use of its data as the experimental “control” or baseline to which all subsequent semesters would be compared following introduction of variables.

**Directed Discovery-Based Exercises**

The variable introduced for the Fall 2005 semester was the replacement of PowerPoint presentations and TA lectures with directed discovery-based exercises. The exercises involving identification of minerals were already somewhat discovery-based because the procedures for identification require handling the minerals and using lab tools to test streak, hardness, and other mineral properties. The rock identification labs were somewhat discovery-based during the baseline semester as well. Identification of a schist sample (M40) was the only question on the Mineral and Rock test that showed a significant increase (p<0.05) (Fig. 9) in this semester, while six other questions about minerals, rocks, and their properties and formation showed significant decreases (p<0.05). Elimination of PowerPoint presentations and lectures reduced learning of rock identification properties by as much as 11.7%, while not significantly affecting (p<0.05) the ability to identify the sample (Fig. 9).

Subject material that is unique to geosciences such as relative sizes of the types of volcanoes (M23) or formation of vesicles in ejecta (M21) seems to be learned better when introduced by lectures and PowerPoint presentations than through directed discovery-based exercises (Fig. 9). Question M23 showed a decrease of 10.2% and question M21 showed a decrease of 11.7% with the elimination of PowerPoint-based
lectures. Recognition of grain arrangement in a sedimentary rock sample (M33) decreased by 11.3% and identification of the compositional category of coquina (M38) decreased by 9%, when the PowerPoint-based lectures about these rock properties were eliminated.

Discovery-based exercises were added to the igneous and sedimentary rock labs to enhance the identification procedures taught by traditional methods. A large, laminated diagram that was used to place the hand samples upon to help students understand environments of formation was added to the igneous rock lab (Fig. 23). A similar diagram was used in the sedimentary rock lab to place the hand samples into depositional environments (Fig. 24). Although these diagrams did not significantly (p<0.05) affect measurable increases on the test questions, many students commented that the diagrams made it easier to understand environments of formation and deposition.

Figure 23: Diagram for Environments of Formation of Igneous Rocks
Weekly Quizzes

Analysis of the study data shows that memorization, especially of vocabulary, is enhanced by weekly quizzes (Fig 11). All of the significant (p<0.05) Level 1 (memorization) questions showed increases between 5.8 and 16.5% in correct responses during the Spring 2006 semester, when quizzes were introduced. The decrease in Level 2 questions during this semester may be attributed to the fact that rock samples were not used during the weekly quizzes, so the quizzes did not give the students additional opportunities for recognition of rock properties. Effects of quizzes on identification of specific rock samples are not consistent, as would be expected because the samples were not supplied for nor tested on the quizzes.
Final Exams

Quantitative analysis of the Final Exam questions revealed several effects of changes in teaching methods on learning.

Coastal Processes Take-Home Lab

Most students had difficulty learning independently from the manual outside of lab without help from TAs. The two-day Fall Break that occurs in mid-October is problematic for the Earth Science I Lab schedule. Classes are cancelled for Tuesday, but held as usual on Wednesday and Thursday, the three days labs are taught. The change in the schedule puts the Tuesday sections of the lab one week behind the other two for the remainder of the semester. During the Fall 2005 semester, it was decided that cancellation of all lab meetings for that week and assignment of take-home lab exercises would keep all sections of the lab on the same weekly schedule. The Coastal Processes Lab was chosen as the take-home exercise because the entire exercise was contained in the lab manual and no hands-on experiment in the lab was required. The TAs felt that the readings that precede the exercise in the manual are clear and the questions are self-explanatory. In addition, TAs offered help at office hours for those students who wished more explanation. Unfortunately, many of the students either did not complete the exercise at all, or did not do well on it. During the Mississippi lab, which functions as a review for the Final Exam and should contain merely review material, the TAs found they spent a disproportionate amount of time explaining coastal processes, and the percentage of correct responses on the test questions (Fig. 10, F63, F64, F68, and F69) decreased between 13.7 and 25.7%, indicating that the concepts were not mastered to the
degree that they were when TAs presented the material and answered questions during completion of the exercise in the lab. In the Spring 2006 semester, when the Coastal Processes Lab was once again taught in the lab, 10 of 11 coastal questions (Figs. 12 and 13, F61-F69 and F96-F97) showed significant increases between 12.4 and 24.3%, as expected.

Directed Discovery-Based Exercises

Analysis of study data and personal observations indicate that some skills and concepts are far better taught by hands-on experience with guidance from the instructors than by PowerPoint presentations (Fig. 10). For example, use of geologic maps (F23) increased by 9.6%, understanding of stream processes (questions F44 and F45) increased by 8.8 and 8% respectively, and understanding of glacial processes (F74 - F77) increased between 9.7 and 40.3% with the introduction of directed discovery-based exercises. Glacial processes in particular tend to be difficult concepts to convey to Mississippi students, many of whom have never even seen snow. Significant increases (p<0.05) in all four of the questions (F74 - F77) clearly shows that use of the “slime glacier” (Fig. 25) to demonstrate the way a valley glacier moves and how moraines and piedmont glaciers are formed greatly enhanced understanding of glacial processes.
Figure 25: The “Slime” Glacier is demonstrated in front of the lab.
Analysis of data shows that directed discovery-based learning enhances learning of some concepts, but not necessarily vocabulary. Geologic structures were taught with a directed discovery-based exercise involving Crayola Model Magic® (Appendix C). Students used the modeling compound to simulate folds of various types (Fig. 26 & 27) and then diagrams in the book to correlate them to the geologic structures formed by the same stresses in ductile rocks. Wooden blocks (Fig. 28) were used to demonstrate the various types of faults and the stresses that produce them. It appeared during the lab session that the students were grasping the concepts of the types of stresses and their resultant structures, yet decreases of 10.7% and 12.9% show that the concepts were not paired with the related vocabulary (Fig.10, F12 and F15).

Figure 26: Students use Model Magic® to simulate the results of various stresses on ductile rocks.
Figure 27: The “rocks” elongate and thin in response to application of continued stress.

Figure 28: Students discover the direction of movement along a reverse fault as a result of compressional stress.
Most and Least Favorite Labs

Hands-on activities made the labs more enjoyable for the students while maintaining learning percentages comparable to the baseline. During the Fall 2005, when directed discovery-based exercises were first introduced, the students responded positively to the hands-on activities (Fig. 19), with 21% citing the Topographic Maps and Public Land Survey Lab, 19% choosing the Mississippi Lab, 16% naming the Streams and Groundwater Lab, and 9% citing the Geologic Structure Lab as a favorite. The contour box exercise (Figs. 29 - 31) in the maps lab, the flume experiments (Figs. 32 - 34), the “slime glacier” (Figs 26), and the Model Magic exercises (Figs. 27 & 28) in the structure lab were cited most often as the reasons these labs were favored. If the lab experience is more fun for the students without an accompanying decrease in learning, then the addition of the exercises can be considered an improvement.

Figure 29: Students pour colored water into a contour box as the first step in creating a topographic map on the lid of the box.
Figure 30: After each consecutive centimeter of water is added, students draw the contact between the water and the volcano onto the lid with an erasable marker.

Figure 31: When the volcano is submerged, the final topographic map is complete.
Figure 32: Students adjust the hose until the water level remains constant to simulate stream flow in the flume.

Figure 33: As the colored, salty, ice water is added upstream, the pollution flows along the bottom of the flume.
The labs cited most often as favorites in the experimental semesters were those in which the students could recognize relevance to their daily lives. The Mississippi Lab was popular with students, many of whom stated that they enjoyed learning new information about their home state. Many students also commented that they enjoyed the Earthquake Lab because they did not know that earthquakes could occur in Mississippi or what type of land they should avoid when building a home. Other students found the Streams and Groundwater Lab interesting because they learned about the hazards of pollutants at the bottom of streams (Fig. 32 – 34) where the catfish live (Appendix C).

The lab exercises that were cited as least favorites throughout the course of the study were those that the students perceived as either too difficult to understand or
irrelevant to their lives outside the lab. Map Labs were overwhelmingly disliked (45%) until the introduction of the contour boxes (Fig. 29 – 31), which the students enjoyed working with and which enhanced their understanding of three-dimensional visualization. Because the students found the take-home format difficult during the Fall 05 Semester, the Coastal Processes Lab was reported as least favorite by 17% of students. When the lab was taught in the classroom the following semester, it returned to 4%, much closer to its baseline level. The nearly constant level of 20-25% of students citing Mineral and Rock Labs as their least favorite is explained by their perception that the material is irrelevant. The students who chose these as their least favorites most often said that rocks were boring, and they just didn’t care about rocks.

**Inherent Limitations of the Study**

**Human Subjects**

Inherent in any study involving human subjects are inconsistencies that cannot be controlled by the researcher. In this study, there were two sets of human subjects whose behavior was crucial to the outcome of the study, the students and the TAs. Most of the problems associated with the students were adequately eliminated by the large size of the sample and its demographic representation of the undergraduate student body as a whole. On the other hand, the small group of TAs who taught the course and their direct involvement in the teaching of the labs and writing of the quizzes was less easily controlled by the researcher. The position of Lab Coordinator allowed some degree of control. However, it must be recognized that this is not a position of authority, but requires voluntary cooperation from the TAs. Also, the TAs had different amounts of
teaching experience, so they followed directions with varying degrees of accuracy and enthusiasm. Overall, the standardization appears to have been a success.

**Hurricane Katrina**

Hurricane Katrina had several negative effects on the Earth Science I Lab. Lab sessions were cancelled during the week the storm hit the Mississippi coast, which resulted in a slightly reduced curriculum and the elimination of the “slime glacier” demonstration in the Fall 2005 semester. In addition, several students from other universities near the coast entered the course several weeks into the semester and needed to work with TAs to get caught up to date with the course. Some material (particularly minerals and igneous rocks) may have been learned in less detail as a result. Many of the students already at MSU had loved ones and homes more directly affected by the storm, so absenteeism and distraction from concentration on studies were common through September and October of 2005.

Hurricane Katrina had the positive effect of stimulating curiosity about coastal processes for many students who might otherwise have had little interest. Comparison of satellite photographs of the Mississippi coast and barrier islands before and after the storm (Figs. 35 and 36) were used in the lab as a directed discovery-based activity, and many students lingered over the photographs and discussed them at length. This would suggest that it would be advantageous for the students to have access to a sand and water table that could be used to demonstrate coastal processes to encourage the heightened interest to continue.
Figure 35: The Mississippi Coast before Hurricane Katrina (July 8, 2000).

Figure 36: The Mississippi Coast after Hurricane Katrina (October 18, 2005).
Conclusions and Recommendations

Standardization

It is recommended that standardization should be attempted for all courses with large enough enrollments to require several sections taught by different instructors. Standardization of large-enrollment lab courses allows careful analysis of the effects of changes made to improve the course. The data set used in this study included 150 - 200 students in each of the three semesters, each responding to a total of 151 questions, yielding over 82,000 individual responses to test questions to be used as data points. Such a large data set for quantitative analysis would not be possible in only three semesters without standardization that allowed equal treatment of all sections.

PowerPoint-Based Lectures

Lectures and PowerPoint presentations increase learning of some key elements of geoscience subject matter; they should be used to convey basic information upon which the laboratory exercises can build. Photographs and diagrams drawn from many sources and included in PowerPoint presentations can enhance the understanding of the subject material by providing students with ideal images and numerous illustrative examples.

Pre-Lab Exercises

Significant improvement (p<0.05) in learning as a response to the addition of pre-lab exercises was not found in this study; use should be limited or discontinued. Students were often observed completing the pre-lab exercises in the 5 or 10 minutes immediately preceding lab, so the exercise was completed with little attention paid to what was being written and with no time to review it for understanding. More extensive pre-lab exercises
that require reading and absorption of the material from the manual prior to use in the lab might show different results.

*Directed Discovery-Based Exercises*

Directed discovery-based learning is useful and increases learning and enjoyment of the lab for many of the students according to their answers to questions #98 and 99 on the Final Exam; hands-on activities should be used in the lab to enhance understanding and morale. TAs reported having a better time in lab and experiencing a more positive attitude in general from their students with the addition of the hands-on activities. TAs reported being asked, “What are we doing today?” with a more enthusiastic tone of voice than in the baseline semester. In addition, it is recommended that exams be redesigned so that questions focus more on testing concepts rather than vocabulary to fairly assess the success of the activities.

*Weekly Quizzes*

Weekly quizzes increase memorization of vocabulary and may improve higher-level learning as well; they should be used whenever feasible. Addition of weekly quizzes to the curriculum resulted in increases on 34 of 42 significant questions (p<0.05).

*Maximization*

Cumulative effects will be maximized by the simultaneous use of all of these teaching tools. Different students respond to different teaching methods. Use of a variety of approaches to the dissemination of geoscience information to mostly novice non-major should yield the greatest learning.
CHAPTER VII

CONCLUSIONS

- Elimination of PowerPoint presentations and lectures reduced learning of rock properties by as much as 17.6%
- Some subject material that is unique to geosciences is learned 9-12.9% better when introduced by lectures and PowerPoint presentations than through directed discovery-based exercises.
- Most students had difficulty learning independently from the manual outside of lab without help from TAs. Learning of material reduced by 13.7-25.7% when students did not have classroom instruction.
- Some skills and concepts are far better taught by hands-on experience with guidance from the instructors than by PowerPoint presentations. Discovery-based exercises increased understanding of geologic maps by 9.6%, stream processes by 8-8.8%, and glacial processes by 9.7 – 40.3%.
- Directed discovery-based learning enhances learning of concepts, but not necessarily vocabulary.
- Learning of vocabulary was not improved with pre-lab exercises, but was increased by 4 – 20% with the addition of weekly quizzes.
• Learning of materials at all three learning levels was increased by 4-38.3% with weekly quizzes.

• Hands-on activities made the labs more enjoyable for 25-30% of the students while maintaining learning percentages comparable to the baseline.

• The labs cited most often 35-38% as favorites in the experimental semesters were those in which the students could recognize relevance to their daily lives.
REFERENCES


Kirkland, Brenda L., 2006. Personal communication.


November 10, 2004

Julia Johnston
1206 Seventh Street North
Columbus, MS 39701

Re: IRB Docket #04-298: Improving Teaching of Earth Science Lab

Dear Ms. Johnston:

The above referenced project was reviewed and approved via administrative review on November 10, 2004 in accordance with 45 CFR 46.101 b(1). Continuing review is not necessary for this project. However, any modification to the project must be reviewed and approved by the IRB prior to implementation. Any failure to adhere to the approved protocol could result in suspension or termination of your project. The IRB reserves the right, at any time during the project period, to observe you and the additional researchers on this project.

Please refer to your IRB number (#04-298) when contacting our office regarding this application.

Thank you for your cooperation and good luck to you in conducting this research project. If you have questions or concerns, please contact me at tarwood@research.msstate.edu or 325-32.

Sincerely,

Tracy S. Arwood
Director

cc: Brenda Kirkland
BEFORE SUBMITTING YOUR PROTOCOL FOR IRB REVIEW, MAKE SURE YOU HAVE INCLUDED THE FOLLOWING (IF APPLICABLE):

- Survey, Questionnaire or Interview Questions
- Consent and Assent forms
- Recruiting materials
- Permission letters from participating institutions
- Signed Investigator Assurance form
- Clear, concise description of procedures to be used (Feel free to also attach any proposals that may further explain your project.)

Additionally, these assurances must be made:

- All personnel listed must have completed IRB/Human Subjects Training. If not, your application cannot be approved until the training has been completed. See our website for training dates and times. [http://www.msstate.edu/dept/compliance/irb/irbregistration.htm](http://www.msstate.edu/dept/compliance/irb/irbregistration.htm)

- If applicable, the advisor has thoroughly reviewed this application to ensure readability and accuracy.

PLEASE NOTE:

- **THE DETERMINATION OF THE IRB WILL BE COMMUNICATED TO YOU IN WRITING. SUBMISSION OF AN APPLICATION TO THE IRB DOES NOT EQUAL IRB APPROVAL. YOU MAY NOT BEGIN THIS RESEARCH UNTIL YOU HAVE IRB APPROVAL.**

- **IF YOUR RESEARCH HAS NOT YET RECEIVED FUNDING NEEDED TO CREATE INSTRUMENTS AND OTHER ASSOCIATED MATERIALS, PROVIDE A TIMELINE OF WHEN THOSE ITEMS WILL BE DEVELOPED. YOUR APPLICATION WILL BE REVIEWED FOR “118 DESIGNATION” (SEE [http://www.msstate.edu/dept/compliance/irb/irbawardchanges.htm](http://www.msstate.edu/dept/compliance/irb/irbawardchanges.htm) FOR MORE DETAILS).**

If you have any questions, please feel free to contact our office at 325-5220 or by email at jmillar@research.msstate.edu or tarwood@research.msstate.edu.

Send to:
IRB
Campus Mailstop 9563
PO Box 6223, Mississippi State, MS 39762
8A Morgan Street
Project Title: Improving Teaching of Earth Science I Lab

As Primary Investigator, I have ultimate responsibility for the performance of this study, the protection of the rights and welfare of the human subjects, and strict adherence by all co-investigators and research personnel to all Institutional Review Board (IRB) requirements, federal regulations, and state statutes for human subjects research. I hereby assure the following:

The information provided in this application is accurate to the best of my knowledge.

All named individuals on this project have been given a copy of the protocol and have acknowledged an understanding of the procedures outlined in the application.

All experiments and procedures involving human subjects will be performed under my supervision or that of another qualified professional listed on this protocol.

I understand that, should I use the project described in this application as a basis for a proposal for funding (either intramural or extramural), it is my responsibility to ensure that the description of human subjects use in the funding proposal(s) is identical in principle to that contained in this application. I will submit modifications and/or changes to the IRB as necessary to ensure these are identical.

I and all the co-investigators and research personnel in this study agree to comply with all applicable requirements for the protection of human subjects in research including, but not limited to, the following:

- Obtaining the legally effective informed consent of all human subjects or their legally authorized representatives, and using only the currently approved, consent form (if applicable); and
- Making no changes to the approved protocol or consent form without first having submitted those changes for review and approval by the Institutional Review Board; and
- Reporting serious and unexpected adverse effects to IRB Administration verbally within 48 hours and in writing within 10 days of occurrence, and all other unexpected adverse events in writing within 10 days of occurrence; and
- Promptly providing the IRB with any information requested relative to the project; and
- Promptly and completely complying with an IRB decision to suspend or withdraw its approval for the project; and
- Obtaining continuing review prior to the date approval for this study expires. I understand if I fail to apply for continuing review, approval for the study will automatically expire, and study activity must cease until IRB current approval is obtained.
- Your study and any associated records may be audited by the IRB to ensure compliance with the approved protocol.

Name of Primary Investigator / Researcher: Julia G. Johnston

Signature:

I assume responsibility for ensuring the competence, integrity and ethical conduct of the investigator(s) for this research project. The investigator(s) is/are fully competent to accomplish the goals and techniques stated in the attached proposal. Further, I certify that I have thoroughly reviewed this application for readability and accuracy and the study is clearly described herein.
THE MISSISSIPPI STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD
FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH

Protocol Submission Form

PRINCIPAL INVESTIGATOR / RESEARCHER INFORMATION
Name: Julia Johnston
Daytime Phone Number: 325-2913
Mailing Address: 1206 Seventh Street North
If on-campus, provide Mailstop
City/State/Zip: Columbus, MS  39701
E-Mail Address: jgi27@msstate.edu
Department: Geosciences
IRB and Human Subjects Protetions Education completed on 11/01/04.

FACULTY ADVISOR (Faculty member supervising the student for this project)
If you are a student, you must have an advisor for this project.
Advisor: Dr. Brenda L. Kirkland
Daytime Phone Number: 325-2911
Advisor=s E-Mail Address: blk39@msstate.edu
Department: Geosciences
Campus Mail Stop: 9537
IRB and Human Subjects Protetions Education completed on _____________

TITLE of project: Improving Teaching of Earth Science I Lab

ORIGINAL SUBMISSION

PROJECT PERIOD:  upon IRB Approval  to 5/2006

STUDY FUNDING
Provide information about how the study costs will be supported

  X  Personal Funds (for incentives only)  X  No cost study

ADDRESS EACH OF THE FOLLOWING ITEMS IN YOUR WRITTEN PROTOCOL.

I.  Personnel & Qualifications
NOTE:

- As principal investigator, it is your responsibility to ensure that all individuals conducting procedures described in this application are adequately trained prior to involving human participants.
- All personnel listed on this application are required to successfully complete the MSU IRB & Human Subjects training course or an MSU IRB approved alternative. APPROVAL WILL NOT BE GRANTED UNTIL ALL INDIVIDUALS HAVE COMPLETED THIS TRAINING.
- As personnel change, you must submit a modification request to the IRB for approval before they can work with human subjects or identifiable or confidential information.

A. Including yourself, provide the name of each individual who will be responsible for the design or conduct of the study, have access to human participants, or have access to identifying or confidential information.

Julia Johnston  
Dr. Brenda Kirkland  
Dr. John Mylroie  
Dr. Christopher Dewey  

B. For each person identified above, identify his/her role in the project and clearly state the procedures or techniques he/she will be performing.

Julia Johnston is Graduate Student who will be Primary Researcher. Dr. Kirkland, Dr. Mylroie, and Dr. Dewey are graduate advisors on thesis.

II. Research Protocol

1. **SITE OF WORK:**
All labs are taught at quizzes and tests administered in the Earth Science I Lab, 304 Hilbun Hall, MSU Campus. All tabulation of data will be done in Researcher’s office on Graduate Student Office Computer. Follow-up assessment will also be conducted in 304 Hilbun Hall.

2. **Brief description of the GENERAL PURPOSE of the project:**
In your view, what **BENEFITS** may result from the study that would justify asking the subjects to participate? The study is to be conducted as a thesis for Master’s Degree in Geosciences and possible publication. The main benefit of the study is to determine the most effective teaching methods to improve student learning and retention of the Earth Science I Lab material. The intention is to fine-tune teaching methods to make the lab more interesting and enjoyable to the students while improving their overall understanding of the subject matter.

3. **Give details of the PROCEDURES that relate to the subjects' participation, include at a minimum the following information (append additional page(s) if necessary):**
a) List ALL vulnerable subject populations to be included and additional precautions being taken to ensure their protection.
   No special precautions should be necessary, as the students will simply be taking part in their regular lab activities.

b) How will the subjects be selected and recruited?
   Subjects will include all students who enroll in Earth Science I Lab and sign a consent form for the use of their grades. Recruitment for follow-up study will be included in the consent form. Those agreeing to be contacted for follow-up study will be contacted by e-mail to be informed of time of follow-up study.

c) What inducement will be offered?
   For the main study, simply the chance to participate in the improvement of the Lab for future students. For those who agree to the follow-up study, a coupon for $1-2 for use at a fast-food restaurant will be purchased from personal funds and given to participants as an incentive for their participation.

d) How many subjects will be used? List any salient characteristics of subjects, i.e., age range, sex, institutional affiliation, other pertinent characterizations.
   I anticipate the enrollment of approximately 280-300 students during a Spring or Fall semester, with approximately 20-30 students in the Summer Lab session. I anticipate a high percentage (90-95%) will consent to use of their grades. I anticipate approximately 30-50 students will participate each semester in the follow-up study, maybe 3-5 of the summer students to participate in the follow-up.

e) Number of times researchers will interact with each subject? 10-15 times.

f) What will the subjects do, or what will be done to them, in the study?
   Subjects will participate in their regular lab course curriculum. Only those who volunteer for the follow-up study will be asked to do anything additional.

4. How do you intend to obtain the subjects' INFORMED CONSENT?
   Attached consent form will be given to each student with the syllabus on the first day of lab each semester, to be signed and returned before they leave the classroom that day. For the first semester (Fall/2004) this consent form will be given to the students on Final Exam day, to be signed and returned before leaving the lab that day.

5. Assessment of RISK
   I anticipate no risk whatsoever, as all students will be participating in their regular coursework and strict confidentiality will be maintained.

6. How do you ensure CONFIDENTIALITY of information collected?
   At a minimum, provide the following information:
   Who will have access to the data? Where will data be stored? Where will signed consent forms be stored (be specific regarding location)? What identifiers (direct or indirect) will be collected? What purpose do the identifiers serve? When will identifiers be removed or “de-linked” from the data? (Identifiers include a code
number, which may be linked to another document containing names or other identifying information.) **Will the data be retained or destroyed? If the data will be destroyed, how and at what point in time?**

Access to the data will be limited to the Graduate Teaching Assistants for the course and the Graduate Committee named above. All data will be in statistical form only, and no names of subjects will be reported. All quizzes and tests are stored in Graduate Teaching Assistants’ offices in the Geosciences department. Signed consent forms will be stored in the Researcher’s Office. Names of students will be used as identifiers for comparison to follow-up data, but will be removed before when data is tabulated. Individual scores will never be used in final reports, only averages and percent increases or decreases in those averages will be reported or published.

7. **Are approvals needed from another MSU regulatory committee (i.e. IACUC for animals or IBC for infectious agents or recombinant DNA)?** If so, please attach approval letter(s) from appropriate committee(s). If approval has not yet been obtained, where are you at in the approval process?  

N/A
CONSENT FORM FOR RESEARCH STUDY

Title of Study: Improving Teaching of Earth Science I Lab

Study Site: MSU Earth Science I Lab, 304 Hilburn Hall

Name of Researcher(s) & University affiliation: Julia Johnston, Graduate Student and Dr. Brenda Kirkland, Assistant Professor of Geosciences

What is the purpose of this research project?
To improve the Earth Science I Lab to make it more fun and interesting, making the material easier for the students to learn and retain.

How will the research be conducted?
Lab assignment, quiz, and test scores will be used to decide where changes should be made and comparisons of the grades from one semester to others will be used to assess what effect the changes have resulted in. Volunteers will also participate in a short follow-up study to determine retention after the coursework has been completed. A fast-food coupon will be offered as incentive for participation in the follow-up study.

Are there any risks or discomforts to me because of my participation? None.

Does participation in this research provide any benefits to others or myself? None, other than the improvements made to the course for future students of the Earth Science I Lab and the possible incentive for follow-up assessment.

Will this information be kept confidential?
All information will be in the form of statistics only. No grades or answers to questions will be linked to a particular student. No names of students will be used in any way in the reporting of the data. Full confidentiality will be maintained.

Who do I contact with research questions?
If you should have any questions about this research project, please feel free to contact Julia Johnston at 325-2913 or by e-mail at jgj27@msstate.edu. The Instructor for the course and graduate advisor for this project is Dr. Brenda L. Kirkland, who can be reached at 325-2911 or by e-mail at BLK39@msstate.edu. For additional information regarding your rights as a research subject, please feel free to contact the MSU Regulatory Compliance Office at 662-325-3294.

What if I do not want to participate?
Please understand that your participation is voluntary, your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled, and you may discontinue your participation at any time without penalty or loss of benefits. Whether or not you choose to participate in this study will have NO EFFECT ON YOUR GRADE IN THIS COURSE.

Name (Please Print)

_____________________________   __________
Participant Signature     Date

_____________________________   __________
Investigator Signature     Date


If you would be willing to allow me to use your digital photograph in my thesis, for projection, on a poster, or for publication, please sign below.

Name (Please print)________________________________________________________

Signature _______________________________________________________    Date ______________

If you would be willing to give me less than a hour of your time for a follow-up study 3-4 months after your final exam, please give me your e-mail address and/or phone number so that I may contact you. I will offer you a coupon for a discount at a fast-food restaurant to thank you for your time and for your participation in this follow-up.

Name (Please Print)______________________________________________

e-mail address_________________________________________________________________

phone #________________________________________________________________________

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APPENDIX B

TESTS
1. What color is the streak for mineral J? (Pyrite)
   A) White
   B) Dark Gray
   C) Green
   D) Yellow
   E) Pink

2. Identify mineral J.
   A) Graphite
   B) Galena
   C) Plagioclase Feldspar
   D) Olivine
   E) Pyrite

3. Mineral J has which type of luster?
   A) Metallic
   B) Non-Metallic
   C) Hard
   D) Soft

4. Is mineral K hard or soft? (K-spar)
   A) Hard (>5 on Moh’s scale)
   B) Soft (<5 on Moh’s scale)

5. Identify mineral K.
   A) Pyrite
   B) Olivine
   C) Talc
   D) Sulfur
   E) Potassium Feldspar

6. “The shape that crystals for a mineral will have with sufficient room and time to grow”
   is the definition of:
   A) Color
   B) Luster
   C) Streak
   D) Cleavage
   E) Crystal form
7. Which tool is used to identify mineral hardness?
   A) White Streak plate
   B) Magnet
   C) Glass plate
   D) Black Streak Plate
   E) A & D

8. What is the hardness of mineral I? (Calcite)
   A) Hard (>5 on Moh’s scale)
   B) Soft (<5 on Moh’s scale)

9. What is the streak of mineral I?
   A) White
   B) Black or dark gray
   C) Yellow
   D) Green
   E) Absent

10. What type of cleavage does mineral I exhibit?
    A) Basal
    B) Rhombohedral
    C) Cubic
    D) Conchoidal
    D) No cleavage

11. Which one of the following is not one of the “Big 6” common mineral properties?
    A) Color
    B) Reaction to hydrochloric acid
    C) Crystal form (habit)
    D) Cleavage/Fracture
    E) Streak

12. For which mineral is color not a reliable diagnostic property?
    A) Sulfur
    B) Galena
    C) Quartz
    D) Olivine
    E) Pyrite

13. Identify igneous rock L. (Diortie)
    A) Obsidian
    B) Diorite
    C) Pumice
    D) Gabbro
    E) Andesite
14. What is the extrusive equivalent of rock L?
   A) Basalt  
   B) Andesite  
   C) Rhyolite  
   D) Scoria

15. What texture below indicates an igneous rock as extrusive in origin?
   A) Phaneritic  
   B) Aphanitic  
   C) Porphyritic  
   D) Glassy  
   E) Vesicular

16. What is the composition of igneous rock M? (Basalt)
   A) Felsic  
   B) Intermediate  
   C) Mafic  
   D) Ultramafic

17. What is the texture of igneous rock N? (Pumice)
   A) Phaneritic  
   B) Aphanitic  
   C) Porphyritic  
   D) Glassy (the book also says this, so accept it, but we prefer vesicular)  
   E) Vesicular

18. Extrusive rocks form:
   A) from magma above the surface  
   B) from lava above the surface
   C) from magma below the surface  
   D) from lava below the surface

19. The texture of igneous rock N indicates what kind of origin?
   A) Intrusive igneous rock  
   B) Extrusive igneous rock

20. What type of composition does an igneous rock have if it is composed mainly of light colored minerals (>85%)?
   A) Felsic  
   B) Intermediate  
   C) Mafic  
   D) Ultramafic
21. Identify igneous rock O. (Granite)
   A) Pumice
   B) Granite
   C) Rhyolite
   D) Andesite
   E) Scoria

22. Felsic magmas are formed by the partial melting of which type of crust?
   A) Oceanic crust
   B) Continental Crust
   C) Island Crust
   D) Bread Crust

23. Vesicles form from:
   A) Chunks of rock floating in magma
   B) Gasses escaping from lava
   C) Minerals dissolving
   D) Air forcing its way into lava

24. Porphyritic texture is a result of:
   A) Fast cooling at the surface
   B) Slow cooling below the surface
   C) Slow cooling at first, followed by fast cooling later
   D) Instantaneous cooling under the sea

25. Which type of volcano is the largest?
   A) Cinder cone
   B) Composite volcano
   C) Shield volcano

26. Which type of lava forms shield volcanoes?
   A) Felsic
   B) Intermediate
   C) Mafic
   D) Ultramafic

27. In an igneous rock, what does composition describe?
   A) Refers to the different types of minerals in the rock
   B) Describes the location where the rock was found
   C) The rock’s protolith (parent rock)
   D) The size, shape, and arrangement of the rock’s constituent parts
28. The presence of fossils indicates which type of rock?
   A) Igneous
   B) Sedimentary
   C) Metamorphic
   D) Mineral

29. Identify sedimentary rock P. (Fossiliferous Limestone)
   A) Sandstone
   B) Shale
   C) Chert
   D) Fossiliferous Limestone
   E) Conglomerate

30. What compositional category does sedimentary rock Q belong to? (Coquina)
   A) Detrital
   B) Biochemical
   C) Chemical

31. Sandstones are composed mostly of what mineral?
   A) Augite
   B) Quartz
   C) Basalt
   D) Pyrite

32. Identify sedimentary rock R. (Sandstone)
   A) Coquina
   B) Breccia
   C) Sandstone
   D) Chalk
   E) Chert

33. What is the grain arrangement for sedimentary rock S? (Breccia)
   A) Poorly sorted
   B) Moderately sorted
   C) Well sorted

34. What is the grain (sediment) size of sedimentary rock S? (Hint: Look at the largest sediment).
   A) Gravel
   B) Sand
   C) Silt
   D) Clay
35. Where does the sedimentary rock coal form?
   A) Beaches
   B) Deep Ocean
   C) Streams
   **D) Swamps**
   E) Mountains

36. Where does the sediment that forms sandstone come from?
   **A) Mechanical/chemical weathering of pre-existing rock**
   B) Secretions from reef-dwelling creatures
   C) Swamps (decaying plant life)
   D) Precipitation from seawater
   E) Fossil remains

37. The only difference between conglomerates and breccias is that conglomerates have **rounded** gravel-sized sediments and breccias have **angular** gravel-sized sediments. What does the shape of the sediments reveal about these two sedimentary rocks?
   A) The sediments in the breccia traveled much farther from their source than the sediments in the conglomerate.
   **B) The sediments in the conglomerate traveled much farther than the sediments in the breccia.**
   C) The conglomerate sediments were transported by a small stream, while the breccia sediments were transported by a large river.
   D) The sediments in the conglomerate came from igneous rock, while the sediments in the breccia came from metamorphic rock.
   E) The shape of the sediment grains doesn’t reveal anything

38. Which sedimentary rock is formed by the precipitation of dissolved minerals from solution (ocean water)?
   A) Breccia
   B) Sandstone
   C) Chalk
   **D) Chert**
   E) Coquina

39. Identify metamorphic rock T. **(Marble)**
   **A) Marble**
   B) Gneiss
   C) Schist
   D) Quartzite
   E) Slate
40. What is the parent rock (protolith) for Quartzite?
   A) Limestone
   B) Slate
   C) Granite
   D) Sandstone
   E) Shale

41. Metamorphic Grade means:
   A) Parent rock
   B) Intensity of metamorphism
   C) Mineral composition
   D) Grain size

42. Identify metamorphic rock U. (Schist)
   A) Gneiss
   B) Schist
   C) Slate
   D) Quartzite
   E) Marble

43. What is the general texture for metamorphic rock U?
   A) Foliated
   B) Unfoliated
   C) Phaneritic
   D) Aphanitic

44. This rock is the parent rock for Slate, Phyllite, Schist, and Gneiss.
   A) Limestone
   B) Sandstone
   C) Shale
   D) Conglomerate
   E) Basalt
Matching: Choose one of the following for the question below. Letters MAY BE used more than once.

A) Mineral
B) Igneous Rock
C) Sedimentary Rock
D) Metamorphic Rock
E) Igneous, Sedimentary, and Metamorphic Rock

45. Forms from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation. C

46. An inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline structure. A

47. Forms from molten rock (magma or lava). B

48. What type of rock can be changed by a metamorphic event? E

49. Forms by changing from one form to another by intense heat, intense pressure, or the action of hot watery fluids. D

50. The basic building-block of all rocks. A
1. What color is the streak for mineral A (Sulfur)?
   A) White
   B) Dark Gray
   C) Green
   D) Yellow
   E) Pink

2. Mineral A has which type of luster?
   A) Metallic
   B) Non-Metallic
   C) Hard
   D) Soft

3. Identify mineral A.
   A) Graphite
   B) Galena
   C) Plagioclase Feldspar
   D) Sulfur
   E) Pyrite

4. Is mineral B hard or soft? (Talc)
   A) Hard (>5 on Moh’s scale)
   B) Soft (<5 on Moh’s scale)

5. Identify mineral B.
   A) Pyrite
   B) Olivine
   C) Talc
   D) Sulfur
   E) Potassium Feldspar

6. Which one of the following is not one of the 6 common properties we used to identify minerals?
   A) Color
   B) Reaction to hydrochloric acid
   C) Luster
   D) Cleavage
   E) Streak
7. Which tool(s) is/are used to identify mineral hardness?
   A) Glass plate
   B) Iron Nail
   C) Penny
   D) Fingernail
   E) All of the above

8. What is the hardness (from Moh’s Scale) of mineral C? (Fluorite)
   A) Hard >5
   B) 4
   C) 3
   D) <2.5

9 What is the streak of mineral C?
   A) Black
   B) White
   C) Green
   D) Pink
   E) Absent

10. The cleavage of mineral X is: (Mica)
    A) Excellent to Good
    B) Fair to Poor
    C) Absent
    D) Ugly

11. Which one of the following is not an igneous texture?
    A) Aphanitic
    B) Phaneritic
    C) Glassy
    D) Microcrystalline
    E) Porphyritic

12. Identify igneous rock D. (Gabbro)
    A) Granite
    B) Diorite
    C) Pumice
    D) Gabbro
    E) Andesite

13. What is the extrusive equivalent of rock D?
    A) Basalt
    B) Andesite
    C) Rhyolite
    D) Pumice
14. What type of composition does an igneous rock have if it is composed mainly of light colored minerals?
   A) Felsic  
   B) Intermediate  
   C) Mafic  
   D) Ultramafic

15. Extrusive rocks form:
   A) from magma above the surface  
   B) from lava above the surface  
   C) from magma below the surface  
   D) from lava below the surface

16. What texture below indicates an igneous rock as intrusive in origin?
   A) Phaneritic  
   B) Aphanitic  
   C) Porphyritic  
   D) Glassy  
   E) Vesicular

17. What is the composition of igneous rock E? (Rhyolite)
   A) Felsic  
   B) Intermediate  
   C) Mafic  
   D) Ultramafic

18. What is the texture of igneous rock F? (Scoria)
   A) Phaneritic  
   B) Aphanitic  
   C) Porphyritic  
   D) Glassy  
   E) Vesicular

19. The texture of igneous rock F indicates what kind of origin?
   A) Intrusive igneous rock  
   B) Extrusive igneous rock

20. Felsic magmas are formed by the partial melting of which type of crust?
   A) Oceanic crust  
   B) Continental Crust  
   C) Island Crust  
   D) Bread Crust
21. Vesicles form from:
   A) Chunks of rock floating in magma
   B) Gasses escaping from lava
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   A) Fast cooling at the surface
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23. Which type of volcano is the largest?
   A) Cinder cone
   B) Composite volcano
   C) Shield volcano

24. Which type of lava forms shield volcanoes?
   A) Felsic
   B) Intermediate
   C) Mafic
   D) Ultramafic

25. Identify igneous rock G. (Granite)
   A) Pumice
   B) Granite
   C) Rhyolite
   D) Andesite
   E) Scoria

26. In an igneous rock, what does composition describe?
   A) Refers to the different types of minerals in the rock
   B) Describes the location where the rock was found
   C) The rock’s protolith (parent rock)
   D) The size, shape, and arrangement of the rock’s constituent parts

27. Identify sedimentary rock H. (Coquina)
   A) Sandstone
   B) Shale
   C) Chert
   D) Conglomerate
   E) Coquina
28. What compositional category does sedimentary rock I belong to? (Coal)
   A) Detrital
   B) Biochemical
   C) Chemical

29. Sandstones are formed in which sedimentary environment(s)?
   A) Beach
   B) Reef
   C) Mountains
   D) Desert
   E) A and D

30. Identify sedimentary rock J. (Chalk)
   A) Coquina
   B) Breccia
   C) Sandstone
   D) Chalk
   E) Chert

31. What is the depositional environment of sedimentary rock Z? (Rock Salt)
   A) Subaerial
   B) Subaqueous
   C) Subsurface
   D) Subsandwich

32. What is the grain arrangement for sedimentary rock K? (Conglomerate)
   A) Poorly sorted
   B) Moderately sorted
   C) Well sorted

33. What is the grain (sediment) size of sedimentary rock K? (Hint: Look at the largest sediment).
   A) Gravel
   B) Sand
   C) Silt
   D) Clay

34. The presence of fossils indicates which type of rock?
   A) Igneous
   B) Sedimentary
   C) Metamorphic
   D) Mineral
35. The only difference between conglomerates and breccias is that conglomerates have **rounded** gravel-sized sediments and breccias have **angular** gravel-sized sediments. What does the shape of the sediments reveal about these two sedimentary rocks?
   A) The sediments in the breccia traveled much farther from their source than the sediments in the conglomerate.
   B) The sediments in the conglomerate traveled much farther than the sediments in the breccia.
   C) The conglomerate sediments were transported by a small stream, while the breccia sediments were transported by a large river.
   D) The sediments in the conglomerate came from igneous rock, while the sediments in the breccia came from metamorphic rock.
   E) The shape of the sediment grains doesn’t reveal anything.

36. Which sedimentary rock is formed by the precipitation of dissolved silica from solution (ocean water)?
   A) Breccia
   B) Sandstone
   C) Chalk
   D) Chert
   E) Coquina

37. Where does the sedimentary rock coal form?
   A) Beaches
   B) Deep Ocean
   C) Streams
   D) Swamps
   E) Mountains

38. Where does the sediment that forms sandstone come from?
   A) Mechanical/chemical weathering of pre-existing rock
   B) Secretions from reef-dwelling creatures
   C) Swamps (decaying plant life)
   D) Precipitation from seawater
   E) Fossil remains

39. Identify metamorphic rock L. (Quartzite)
   A) Marble
   B) Gneiss
   C) Schist
   D) Quartzite
   E) Slate
40. Identify metamorphic rock M. (*Gneiss*)
   A) Gneiss
   B) Schist
   C) Slate
   D) Quartzite
   E) Marble

41. What is the **general** texture for metamorphic rock M?
   A) Foliated
   B) Unfoliated
   C) Phaneritic
   D) Aphanitic

42. Which rock is the parent rock for Slate, Phyllite, Schist, and Gneiss?
   A) Limestone
   B) Sandstone
   C) Shale
   D) Conglomerate
   E) Basalt

43. What is the parent rock (protolith) for Quartzite?
   A) Limestone
   B) Slate
   C) Granite
   D) **Sandstone**
   E) Shale

44. Metamorphic Grade means:
   A) Parent rock
   B) **Intensity of metamorphism**
   C) Mineral composition
   D) Grain size
Matching: Choose one of the following for the question below. Letters MAY BE used more than once.

A) Mineral
B) Igneous Rock
C) Sedimentary Rock
D) Metamorphic Rock
E) Igneous, Sedimentary, and Metamorphic Rock

45. What type of rock can be changed by a metamorphic event? E
46. An inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline structure. A
47. Forms by changing from one form to another by intense heat, intense pressure, or the action of hot watery fluids. D
48. Forms from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation. C
49. The basic building-block of all rocks. A
50. Forms from molten rock (magma or lava). B
1. What color is the streak for mineral A (Sulfur)?
   A) White
   B) Dark Gray
   C) Green
   D) Yellow
   E) Pink

2. Mineral A has which type of luster?
   A) Metallic
   B) Non-Metallic
   C) Hard
   D) Soft

3. What is the Moh’s scale hardness of mineral A?
   A) Hard (>5.5)
   B) 5
   C) 3 or 4
   D) 1 or 2

4. Mineral A’s specific gravity is:
   A) high.
   B) average.
   C) low.
   D) absent.

5. Identify mineral A.
   A) Graphite
   B) Galena
   C) Plagioclase Feldspar
   D) Sulfur
   E) Pyrite

6. Which one of the following is not one of the 6 common properties we used to identify minerals?
   A) Color
   B) Reaction to hydrochloric acid
   C) Luster
   D) Cleavage
   E) Streak
7. Which tool(s) is/are used to identify mineral hardness?
   A) Glass plate
   B) Iron Nail
   C) Penny
   D) Fingernail
   E) All of the above

8. The cleavage of mineral B is: (Mica)
   A) Excellent to Good
   B) Fair to Poor
   C) Absent
   D) Ugly

9. What is the hardness (from Moh’s Scale) of mineral C? (Fluorite)
   A) Hard >5
   B) 4
   C) 3
   D) <2.5

10. Which one of the following is not an igneous texture?
    A) Aphanitic
    B) Phaneritic
    C) Glassy
    D) Microcrystalline
    E) Porphyritic

11. What is the composition of igneous rock D? (Gabbro)
    A) Felsic
    B) Intermediate
    C) Mafic
    D) Ultramafic

12. What is the texture of igneous rock D?
    A) Phaneritic
    B) Porphyritic
    C) Aphanitic
    D) Vesicular
    E) Glassy

13. What is the cooling history of igneous rock D?
    A) Fast – at or above the surface
    B) Slow – deep under the surface
    C) Slow then fast
    D) Fast then slow
14. Identify igneous rock D.
   A) Granite
   B) Diorite
   C) Pumice
   D) Gabbro
   E) Andesite

15. What is the extrusive equivalent of rock D?
   A) Basalt
   B) Andesite
   C) Rhyolite
   D) Pumice

16. What type of composition does an igneous rock have if it is composed *mainly* of light colored minerals?
   A) Felsic
   B) Intermediate
   C) Mafic
   D) Ultramafic

17. Extrusive rocks form:
   A) from magma above the surface
   B) from lava above the surface
   C) from magma below the surface
   D) from lava below the surface

18. What texture below indicates an igneous rock as *intrusive* in origin?
   A) Phaneritic
   B) Aphanitic
   C) Porphyritic
   D) Glassy
   E) Vesicular

19. Felsic magmas are formed by the partial melting of which type of crust?
   A) Oceanic crust
   B) Continental Crust
   C) Island Crust
   D) Bread Crust

20. Identify igneous rock E. *(Granite)*
   A) Pumice
   B) Granite
   C) Rhyolite
   D) Andesite
   E) Scoria
21. The texture of igneous rock F indicates what kind of origin? (Scoria)
   A) Intrusive igneous rock
   B) Extrusive igneous rock

22. What is the texture of igneous rock F?
   A) Phaneritic
   B) Aphanitic
   C) Porphyritic
   D) Glassy
   E) Vesicular

23. Vesicles form from:
   A) Chunks of rock floating in magma
   B) Gasses escaping from lava
   C) Minerals dissolving
   D) Air forcing its way into lava

24. Porphyritic texture is a result of:
   A) Fast cooling at the surface
   B) Slow cooling below the surface
   C) Slow cooling at first, followed by fast cooling later
   D) Instantaneous cooling under the sea

25. Which type of volcano is the largest?
   A) Cinder cone
   B) Composite volcano
   C) Shield volcano

26. Which is the compositional category of sedimentary rock H? (Coquina)
   A) Detrital
   B) Biochemical
   C) Chemical

27. What is the depositional environment of sedimentary rock H?
   A) Reef
   B) Deep sea
   C) Desert
   D) Swamp

28. Identify sedimentary rock H.
   A) Sandstone
   B) Shale
   C) Chert
   D) Conglomerate
   E) Coquina
29. Sandstones are formed in which sedimentary environment(s)?
   A) Beach
   B) Reef
   C) Mountains
   D) Desert
   E) A and D

30. What is the compositional category of sedimentary rock I? (Coal)
   A) Detrital
   B) Biochemical
   C) Chemical

31. What is the depositional environment of sedimentary rock I?
   A) Reef
   B) Deep sea
   C) Desert
   D) Swamp

32. Identify sedimentary rock I.
   A) Chalk
   B) Chert
   C) Coal
   D) Conglomerate
   E) Coquina

33. What is the grain arrangement for sedimentary rock K? (Conglomerate)
   A) Poorly sorted
   B) Moderately sorted
   C) Well sorted

34. What is the grain shape of sedimentary rock K?
   A) Angular
   B) Rounded
   C) Chunky
   D) Platy

35. Identify sedimentary rock K.
   A) Anthracite
   B) Breccia
   C) Conglomerate
   D) Dolomite
   E) Either A or B
36. The presence of fossils indicates which type of rock?
   A) Igneous
   B) Sedimentary
   C) Metamorphic
   D) Mineral

37. The only difference between conglomerates and breccias is that conglomerates have rounded gravel-sized sediments and breccias have angular gravel-sized sediments. What does the shape of the sediments reveal about these two sedimentary rocks?
   A) The sediments in the breccia traveled much farther from their source than the sediments in the conglomerate.
   B) The sediments in the conglomerate traveled much farther than the sediments in the breccia.
   C) The conglomerate sediments were transported by a small stream, while the breccia sediments were transported by a large river.
   D) The sediments in the conglomerate came from igneous rock, while the sediments in the breccia came from metamorphic rock.
   E) The shape of the sediment grains doesn’t reveal anything

38. Where does the sediment that forms sandstone come from?
   A) Mechanical/chemical weathering of pre-existing rock
   B) Secretions from reef-dwelling creatures
   C) Swamps (decaying plant life)
   D) Precipitation from seawater
   E) Fossil remains

39. What is the texture of metamorphic rock L? (Quartzite)
   A) Schistocity
   B) Crystalline
   C) Microcrystalline
   D) Gneissic banding
   E) Sandy

40. Identify metamorphic rock L.
   A) Schist
   B) Quartzite
   C) Phyllite
   D) Marble

41. What is the parent rock for metamorphic rock L?
   A) Limestone
   B) Slate
   C) Granite
   D) Sandstone
   E) Shale
42. What is the **general** texture for metamorphic rock M? (Gneiss)
   A) Foliated
   B) Unfoliated
   C) Phaneritic
   D) Aphanitic

43. Identify metamorphic rock M.
   A) Gneiss
   B) Schist
   C) Slate
   D) Quartzite
   E) Marble

44. What is the parent rock for metamorphic rock M?
   A) Limestone
   B) Sandstone
   C) Shale
   D) Conglomerate
   E) Basalt

**Matching:** Choose one of the following for the question below. Letters **MAY BE** used more than once.

A) Mineral
B) Igneous Rock
C) Sedimentary Rock
D) Metamorphic Rock
E) Igneous, Sedimentary, and Metamorphic Rock

45. What type of rock can be changed by a metamorphic event? E

46. An inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline structure. A

47. Forms by changing from one form to another by intense heat, intense pressure, or the action of hot watery fluids. D

48. Forms from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation. C

49. The basic building-block of all rocks. A

50. Forms from molten rock (magma or lava). B
We encourage all students to **ask a TA** if a question or diagram is not absolutely clear. During the exam, students are NOT allowed to talk to each other **for any reason**.

Please choose the **best** answer for each question.

**Cellular phones are not allowed at the exam.**

Turn the phone off and put it away. If your phone makes any noise (including vibration) during the exam, you will lose 10 points off the exam grade.

Your phone **MAY NOT** be used as a calculator. If you need a calculator, ask for one.
Lab # 6 - Relative Age Dating

Match the Law to its definition (Questions 1-5). Each letter will be used only once.

A) Law of Inclusions  
B) Law of Cross-Cutting  
C) Law of Superposition  
D) Law of Original Horizontality  
E) Law of Lateral Continuity

1) Anything that cuts across a stratum or flow must be younger than the bed it cuts.

2) Sedimentary strata and lava flows are laid down horizontally. Any variation happened after they were initially deposited.

3) The oldest layer is at the bottom, younger layers on top.

4) An inclusion is older than its surrounding matrix.

5) Strata and lava flows extend laterally in all directions until they pinch out or reach the edge of their depositional basins.

Refer to Diagram A for questions 6 – 9.

6) List the events in order from oldest to youngest (letter X is the oldest rock).
   
   A) X,B,H,S,M,I,F,U,C,P  
   B) X,B,H,S,M,U,C,P,F,I  
   C) X,B,H,S,M,F,U,C,P,I  
   D) X,M,S,H,B,F,U,P,C,I  
   E) X,I,B,H,F,S,M,U,P,C

7) What law is used to determine that the igneous intrusion I is younger than sedimentary rock layer P?
   
   A) Law of Inclusions  
   B) Law of Cross-Cutting  
   C) Law of Superposition  
   D) Law of Original Horizontality  
   E) Law of Lateral Continuity

8) What type of unconformity is below layer C?
   
   A) Disconformity
B) Angular unconformity
C) Nonconformity

9) What law is used to determine that sedimentary rock layer H is older than sedimentary rock layer M?

A) Law of Inclusions
   B) Law of Cross-Cutting
   C) Law of Superposition
   D) Law of Original Horizonality
   E) Law of Lateral Continuity

**Lab #7 – Geologic Structures and Geologic Maps**

Match the tectonic stress to the geologic structure it creates (Questions 10-13).
Letters may be used more than once.

A) Shear stress
B) Compressional stress
C) Tensional stress

10) Which stress causes reverse or thrust faults to occur?
11) Which stress causes normal faults?
12) Which stress causes folds such as anticlines and synclines?
13) Which stress causes left or right lateral faults?

14) What is the geologic structure depicted in Diagram B?

   A) Symmetrical anticline
   B) Asymmetrical anticline
   C) Symmetrical syncline
   D) Asymmetrical syncline

15) What is the geologic structure depicted in Diagram C?

   A) Symmetrical anticline
   B) Asymmetrical anticline
   C) Symmetrical syncline
   D) Asymmetrical syncline
16) What type of fault is depicted on the Road Cut Cross Section at letter Y?

A) Normal
   B) Reverse
   C) Thrust
   D) Right lateral
   E) Left lateral

17) What type of fault is depicted on the New England Map at letter X?

   A) Normal
   B) Reverse
   C) Thrust
   D) Right lateral
   E) Left lateral

**Match each structural term to its definition (Questions 18-22). Each letter may be used only once.**

A) Dip
   B) Joint
   C) Attitude
   D) Strike
   E) Fault

18) A crack in the rock where no movement of the rocks on either side of the crack has taken place

19) A break in the rock where movement has occurred

20) On a flat surface, the direction a bed trends

21) The angle between a horizontal plane and the inclined stratum, fault, or fracture

22) The orientation of a rock formation or surface

23) How do you determine the age of a particular color on the map?

   A) The lighter colors are always older
   B) The darker colors are always older
   C) They are color-coded in the legend – oldest on the top
   D) They are color-coded in the legend – oldest on the bottom
24) What do the different colors and abbreviations on a geologic map represent?

A) Soil types
B) Vegetation types
C) Rock formations
D) Elevations

Lab #8 – Topographic Maps

Use the globe – Diagram D to answer questions 25 and 26.

25) What are the latitude and longitude of Letter X (latitude is listed first)?

A) 40°N, 45°W
B) 45°E, 40°S
C) 45°S, 45°E
D) 40°W, 45°N
E) 40°S, 45°E

26) What are the latitude and longitude of Letter Y (latitude is listed first)?

A) 15°N, 80°W
B) 80°N, 15°W
C) 15°S, 80°E
D) 80°S, 15°E
E) 15°W, 80°N

27) The North and South Poles are:

A) Unrelated to latitude or longitude
B) Minimum longitude
C) Maximum longitude
D) Minimum latitude
E) Maximum latitude

28) What is another name for 0° latitude?

A) 180° Meridian (International Dateline)
B) Equator
C) Prime Meridian
D) North Pole
E) South Pole
29) Where is elevation assumed to be 0 feet or meters?

A) Prime Meridian  
B) Sea level  
C) North Pole  
D) Equator  
E) The top of the highest hill

30) What is the maximum possible longitude?

A) 0°  
B) 90°  
C) 180°  
D) 270°  
E) 360°

31) What is the maximum possible latitude?

A) 0°  
B) 90°  
C) 180°  
D) 270°  
E) 360°

Use the topographic map of Fairfield, Pennsylvania to answer questions 32 - 42.

32) What extent of longitude is covered by this map?

A) 39° 45’ 00” to 39° 52’ 30”  
B) 77° 15’ 00” to 77° 22’ 30”  
C) 39° 45’ 00” to 77° 15’ 00”  
D) 77° 22’ 30” to 39° 52’ 30”

33) What extent of latitude is covered by this map?

A) 39° 45’ 00” to 39° 52’ 30”  
B) 77° 15’ 00” to 77° 22’ 30”  
C) 39° 45’ 00” to 77° 15’ 00”  
D) 77° 22’ 30” to 39° 52’ 30”

34) This map is:

A) Not a quadrangle at all  
B) A 7 1/2-minute quadrangle  
C) A 15-minute quadrangle  
D) Neither, it has uneven dimensions
35) This map was made in 1947. The magnetic declination that year was:

A) 0°
B) 27°
C) 5° 30’
D) Not indicated on this map

36) The fractional scale on this map is 1:25,000. This means:

A) 1 inch on the map = 25,000 feet on the earth’s surface
B) 1 inch on the map = 25,000 inches on the earth’s surface
C) 1 mile = 25,000 inches on the earth’s surface
D) 1 inch on the map = 25,000 miles on the earth’s surface

37) The contour interval of this map is:

A) Different on different parts of the map
B) Not specified
C) 10 feet
D) 20 feet
E) 50 feet

38) What direction does Plum Run flow? (Hint 1: Look in the bottom half of the map. The stream, Plum Run, runs right through the word FREEDOM.) (Hint 2: Look at the contour lines).

A) Northwest to southeast
B) Southeast to northwest
C) Southwest to northeast
D) Northeast to southwest

39) What is the closest **index** contour to the top of Kerr Hill?

A) 500 feet
B) 600 feet
C) 700 feet
D) 800 feet
E) 900 feet
40) What is the change in elevation (relief) from the top of Kerr Hill to the main intersection in Knoxlyn?

A) 2.2 inches  
B) 17 feet  
C) 600 feet  
D) 360 feet  

41) What is the distance from the top of Kerr Hill to the main intersection in Knoxlyn?

A) 2.2 inches  
B) 0.85 feet  
C) 0.85 miles  
D) 3 miles  

42) What is the average gradient from the top of Kerr Hill to the main intersection in Knoxlyn?

A) 1 in/mile  
B) 423 feet/mile  
C) 706 feet/mile  
D) 200 feet/mile  

Lab #9 – Streams and Groundwater Processes

Match each stream term to its definition (Questions 43 – 47). Each letter may be used only once.

A) Intermittent  
B) Drainage basin  
C) Perennial  
D) Dendritic  
E) Base level

43) Flows year-round. Represented by a solid blue line on a topo map.  
44) Does NOT flow year-round. Represented by a dashed or dotted line on a topo map.  
45) The most common type of stream drainage pattern.  
46) The entire area of land that is drained by one stream or one system.  
47) The lowest elevation to which a stream can erode.
Refer to the map of Memphis, Tenn. – Ark. for questions 48 - 52.

48) What type of stream channel is the Loosahatchie River (north of Memphis)?
   A) Straight
   B) Meandering
   C) Braided

49) What feature is the white area on the inside of the meander just west of Vice Presidents Island?
   A) Cut bank
   B) Point bar
   C) Tombolo
   D) Oxbow lake
   E) Alluvial fan

50) Which island that is now in Arkansas would once have been in Tennessee?
   A) President’s Island
   B) Vice President’s Island
   C) Frames Island
   D) City Island
   E) Robinson Crusoe Island

51) What is the best reason to avoid using a river as a border? (Hint: Look at the wording in the river at the top and bottom of the map.)
   A) Because the river will flood
   B) Because the river will eventually dry out
   C) Because the river will change course over time
   D) Because you can’t drive across the river
   E) Because it is easy for immigrants to cross the river

52) What feature is Hopefield Chute (in the north central section of the map)?
   A) Cut bank
   B) Point bar
   C) Tombolo
   D) Oxbow lake
   E) Alluvial fan
53) What type of valley is characteristic of a straight stream channel?

A) U-shaped  
B) V-shaped  
C) S-shaped  
D) Y-shaped  
E) L-shaped

54) In Diagram E, what letter marks the recharge location for the confined aquifer?

A) W  
B) X  
C) Y  
D) Z  
E) Not labeled

55) What is (are) the danger(s) of overpumping a well?

A) Lowering of the vadose water table  
B) Salt-water intrusion  
C) Subsidence of the land surface  
D) All of the above  
E) None of the above

Lab # 10 – Coastal Processes

Match each coastal structure to its definition (Questions 56-59). Each letter may be used only once.

A) Sea wall  
B) Groin  
C) Jetty  
D) Breakwater

56) Built parallel to the shoreline and offshore (in the ocean) to reduce wave energy

57) Built parallel to the shoreline and against the beach to prevent erosion

58) Built perpendicular to the shoreline to trap sand or build up a beach

59) Built perpendicular to the shoreline, usually in pairs, to keep a harbor open
60) What is the biggest problem associated with building jetties and groins?

A) They are not attractive and harm the tourism business
B) They are dangerous to sea creatures
C) They are dangerous to humans
D) They disturb the natural sediment transport and cause erosion
E) Both B and C

61) Exposed marine terraces, wide beaches, and salt marshes are features of what type of coastline?

A) Gulf coast
B) River coast
C) Submergent coast
D) Emergent coast

62) A submergent coastline can be caused by:

A) Sea level lowering
B) Sea level rising
C) The land sinking (subsidence)
D) Both A and C
E) Both B and C

63) What feature below cannot reveal the direction of the longshore current?

A) Spit
B) Jetty
C) Sea wall
D) Groin
E) All of the above

64) In Diagram F, what natural coastal feature is letter U?

A) Estuary
B) Spit
C) Salt marsh
D) Sea stack
E) Marine terrace

65) In Diagram F, which direction is the longshore current flowing?

A) Northeast
B) Southeast
C) Southwest
D) Northwest
66) What natural coastline feature can be used to determine the direction of the longshore current?

A) Estuary
B) Spit
C) Salt marsh
D) Wave-cut cliff
E) Stack

**Lab # 11 – Glacial Processes**

67) In Diagram G, what erosional feature is indicated by letter M?

A) Medial moraine
B) Horn
C) Arête
D) Lateral moraine
E) Cirque

68) In Diagram G, what type of glacier created erosional feature L?

A) Cirque glacier
B) Piedmont glacier
C) Ice sheet
D) Valley glacier
E) Continental glacier

69) In Diagram H, what depositional feature is indicated by letter K?

A) Medial moraine
B) Horn
C) Arête
D) Lateral moraine
E) Cirque

70) In Diagram H, what depositional feature is indicated by letter J?

A) Medial moraine
B) Horn
C) Arête
D) Lateral moraine
E) Cirque
Match each glacial term to its definition (Questions 71-75). Each letter may be used only once.

A) Snowline
B) Accumulation
C) Terminus
D) Ablation
E) Retreat

71) The bottom end or nose of the glacier.
72) Addition of snow and ice to the glacier.
73) Loss of snow and ice from the glacier.
74) The glacier is ablating faster than it is accumulating.
75) The dividing line between the zone of accumulation and the zone of ablation.

76) What is (are) the reasons we study glaciers?
   A) They can be good indicators of global warming
   B) They are responsible for a lot of North American topography
   C) They are the reason we have good farm land in America
   D) They covered large areas of America in the past
   E) All of the above

77) What type of glacier was formed below the rock with the “slime” in lab?
   A) Cirque glacier
   B) Piedmont glacier
   C) Ice sheet
   D) Valley glacier
   E) Continental glacier

78) Where in the world today are ice sheets still present?
   A) Antarctica
   B) Cascade Mountain Range
   C) Andes Mountains
   D) Greenland
   E) Both A and D
79) How can you recognize a hanging valley?

A) There is a waterfall.
B) Two river valleys come together.
C) A river valley is cut off by a glacier valley.
D) There is a noose on one end.
E) Both A and C.

80) What depositional feature marks the furthest extent of the glacier’s advance?

A) Medial moraine
B) Lateral moraine
C) Recessional moraine
D) Terminal moraine
E) Last moraine

Lab # 11 Continued – Public Land Survey System (PLS)

81) What are the dimensions of a Section?

A) 6 mi. x 6 mi.
B) 1 mi. x 1 mi.
C) 36 mi. x 36 mi.
D) 1 mi. x 6 mi.
E) None of the above

82) When and where was the PLS system first invented?

A) In Starkville in the new millennium.
B) In Mississippi in the 1900’s
C) In Canada in the 1800’s.
D) In North America in the 1700’s.
E) In Europe in the 1600s

Use the Map of Memphis, Tenn. – Ark. To answer questions 83 - 85. DO NOT WRITE ON THE MAP!

83) What named feature is located at T7N, R9E, Sec.10?

A) Chicken Island
B) Pleasant Hill Church
C) Redman Point
D) Green Hill Church
E) Harvard
84) What feature is located at T5N, R10W, Sec. 9, SW ¼?

A) St. John’s Church  
B) Grassy Lake  
C) Fletcher Lake  
D) Waverly  
E) Swan Lake

85) In what Township, Range, and Section do you find White Chapel School (east of the Frank C. Pidgeon Industrial Development).

A) T1S, R8W, Sec. 2  
B) T1S, R9W, Sec. 2  
C) T5N, R10W, Sec. 2.  
D) T5N, R9W, Sec. 2.

Lab # 12 – Mississippi

86) Look at the Tishomingo County photograph (Fig. 28). What far-away event caused the folding of the layers of rock on this lake shore in Tishomingo County, MS?

A) The folding of the Appalachian Mountains  
B) Earthquakes in California  
C) Eruption of Mt. St. Helen’s  
D) Tsunamis in the Indian Ocean  
E) Glaciation in Ohio

Use the Mississippi Geologic Map for Questions 87 & 88.

87) What type of Quaternary deposits make up the area of the state known as “The Delta”?

A) Loess  
B) Citronelle formation  
C) Alluvium  
D) Marine sediments  
E) Volcanic ash

88) What three rock units underlie the soils in Oktibbeha County?

A) Tuscaloosa Group, Eutaw Group, and Selma Group  
B) Selma Group, Midway Group, and Wilcox Group  
C) Claiborne Group, Jackson Group, and Vicksburg Group  
D) Forest Hill Formation, Catahoula Formation, and Pascagoula Formation  
E) Hattiesburg Formation, Citronelle Formation, and Loess
Use the Starkville Topographic Map to answer questions 89 – 95.

89) What do the purple areas on the map represent?

A) Man-made structures  
B) Natural structures  
C) Extension of urban areas  
D) Photorevision of the map  
E) Both C and D

90) The contour interval on this map is 10 feet. What is the approximate elevation of Hilbun Hall?

A) 390 feet  
B) 310 feet  
C) 280 feet  
D) 200 feet  
E) 140 feet

91) What type of stream channel does the Catalpa Creek exhibit Sections 25 and 30 (in the Southeast corner of the map)?

A) Straight  
B) Meandering  
C) Braided  
D) Intermittent

92) Look carefully at Hollis Creek, Skinner Creek, Tobacco Juice Creek, and the tributaries that lead into Catalpa Creek on the South side of the map. What type of streams are they?

A) Intermittent  
B) Perennial  
C) Anastamosing  
D) Braided

93) Where does the city water in Starkville come from?

A) Directly from the Tennessee-Tombigbee Waterway  
B) They buy it from Columbus and then process it  
C) From the creeks in question #92  
D) The water towers on the MSU campus  
E) Wells that draw from the Gordo aquifer
94) In what Township, Range, and Section does most of MSU lie?

A) T19N, R15E, Sec. 30  
B) T18N, R15E, Sec. 18  
C) T18N, R14E, Sec. 1  
D) T19S, R14E, Sec. 1  
E) T19N, R14W, Sec. 1

95) What is the only glacial “feature” found in Mississippi?

A) Terminal moraines  
B) Loess  
C) Kettle lakes  
D) U-shaped valleys  
E) Arêtes

Use the map of the Mississippi Gulf Coast to answer questions 96 & 97.

96) Which direction is the longshore current flowing in this section of the Gulf of Mexico?

A) Northeast  
B) Northwest  
C) Southeast  
D) Southwest  
E) Due north

97) Bayou is another name for Estuary. What does the abundance of Bayous in this area indicate?

A) Spits are building because the bayous are widening  
B) Longshore currents are removing the land  
C) The Mississippi River is migrating eastward  
D) Hurricanes are forcing the water into the bayous  
E) Sea level is rising in the Gulf, flooding river valleys
98) What was your favorite lab? Why? (There is no wrong answer, write as much as you like)

99) What was your least favorite lab? Why? (There is no wrong answer, write as much as you like)
100) What is your TA’s name?

**BONUS QUESTION:**

Think all the way back to the FIRST DAY of lab.

You have just won the lottery and your friends tell you, “California is the place you ought to be” so you load up the truck and move to Beverly (as in Los Angeles). You must decide on which property to build your mansion. Which of these choices would be the **worst** location to build on in an earthquake-prone area?

A) Sandstone rock  
B) Compacted sediment (not lithified into rock)  
C) Gneiss rock  
D) Granite rock  
E) An old landfill now covered with dirt and grass

**Have a great summer**
|    |    | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13  | 14  | 15 | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | 31  | 32  | 33  | 34  | 35  | 36  | 37  | 38  | 39  | 40  |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1  | B  | 41 | C  | 81 | B  |
| 2  | D  | 42 | B  | 82 | D  |
| 3  | C  | 43 | C  | 83 | C  |
| 4  | A  | 44 | A  | 84 | E  |
| 5  | E  | 45 | D  | 85 | B  |
| 6  | D  | 46 | B  | 86 | A  |
| 7  | B  | 47 | E  | 87 | C  |
| 8  | A  | 48 | B  | 88 | B  |
| 9  | C  | 49 | B  | 89 | E  |
| 10 | B  | 50 | E  | 90 | A  |
| 11 | C  | 51 | C  | 91 | B  |
| 12 | B  | 52 | D  | 92 | A  |
| 13 | A  | 53 | B  | 93 | E  |
| 14 | C  | 54 | B  | 94 | C  |
| 15 | B  | 55 | D  | 95 | B  |
| 16 | A  | 56 | D  | 96 | D  |
| 17 | D  | 57 | A  | 97 | E  |
| 18 | B  | 58 | B  | 98 | anything |
| 19 | E  | 59 | C  | 99 | anything |
| 20 | D  | 60 | D  | 100 | YOUR NAME |
| 21 | A  | 61 | D  |    |
| 22 | C  | 62 | E  |    | BONUS | E |
| 23 | D  | 63 | C  |    |
| 24 | C  | 64 | B  |    |
| 25 | E  | 65 | D  |    |
| 26 | B  | 66 | B  |    |
| 27 | E  | 67 | B  |    |
| 28 | B  | 68 | A  |    |
| 29 | B  | 69 | D  |    |
| 30 | C  | 70 | A  |    |
| 31 | B  | 71 | C  |    |
| 32 | B  | 72 | B  |    |
| 33 | A  | 73 | D  |    |
| 34 | B  | 74 | E  |    |
| 35 | C  | 75 | A  |    |
| 36 | B  | 76 | E  |    |
| 37 | D  | 77 | B  |    |
| 38 | A  | 78 | E  |    |
| 39 | D  | 79 | E  |    |
| 40 | D  | 80 | D  |    |
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**Relative Age Dating Lab**

Match the Law to its definition (Questions 1-5). Each letter will be used only once.

A) Law of Inclusions  
B) Law of Cross-Cutting  
C) Law of Superposition  
D) Law of Original Horizontality  
E) Law of Lateral Continuity

1) Anything that cuts across a stratum or flow must be younger than the bed it cuts. **B**

2) Sedimentary strata and lava flows are laid down horizontally. Any variation happened after they were initially deposited. **D**

3) The oldest layer is at the bottom, younger layers on top. **C**

4) An inclusion is older than its surrounding matrix. **A**

5) Strata and lava flows extend laterally in all directions until they pinch out or reach the edge of their depositional basins. **E**

Refer to Diagram A for questions 6 – 9.

6) List the events in order from oldest to youngest (letter X is the oldest rock).

   A) X,B,H,S,M,I,F,U,C,P  
   B) X,B,H,S,M,U,C,P,F,I  
   C) X,B,H,S,M,F,U,C,P,I  
   D) X,M,S,H,B,F,U,P,C,I  
   E) X,I,B,H,F,S,M,U,P,C

7) What law is used to determine that the igneous intrusion **I** is younger than sedimentary rock layer **P**? 

   A) Law of Inclusions  
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8) What type of unconformity is below layer **C**? 

   A) Disconformity  
   B) Angular unconformity  
   C) Nonconformity
9) What law is used to determine that sedimentary rock layer H is older than sedimentary rock layer M?

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**Geologic Structures and Geologic Maps Lab**

Match the tectonic stress to the geologic structure it creates (Questions 10-13). Letters may be used more than once.

   A) Shear stress
   B) Compressional stress
   C) Tensional stress

10) Which stress causes reverse or thrust faults to occur? **B**

11) Which stress causes normal faults? **C**

12) Which stress causes folds such as anticlines and synclines? **B**

13) Which stress causes left or right lateral faults? **A**

14) What is the geologic structure depicted in Diagram B?

   A) Symmetrical anticline
   B) Asymmetrical anticline
   C) Symmetrical syncline
   D) Asymmetrical syncline

15) What is the geologic structure depicted in Diagram C?

   A) Symmetrical anticline
   B) Asymmetrical anticline
   C) Symmetrical syncline
   D) Asymmetrical syncline
16) Which of the following is a type of unconformity?

   A) Disconformity  
   B) Nonconformity  
   C) Erosionalconformity  
   D) All of the above  
   E) A and B

17) Synclines have their youngest beds:

   A) in the center.  
   B) on the outside edges.  
   C) anywhere they want.  
   D) on the bottom.  
   E) none of the above.

18) Which type of fault is depicted in the Wooden Blocks diagram?

   A) Normal Fault  
   B) Reverse Fault  
   C) Thrust Fault  
   D) Lateral Fault (Strike-Slip)

19) What tool could you use to show a 3-D representation of a geologic structure such as a fold or fault?

   A) Topographic Map  
   B) Geologic Cross-section  
   C) Geologic Map  
   D) Block Diagram

20) Lengthening is caused by:

   A) Compression  
   B) Tension  
   C) A & B  
   D) None of the above

21) In this type of fault, strata (beds) may be offset vertically:

   A) Normal faults  
   B) Reverse faults  
   C) Strike-slip (lateral) faults  
   D) Thrust faults  
   E) A, B, and D
22) A Geologic Map shows the following information:

A) Distribution of rocks seen at the surface
B) Distribution of rocks just below the soils
C) The locations of Walmarts
D) The geographic extent of populations

23) How do you determine the age of a particular rock formation on the map?

A) The lighter colors are always older
B) The darker colors are always older
C) They are color-coded in the legend – oldest on the top
D) They are color-coded in the legend – oldest on the bottom

24) What do the different colors and abbreviations on a geologic map represent?

A) Soil types
B) Vegetation types
C) Rock formations
D) Elevations

**Topographic Maps and PLS Lab**

Use the globe – Diagram D to answer questions 25 and 26.

25) What are the latitude and longitude of Letter X (latitude is listed first)?

A) 40°N, 45°W
B) 45°E, 40°S
C) 45°S, 45°E
D) 40°W, 45°N
E) 40°S, 45°E

26) What are the latitude and longitude of Letter Y (latitude is listed first)?

A) 15°N, 80°W
B) 80°N, 15°W
C) 15°S, 80°E
D) 80°S, 15°E
E) 15°W, 80°N
27) The North and South Poles are:
   A) Unrelated to latitude or longitude
   B) Minimum longitude
   C) Maximum longitude
   D) Minimum latitude
   E) Maximum latitude

28) What is another name for 0° latitude?
   A) 180° Meridian (International Dateline)
   B) Equator
   C) Prime Meridian
   D) North Pole
   E) South Pole

29) Where is elevation assumed to be 0 feet or meters?
   A) Prime Meridian
   B) Sea level
   C) North Pole
   D) Equator
   E) The top of the highest hill

30) Which type of line on a Topo map has an elevation marked on it?
   A) Contour Line
   B) Index Contour line
   C) Elevation Line
   D) Map Elevation Line

31) The contour lines on a topo map are very close together. This area is:
   A) a beach
   B) a broad plain
   C) a steep cliff
   D) sea level
   E) rolling hills

Use the topographic map of Fairfield, Pennsylvania to answer questions 32 – 38.

32) The fractional scale on this map is 1:25,000. This means:
   A) 1 inch on the map = 25,000 feet on the earth’s surface
   B) 1 inch on the map = 25,000 inches on the earth’s surface
   C) 1 mile = 25,000 inches on the earth’s surface
   D) 1 inch on the map = 25,000 miles on the earth’s surface
33) The contour interval of this map is:
   A) Different on different parts of the map
   B) Not specified
   C) 10 feet
   D) 20 feet
   E) 50 feet

34) What direction does Plum Run flow? (Hint 1: Look in the bottom half of the map. The stream, Plum Run, runs right through the word FREEDOM.) (Hint 2: Look at the contour lines).
   A) Northwest to southeast
   B) Southeast to northwest
   C) Southwest to northeast
   D) Northeast to southwest

35) What is the closest index contour to the top of Kerr Hill?
   A) 500 feet
   B) 600 feet
   C) 700 feet
   D) 800 feet
   E) 900 feet

36) What is the change in elevation (relief) from the top of Kerr Hill to the main intersection in Knoxlyn?
   A) 2.2 inches
   B) 17 feet
   C) 600 feet
   D) 360 feet

37) What is the distance from the top of Kerr Hill to the main intersection in Knoxlyn?
   A) 2.2 inches
   B) 0.85 feet
   C) 0.85 miles
   D) 3 miles
38) What is the average gradient from the top of Kerr Hill to the main intersection in Knoxlyn?

A) 1 in/mile  
B) 423 feet/mile  
C) 706 feet/mile  
D) 200 feet/mile

39) PLS Stands for:

A) Public Land Survey  
B) Public Library System  
C) Private Land Survey  
D) Private Lakes and Streams  
E) None of the above

40) Use the Map of Memphis. Tenn. – Ark. To answer questions 83 - 85. DO NOT WRITE ON THE MAP!

What named feature is located at T7N, R9E, Sec.10?

A) Chicken Island  
B) Pleasant Hill Church  
C) Redman Point  
D) Green Hill Church  
E) Harvard

41) What feature is located at T5N, R10W, Sec. 9, SW ¼?

A) St. John’s Church  
B) Grassy Lake  
C) Fletcher Lake  
D) Waverly  
E) Swan Lake

42) In what Township, Range, and Section do you find White Chapel School (east of the Frank C. Pidgeon Industrial Development).

A) T1S, R8W, Sec. 2  
B) T1S, R9W, Sec. 2  
C) T5N, R10 W, Sec. 2.  
D) T5N, R9W, Sec. 2.
Streams and Groundwater Processes Lab

Match each stream term to its definition (Questions 43 – 47). Each letter may be used only once.

A) Intermittent
B) Drainage basin
C) Perennial
D) Base level

43) Flows year-round. Represented by a solid blue line on a topo map. C

44) Does NOT flow year-round. Represented by a dashed or dotted line on a topo map. A

45) The entire area of land that is drained by one stream or one system. B

46) The lowest elevation to which a stream can erode. D

47) To calculate the discharge of a stream, you must have:
   A) Ice cubes
   B) Velocity
   C) Area
   D) Salt
   E) B & C

48) A rectangular stream channel is 2 meters wide and the water is 3 meters deep. Your dog drops his ball in the water and it travels 30 meters in 15 seconds. He can swim 3 m/sec. Can he retrieve his ball?
   A) No, the ball is moving too fast
   B) Yes, he can swim faster than the ball
   C) No, the ball will sink
   D) Yes, he can run on top of the water

49) What is the discharge of the stream at the location in the previous question? (Hint: Q=VA)
   A) 2 m/sec
   B) 6 m²/sec
   C) 12 m³/sec
   D) 30 m³/sec
Refer to the map of Memphis, Tenn. – Ark. for questions 50 - 53.

50) Which island that is now in Arkansas would once have been in Tennessee?
   A) President’s Island
   B) Vice President’s Island
   C) Frames Island
   D) City Island
   E) Robinson Crusoe Island

51) What is the best reason to avoid using a river as a border? (Hint: Look at the wording in the river at the top and bottom of the map.)
   A) Because the river will flood
   B) Because the river will eventually dry out
   C) Because the river will change course over time
   D) Because you can’t drive across the river
   E) Because it is easy for immigrants to cross the river

52) What feature is Hopefield Chute (in the north central section of the map)?
   A) Cut bank
   B) Point bar
   C) Tombolo
   D) Oxbow lake
   E) Alluvial fan

53) What type of stream channel is the Loosahatchie River (northeast of Frayser)?
   A) Straight
   B) Meandering
   C) Braided

54) In Diagram E, what letter marks the recharge location for the confined aquifer?
   A) W
   B) X
   C) Y
   D) Z
   E) Not labeled

55) An artesian well is:
   A) a well drilled into an unconfined aquifer that rises to the water-pressure surface
   B) a well drilled into a confined aquifer that rises to the water-pressure surface
   C) a well drilled into an unsaturated aquifer that rises to the water-pressure surface
   D) a well drilled into a vadose aquifer that rises to the water-pressure surface
56) The land you just bought is subsiding at an average annual rate of 2 m/yr. By the time you pay off your 30-year mortgage, your land will be:

A) 30 m higher than now  
B) 60 m higher than now  
C) 60 m lower than now  
D) at the same elevation it is now

57) Which of the following might be sources of groundwater pollution?

A) Leaky underground gas tanks  
B) Local landfill  
C) Laundromat  
D) Agricultural pesticides  
E) All of the above

58) What type of valley is characteristic of a straight stream channel?

A) U-shaped  
B) V-shaped  
C) S-shaped  
D) Y-shaped  
E) L-shaped

Coastal Processes Lab

Match each coastal structure to its definition (Questions 56-59). Each letter may be used only once.

A) Sea wall  
B) Groin  
C) Jetty  
D) Breakwater

59) Built parallel to the shoreline and offshore (in the ocean) to reduce wave energy D

60) Built parallel to the shoreline and against the beach to prevent erosion A

61) Built perpendicular to the shoreline to trap sand or build up a beach B

62) Built perpendicular to the shoreline, usually in pairs, to keep a harbor open C
63) What is the biggest problem associated with building jetties and groins?

A) They are not attractive and harm the tourism business  
B) They are dangerous to sea creatures  
C) They are dangerous to humans  
D) They disturb the natural sediment transport and cause erosion  
E) Both B and C

64) In Diagram F, what natural coastal feature is letter U?

A) Estuary  
B) Spit  
C) Salt marsh  
D) Sea stack  
E) Marine terrace

65) In Diagram F, which direction is the longshore current flowing?

A) Northeast  
B) Southeast  
C) Southwest  
D) Northwest

66) Exposed marine terraces, wide beaches, and salt marshes are features of what type of coastline?

A) Gulf coast  
B) River coast  
C) Submergent coast  
D) Emergent coast

67) A submergent coastline can be caused by:

A) Sea level lowering  
B) Sea level rising  
C) The land sinking (subsidence)  
D) Both A and C  
E) Both B and C

68) What feature below cannot reveal the direction of the longshore current?

A) Spit  
B) Jetty  
C) Sea wall  
D) Groin  
E) All of the above
69) What natural coastline feature can be used to determine the direction of the longshore current?

A) Estuary  
B) Spit  
C) Salt marsh  
D) Wave-cut cliff  
E) Stack  

70) If you live in a coastal town, what should you do if a Hurricane is on the way?

A) Follow evacuation instructions if issued.  
B) Ignore evacuation instructions, ride it out.  
C) Nuke it.  
D) Stroll down to the beach bar for margaritas.  

71) A 1000-year-old seawall is now 300 meters inland. The shoreline in this town has prograded at an average annual rate of:

A) 0.3 m/yr  
B) 3 m/yr  
C) 300 m/yr  
D) 3000 m/yr  

72) What coastal process can have a negative effect on buildings near the coast?

A) Sea level rise  
B) Storm surge  
C) Beach erosion  
D) All of the above
Glacial Processes Lab

Match each glacial term to its definition (Questions 71-75). Each letter may be used only once.

A) Snowline
B) Accumulation
C) Terminus
D) Ablation
E) Retreat

73) The bottom end or nose of the glacier. C
74) Addition of snow and ice to the glacier. B
75) Loss of snow and ice from the glacier. D
76) The glacier is melting and the terminus is moving up the valley. E
77) The dividing line between the zone of accumulation and the zone of ablation. A

78) What is (are) the reasons we study glaciers?
   A) They can be good indicators of global warming
   B) They are responsible for a lot of North American topography
   C) They are the reason we have good farm land in America
   D) They covered large areas of America in the past
   E) All of the above

79) Wind transported glacial deposits are known as what?
   A) Glacial Rock
   B) Horn
   C) Loess
   D) Till

80) Where in the world today are ice sheets still present?
   A) Antarctica
   B) Cascade Mountain Range
   C) Andes Mountains
   D) Greenland
   E) Both A and D
81) Glacial retreat is when:

A) the glacier flows back up its valley  
B) the glacial ice is melting, causing the terminus to move back  
C) people move back from the glacier to avoid icebergs  
D) the glacial till is so high that it hides the glacier from view

82) What useful information can we get from measuring the extent of a glacier over many years (such as a century)?

A) Changes in the amount of pollution in the atmosphere  
B) Changes in climate in the glacial area  
C) Changes in land use in the glacial area  
D) Changes in the animal life in the glacial area

83) From the glacier lab we did, we learned that:

A) mean global temperature is constant  
B) mean global temperature is always rising  
C) mean global temperature is always falling  
D) mean global temperature fluctuates (sometime rises and sometimes falls)

**Mississippi Lab**

84) Frequent Earthquakes (about 250 per year) are felt in northwest Mississippi. These earthquakes are caused by:

A) Igneous intrusion under the Jackson Dome.  
B) Overpumping of the groundwater in Tunica County.  
C) Slippage along the New Madrid Fault.  
D) Subduction of plates under the Mississippi River.  
E) None of the above.

85) The area of Mississippi commonly known as “the Delta” is actually:

A) the delta of the Mississippi River.  
B) the floodplain of the Mississippi River.  
C) an oxbow lake.  
D) the place the Greeks named their letter “delta” after.
86) Look at the Tishomingo County photograph (Fig. 28). What far-away event caused the folding of the layers of rock on this lake shore in Tishomingo County, MS?

A) The compressional stress as the Appalachian Mountains formed  
B) Fault-induced earthquakes in California  
C) Recent eruption of Mt. St. Helen’s  
D) Repeated tsunamis in the Indian Ocean  
F) Repeated glaciation in Ohio

Use the Mississippi Geologic Map for Questions 87 & 88.

87) What type of Quaternary deposits make up the area of the state known as “The Delta”?

A) Loess  
B) Citronelle formation  
C) Alluvium  
D) Marine sediments  
E) Volcanic ash

88) What three rock units underlie the soils in Oktibbeha County?

A) Tuscaloosa Group, Eutaw Group, and Selma Group  
B) Selma Group, Midway Group, and Wilcox Group  
C) Claiborne Group, Jackson Group, and Vicksburg Group  
D) Forest Hill Formation, Catahoula Formation, and Pascagoula Formation  
E) Hattiesburg Formation, Citronelle Formation, and Loess

89) What is the only glacial “feature” found in Mississippi?

A) Terminal moraines  
B) Loess  
C) Kettle lakes  
D) U-shaped valleys  
E) Arêtes

90) What was the glacial feature in Question 89 used for during the Civil War?

A) To make cannonballs  
B) To test out experimental submarines  
C) To barricade Union troops  
D) To dig caves into for hiding from Union troops
91) Fluoride is in high concentration in Starkville’s water. This is because:

A) it is a by-product of natural erosion.
B) it is added purposely to promote dental health.
C) it comes from run-off from factories.
D) All of the above.

92) You are fishing for catfish in your favorite river. 100 yards upstream is a factory that is illegally dumping its waste into the stream. Your wisest choice is:

A) Find a new place to fish
B) Report the illegal dumping to authorities for investigation
C) Shoot the owner of the factory
D) A & B
E) B & C – then you won’t need to do A

93) Where does the city water in Starkville come from?

A) Directly from the Tennessee-Tombigbee Waterway
B) They buy it from Columbus and then process it
C) From the creeks in question #92
D) The water towers on the MSU campus
E) Wells that draw from the Gordo aquifer

94) Storm surge is a major concern to the citizens of:

A) Jackson
B) Biloxi
C) Starkville
D) All of the above
E) None of the above

95) The Mississippi River is which type of stream

A) Braided
B) Straight
C) Meandering
D) Karst
E) Continental
Use the map of the Mississippi Gulf Coast to answer questions 96 & 97.

96) Which direction is the longshore current flowing in this section of the Gulf of Mexico?
   A) Northeast
   B) Northwest
   C) Southeast
   D) Southwest
   E) Due south

97) Bayou is another name for Estuary. What does the abundance of Bayous in this area indicate?
   A) Spits are building because the bayous are widening
   B) Longshore currents are removing the land
   C) The Mississippi River is migrating eastward
   D) Hurricanes are forcing the water into the bayous
   E) Sea level is rising in the Gulf, flooding river valleys

98) What was your favorite lab? Why? (There is no wrong answer, write as much as you like)
99) What was your least favorite lab? Why? (There is no wrong answer, write as much as you like)

100) What is your Lab Instructor’s name?

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Think all the way back to the FIRST DAY of lab.

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A) Sandstone rock  
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4) An inclusion is older than its surrounding matrix. **A**

5) Strata and lava flows extend laterally in all directions until they pinch out or reach the edge of their depositional basins. **E**

Refer to Diagram A for questions 6 – 9.

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A) X,B,H,S,M,I,F,U,C,P  
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C) X,B,H,S,M,F,U,C,P,I  
D) X,M,S,H,B,F,U,P,C,I  
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C) Symmetrical syncline  
D) Asymmetrical syncline

15) What is the geologic structure depicted in Diagram C?

A) Symmetrical anticline  
B) Asymmetrical anticline  
C) Symmetrical syncline  
D) Asymmetrical syncline
16) Which of the following is a type of unconformity?

A) Disconformity  
B) Nonconformity  
C) Erosional conformity  
D) All of the above  
E) A and B

17) Synclines have their youngest beds:

A) in the center.  
B) on the outside edges.  
C) anywhere they want.  
D) on the bottom.  
E) none of the above.

18) Which type of fault is depicted in the Wooden Blocks diagram?

A) Normal Fault  
B) Reverse Fault  
C) Thrust Fault  
D) Lateral Fault (Strike-Slip)

19) What tool could you use to show a 3-D representation of a geologic structure such as a fold or fault?

A) Topographic Map  
B) Geologic Cross-section  
C) Geologic Map  
D) Block Diagram

20) Lengthening is caused by:

A) Compression  
B) Tension  
C) A & B  
D) None of the above

21) In this type of fault, strata (beds) may be offset vertically:

A) Normal faults  
B) Reverse faults  
C) Strike-slip (lateral) faults  
D) Thrust faults  
E) A, B, and D
22) A Geologic Map shows the following information:

A) Distribution of rocks seen at the surface
B) Distribution of rocks seen at depth
C) The locations of Walmarts
D) The geographic extent of populations

23) How do you determine the age of a particular rock formation on the map?

A) The lighter colors are always older
B) The darker colors are always older
C) They are color-coded in the legend – oldest on the top
D) They are color-coded in the legend – oldest on the bottom

24) What do the different colors and abbreviations on a geologic map represent?

A) Soil types
B) Vegetation types
C) Rock formations
D) Elevations

Topographic Maps and PLS Lab

Use the globe – Diagram D to answer questions 25 and 26.

25) What are the latitude and longitude of Letter X (latitude is listed first)?

A) 40°N, 45°W
B) 45°E, 40°S
C) 45°S, 45°E
D) 40°W, 45°N
E) 40°S, 45°E

26) What are the latitude and longitude of Letter Y (latitude is listed first)?

A) 15°N, 80°W
B) 80°N, 15°W
C) 15°S, 80°E
D) 80°S, 15°E
E) 15°W, 80°N
27) The North and South Poles are:

A) Unrelated to latitude or longitude
B) Minimum longitude
C) Maximum longitude
D) Minimum latitude
E) Maximum latitude

28) What is another name for 0° latitude?

A) 180° Meridian (International Dateline)
B) Equator
C) Prime Meridian
D) North Pole
E) South Pole

29) Where is elevation assumed to be 0 feet or meters?

A) Prime Meridian
B) Sea level
C) North Pole
D) Equator
E) The top of the highest hill

30) Which type of line on a topographic map has an elevation marked on it?

A) Contour Line
B) Index Contour line
C) Elevation Line
D) Map Elevation Line

31) The contour lines on a topographic map are very close together. This area is:

A) a beach
B) a broad plain
C) a steep cliff
D) sea level
E) rolling hills

Use the topographic map of Fairfield, Pennsylvania to answer questions 32 – 38.

32) The fractional scale on this map is 1/25,000. This means:

A) 1 inch on the map = 25,000 feet on the earth’s surface
B) 1 inch on the map = 25,000 inches on the earth’s surface
C) 1 mile = 25,000 inches on the earth’s surface
D) 1 inch on the map = 25,000 miles on the earth’s surface
33) The contour interval of this map is:

A) Different on different parts of the map
B) Not specified
C) 10 feet
D) 20 feet
E) 50 feet

34) What direction does Plum Run flow? (Hint 1: Look in the bottom half of the map. The stream, Plum Run, runs right through the word FREEDOM.) (Hint 2: Look at the contour lines).

A) Northwest to southeast
B) Southeast to northwest
C) Southwest to northeast
D) Northeast to southwest

35) What is the closest index contour to the top of Kerr Hill?

A) 500 feet
B) 600 feet
C) 700 feet
D) 800 feet
E) 900 feet

36) What is the change in elevation (relief) from the top of Kerr Hill to the main intersection in Knoxlyn?

A) 2.2 inches
B) 17 feet
C) 600 feet
D) 360 feet

37) What is the distance from the top of Kerr Hill to the main intersection in Knoxlyn?

A) 2.2 inches
B) 0.85 feet
C) 0.85 miles
D) 3 miles
38) What is the average gradient from the top of Kerr Hill to the main intersection in Knoxlyn?

   A) 1 in/mile
   B) 423 feet/mile
   C) 706 feet/mile
   D) 200 feet/mile

39) PLS Stands for:

   A) Public Land Survey
   B) Public Library System
   C) Private Land Survey
   D) Private Lakes and Streams
   E) None of the above

Use the map of Bright Angel, Arizona to answer questions 83 - 85. DO NOT WRITE ON THE MAP!

40) What named feature is located at T31N, R2E, Sec. 30?

   A) Picnic Area
   B) Settling Basin
   C) Horsethief Tank
   D) Long Jim Canyon
   E) Santa Maria Spring

41) What feature is located at T31N, R2E, Sec. 27, NE ¼?

   A) Brush Tank
   B) Coconino Wash
   C) Quarries
   D) Bright Angel Wash
   E) Sewage Disposal

42) In what Township, Range, and Section do you find the National Park Service Training School (hint: look south of the Grand Canyon National Park parking area).

   A) T30N, R1E, Sec. 1
   B) T31N, R2E, Sec. 26
   C) T31N, R2E, Sec. 23
   D) T30N, R2E, Sec. 4
Streams and Groundwater Processes Lab

Match each stream term to its definition (Questions 43 – 47). Each letter may be used only once.

A) Intermittent
B) Drainage basin
C) Perennial
D) Base level

43) Flows year-round. Represented by a solid blue line on a topo map. C

44) Does NOT flow year-round. Represented by a dashed or dotted line on a topo map. A

45) The entire area of land that is drained by one stream or one system. B

46) The lowest elevation to which a stream can erode. D

47) To calculate the discharge of a stream, you must have:
   A) Ice cubes
   B) Velocity
   C) Area
   D) Salt
   E) B & C

48) A rectangular stream channel is 2 meters wide and the water is 3 meters deep. Your dog drops his ball in the water and it travels 30 meters in 15 seconds. He can swim 3 m/sec. Can he retrieve his ball?
   A) No, the ball is moving too fast
   B) Yes, he can swim faster than the ball
   C) No, the ball will sink
   D) Yes, he can run on top of the water

49) What is the discharge of the stream at the location in the previous question? (Hint: Q=VA)
   A) 2 m/sec
   B) 6 m²/sec
   C) 12 m³/sec
   D) 30 m³/sec
Refer to the map of Memphis, Tenn. – Ark. for questions 50 - 53.

50) Which island that is now in Arkansas would once have been in Tennessee?
   A) President’s Island
   B) Vice President’s Island
   C) Frames Island
   D) City Island
   E) Robinson Crusoe Island

51) What is the best reason to avoid using a river as a border? (Hint: Look at the wording in the river at the top and bottom of the map.)
   A) Because the river will flood
   B) Because the river will eventually dry out
   C) Because the river will change course over time
   D) Because you can’t drive across the river
   E) Because it is easy for immigrants to cross the river

52) What feature is Hopefield Chute (in the north central section of the map)?
   A) Cut bank
   B) Point bar
   C) Tombolo
   D) Oxbow lake
   E) Alluvial fan

53) What type of stream channel is the Loosahatchie River (northeast of Frayser)?
   A) Straight
   B) Meandering
   C) Braided

54) In Diagram E, what letter marks the recharge location for the confined aquifer?
   A) W
   B) X
   C) Y
   D) Z
   E) Not labeled

55) An artesian well is:
   A) a well drilled into an unconfined aquifer that rises to the water-pressure surface
   B) a well drilled into a confined aquifer that rises to the water-pressure surface
   C) a well drilled into an unsaturated aquifer that rises to the water-pressure surface
   D) a well drilled into a vadose aquifer that rises to the water-pressure surface
56) The land you just bought is subsiding at an average annual rate of 2m/yr. By the time you pay off your 30-year mortgage, your land will be:

A) 30 m higher than now  
B) 60 m higher than now  
C) 60 m lower than now  
D) at the same elevation it is now

57) What type of valley is characteristic of a straight stream channel?

A) U-shaped  
B) V-shaped  
C) S-shaped  
D) Y-shaped  
E) L-shaped

Coastal Processes Lab

Match each coastal structure to its definition (Questions 56-59). Each letter may be used only once.

A) Sea wall  
B) Groin  
C) Jetty  
D) Breakwater

58) Built parallel to the shoreline and offshore (in the ocean) to reduce wave energy D

59) Built parallel to the shoreline and against the beach to prevent erosion A

60) Built perpendicular to the shoreline to trap sand or build up a beach B

61) Built perpendicular to the shoreline, usually in pairs, to keep a harbor open C

62) What is the biggest problem associated with building jetties and groins?

A) They are not attractive and harm the tourism business  
B) They are dangerous to sea creatures  
C) They are dangerous to humans  
D) They disturb the natural sediment transport and cause erosion  
E) Both B and C
63) In Diagram F, what natural coastal feature is letter U?

A) Estuary
B) Spit
C) Salt marsh
D) Sea stack
E) Marine terrace

64) In Diagram F, which direction is the longshore current flowing?

A) Northeast
B) Southeast
C) Southwest
D) Northwest

65) Exposed marine terraces, wide beaches, and salt marshes are features of what type of coastline?

A) Gulf coast
B) River coast
C) Submergent coast
D) Emergent coast

66) A submergent coastline can be caused by:

A) Sea level lowering
B) Sea level rising
C) The land sinking (subsidence)
D) Both A and C
E) Both B and C

67) What feature below cannot reveal the direction of the longshore current?

A) Spit
B) Jetty
C) Breakwater
D) Groin
E) All of the above
68) What natural coastline feature can be used to determine the direction of the longshore current?

A) Estuary  
B) Spit  
C) Salt marsh  
D) Wave-cut cliff  
E) Stack

69) If you live in a coastal town, what should you do if a Hurricane is on the way?

A) Follow evacuation instructions if issued.  
B) Ignore evacuation instructions, ride it out.  
C) Nuke it.  
D) Stroll down to the beach bar for margaritas.

70) A 2000-year-old seawall is now 500 meters inland. The shoreline in this town has prograded at an average annual rate of:

A) 0.25 m/yr  
B) 25 m/yr  
C) 250 m/yr  
D) 2500 m/yr

71) What coastal process can have a negative effect on buildings near the coast?

A) Sea level rise  
B) Storm surge  
C) Beach erosion  
D) All of the above
Glacial Processes Lab

Match each glacial term to its definition (Questions 71-75). Each letter may be used only once.

A) Snowline
B) Accumulation
C) Terminus
D) Ablation
E) Retreat

72) The bottom end or nose of the glacier. C

73) Addition of snow and ice to the glacier. B

74) Loss of snow and ice from the glacier. D

75) The glacier is melting and the terminus is moving up the valley. E

76) The dividing line between the zone of accumulation and the zone of ablation. A

77) What is (are) the reasons we study glaciers?

A) They can be good indicators of global warming
B) They are responsible for a lot of North American topography
C) They are the reason we have good farm land in America
D) They covered large areas of America in the past
E) All of the above

78) Wind transported glacial deposits are known as what?

A) Glacial Rock
B) Horn
C) Loess
D) Till

79) Where in the world today are ice sheets still present?

A) Antarctica
B) Cascade Mountain Range
C) Andes Mountains
D) Greenland
E) Both A and D
80) Glacial retreat is when:

A) the glacier flows back up its valley  
B) the glacial ice is melting, causing the terminus to move back  
C) people move back from the glacier to avoid icebergs  
D) the glacial till is so high that it hides the glacier from view

81) What useful information can we get from measuring the extent of a glacier over many years (such as a century)?

A) Changes in the amount of pollution in the atmosphere  
B) Changes in climate in the glacial area  
C) Changes in land use in the glacial area  
D) Changes in the animal life in the glacial area

82) From the glacier lab we did, we learned that:

A) mean global temperature is constant  
B) mean global temperature is always rising  
C) mean global temperature is always falling  
D) mean global temperature fluctuates (sometime rises and sometimes falls)

83) Remember the big relief map of Yosemite Valley that we looked at during the glacial processes lab. What glacial feature was especially common to Yosemite Valley?

A) Moraines  
B) Ice Sheets  
C) Hanging Valleys  
D) Mountains

84) Glaciers commonly form valleys in what shape?

A) V-shaped  
B) U-shaped  
C) S-shaped  
D) Y-shaped

85) What type of glacier was created when the two valley glaciers of the slime glacier flowed together at the bottom of the rock?

A) Cirque Glacier  
B) Double Valley Glacier  
C) Ice Sheet  
D) Piedmont Glacier
**Mississippi Lab**

86) Frequent Earthquakes (about 250 per year) are felt in northwest Mississippi. These earthquakes are caused by:

A) Igneous intrusion under the Jackson Dome.
B) Overpumping of the groundwater in Tunica County.
C) Slippage along the New Madrid Fault.
D) Subduction of plates under the Mississippi River.
E) None of the above.

Use the Mississippi Geologic Map for Questions 87 & 88.

87) What type of Quaternary deposits make up the area of the state known as “The Delta”?

A) Loess  
B) Citronelle formation  
C) Alluvium  
D) Marine sediments  
E) Volcanic ash

88) What three rock units are found in Oktibbeha County?

A) Tuscaloosa Group, Eutaw Group, and Selma Group  
B) Selma Group, Midway Group, and Wilcox Group  
C) Claiborne Group, Jackson Group, and Vicksburg Group  
D) Forest Hill Formation, Catahoula Formation, and Pascagoula Formation  
E) Hattiesburg Formation, Citronelle Formation, and Loess

89) The area of Mississippi commonly known as “the Delta” is actually:

A) the delta of the Mississippi River.  
B) the floodplain of the Mississippi River.  
C) an oxbow lake.  
D) the place the Greeks named their letter “delta” after.
90) What is the only glacial “feature” found in Mississippi?

A) Terminal moraines  
B) Loess  
C) Kettle lakes  
D) U-shaped valleys  
E) Arêtes

91) What was the glacial feature in Question 90 used for during the Civil War?

A) To make cannonballs  
B) To test out experimental submarines  
C) To barricade Union troops  
D) To dig caves into for hiding from Union troops

92) You are fishing for catfish in your favorite river. 100 yards upstream is a factory that is illegally dumping its waste into the stream. Your wisest choice is:

A) Find a new place to fish  
B) Report the illegal dumping to authorities for investigation  
C) Shoot the owner of the factory  
D) A & B  
E) B & C – then you won’t need to do A

93) Where does the city water in Starkville come from?

A) Directly from the Tennessee-Tombigbee Waterway  
B) They buy it from Columbus and then process it  
C) From the creeks in question #92  
D) The water towers on the MSU campus  
E) Wells that draw from the Gordo aquifer

94) Storm surge is a major concern to the citizens of:

A) Jackson  
B) Biloxi  
C) Starkville  
D) All of the above  
E) None of the above
95) Which type of stream is the Mississippi River?

A) Braided
B) Straight
C) Meandering
D) Karst
E) Continental

Use the map of the Mississippi Gulf Coast to answer questions 96 & 97.

96) Which direction is the longshore current flowing in this section of the Gulf of Mexico?

A) Northeast
B) Northwest
C) Southeast
D) Southwest
E) Due south

97) Bayou is another name for Estuary. What does the abundance of Bayous in this area indicate?

A) Spits are building because the bayous are widening
B) Longshore currents are removing the land
C) The Mississippi River is migrating eastward
D) Hurricanes are forcing the water into the bayous
E) Sea level is rising in the Gulf, flooding river valleys

98) What was your favorite lab? Why? (There is no wrong answer, write as much as you like)
99) What was your least favorite lab? Why? (There is no wrong answer, write as much as you like)

100) What is your Lab Instructor’s name?

BONUS QUESTION:

Think all the way back to the FIRST DAY of lab.

You have just won the lottery and your friends tell you, “California is the place you ought to be” so you load up the truck and move to Beverly (as in Los Angeles). You must decide on which property to build your mansion. Which of these choices would be the worst location to build on in an earthquake-prone area?

A) Sandstone rock
B) Compacted sediment (not lithified into rock)
C) Gneiss rock
D) Granite rock
E) An old landfill now covered with dirt and grass
APPENDIX C

LABS
Seismic Wave Experiment:
NOTE: You must show your work for all calculations – the answer without the work will be counted as wrong.

Points

0 Length of Wave Line __10.4 m__ We measured this in the hall.

0 Travel time for P wave ___3.5 s___ We measured this in the hall.

3 Velocity of P wave __2.97 m/s__

\[
Velocity = \frac{\text{Distance}}{\text{Time}} \quad \text{so, for the P-Wave: } \quad V = \frac{10.4\text{m}}{3.5\text{s}} = 2.97 \frac{\text{m}}{\text{s}}
\]

which we round to 3.0 m/s, because it's so close.

0 Travel time of S wave _7.0 s_ We measured this in the hall.

3 Velocity of S wave _1.49 m/s_

\[
Velocity = \frac{\text{Distance}}{\text{Time}} \quad \text{so, for the S-Wave: } \quad V = \frac{10.4\text{m}}{7.0\text{s}} = 1.49 \frac{\text{m}}{\text{s}}
\]

which we round to 1.5 m/s (because 1.49 is closer to 1.5 than 1.4)

0 Distance from Starkville to Columbus _26 mi_. We went over this in class – your number should be within 10mi.

3 Time for P wave to get to Columbus _3.9 hr_

\[
\left( \frac{3.5\text{s}}{10.4\text{m}} \right) \left( \frac{1000\text{m}}{1\text{km}} \right) \left( \frac{1\text{km}}{0.621\text{mi}} \right) \left( \frac{1\text{hr}}{3600\text{s}} \right) = 0.15 \text{ hr/mi. for the P wave.}
\]

Now we multiply this result times the distance to get: \((0.15 \text{ hr/mi x 26 mi.}) = 3.9 \text{ hr.}\)

3 Time for S wave to get to Columbus _7.8 hr_

\[
\left( \frac{7.0\text{s}}{10.4\text{m}} \right) \left( \frac{1000\text{m}}{1\text{km}} \right) \left( \frac{1\text{km}}{0.621\text{mi}} \right) \left( \frac{1\text{hr}}{3600\text{s}} \right) = 0.30 \text{ hr/mi. for the S wave.}
\]

Now we multiply this result times the distance to get: \((0.30 \text{ hr/mi x 26 mi.}) = 7.8 \text{ hr.}\)
3 Distance from Starkville to Jackson \(120\text{mi}\) You measured this off the map – anything from 100-120 miles was counted as a right answer.

3 Time for P wave to get to Jackson \(18\text{hr}\) All you have to do now is multiply our hr/mi by the new distance.

\[(0.15 \text{ hr/mi} \times 120 \text{ mi.}) = 18 \text{ hr.}\]

3 Time for S wave to get to Jackson \(36\text{hr}\) And the same thing again.

\[(0.30 \text{ hr/mi} \times 120 \text{ mi}) = 36 \text{ hr.}\]

3 Distance from Starkville to Tupelo \(60\text{mi}\) You measured this off the map – 50 – 70 was acceptable.

3 Time for P wave to get to Tupelo \(9\text{hr}\) All you have to do now is multiply our hr/mi by the new distance.

\[(0.15 \text{ hr/mi} \times 60 \text{ mi}) = 9 \text{ hr.}\]

3 Time for S wave to get to Tupelo \(18\text{hr}\) And the same thing again.

\[(0.30 \text{ hr/mi} \times 60 \text{ mi}) = 18 \text{ hr.}\]

\textbf{Note:} If the distance you measured between cities was slightly different than the one shown here, your answers will vary, but you still received full credit.
MISSISSIPPI LAB – SPRING 2005

RELATIVE AGE DATING AND GEOLOGIC MAP STATION

Compare the Geologic Map of Mississippi to the Geologic Cross-Section.

1) What is the oldest sedimentary formation in Mississippi?

2) What are the youngest deposits?

3) Take a look at the map of the region east of Mississippi and note the slope of the beds on the Geologic Map of Mississippi. What is the source of all the sediments from Mississippian/Devonian to the Vicksburg?

4) What is the source of the alluvium?
GEOLOGIC STRUCTURE STATION

The Jackson Dome is the largest fold feature in the state of Mississippi and it formed from different forces than what we discussed in the structure lab. Look at the color diagram on pages 28-29 and read the handout.

1) Name the type of fold.

2) How was it formed?

Look at the Plate 1 cross-section of Mississippi that was cut North to South (see small reference map that shows where the cut was made). Find the V-shaped, yellow and green fault block in the center of the cross-section (above the word Mississippi).

3) Are the faults that make the V normal, reverse, or lateral faults?

4) How do you know?
PLS STATION

Use the Holly Springs map.

1) What does PLS stand for?

2) What is the named structure (round black dot) located at:
   T4S, R2W, Sec. 5, SW ¼, NE ¼?

3) Write the PLS location of the Clay Pit (NW of town).
   Go as far as two ¼’s.
TOPOGRAPHICAL MAP STATION

Use the Starkville Map.

1) What is the contour interval of this map?

2) What is the elevation at the radio tower due north of Starkville?

3) There is a benchmark on the center of downtown (east of the Courthouse). What is its elevation?

4) There is another benchmark just west of the High School (SW of downtown). What is its elevation?

5) What is the relief between the two benchmarks?

6) What is the distance between the two benchmarks?

7) From your answers to Questions 3 – 6, what is the average gradient from downtown to the high school?
RIVER PROCESSES STATION

Look at the Phillip, MS map.

Locate the Hampton Lake on the western edge of the map.

1) What type of lake is it?

2) How did it form?

3) What type of stream channel does the Tallahatchie River exhibit?

Note the contour interval diagram at the bottom of the map. The NE side of the map uses a 20-ft interval, while the majority of the map uses a 5-ft interval.

4) Explain why the map makers would do this.

5) What river feature is represented by the 5-ft interval section of the map?

6) What are the row of structures indicated by white sections parallel curved contour lines on along the edge between the 20-ft contour section and the 5-ft contour section?

7) How did they form?
GROUNDWATER STATION

Read the Annual Drinking Water Quality Report from Starkville.

1) How many treatment stations does Starkville have?

2) What inorganic contaminant is at the highest level in Starkville’s drinking water?

3) Why is it the highest?

COASTAL PROCESSES STATION

Look at the posters on the wall and the maps of Cat Island. Locate Cat Island and also Ship Island and Horn Island on the Mississippi Geologic Map.

Check out the exposed and submerged spits.

1) Which direction is the longshore current flowing in this part of the Gulf of Mexico?

2) How can you tell?
EARTHQUAKES STATION

Read the pamphlet titled “Earthquakes in Mississippi?” and the back of the map.

1) What is the source of the quakes felt in northwest Mississippi?

2) How many quakes per year are recorded along this fault?

3) Name three things you should do during an earthquake to protect yourself.

Compare this earthquake map and the cross-section at the structure station.

4) What is the source of the ring of quakes in Clarke County?
GLACIERS STATION

Look at the Geologic Map of Mississippi and read the paper found at the station.

1) What is Mississippi’s only “glacial feature”?

2) Where is it found?

3) What was it used for during the Civil War?

4) What is the biggest problem with it now?
KEY FOR MISSISSIPPI LAB

Relative Age Dating Station

1) Mississippian/Devonian
2) Vicksburg
3) Erosion from the Appalachian Mountains
4) Sediments from the Mississippi River

Topographical Map Station

1) 10 ft.
2) 330 ft.
3) 374 ft.
4) 339 ft.
5) 35 ft.
6) approx. 1 mi.
7) 35 ft/mi

Geologic Structure Station

1) Anticline
2) Uplift due to igneous intrusion
3) Normal
4) The headwall moved down
**River Processes Station**

1) Oxbow lake
2) Meander cut-off
3) Meandering
4) The NW area is relatively steep terrain, whereas the rest of the map is very flat.
5) Floodplain
6) Alluvial fans
7) When the streams hit the flat floodplain, the reduction in velocity forced them to deposit their sediment loads.

**Earthquakes Station**

1) The New Madrid Fault
2) About 250 per year
3) Do not panic!
   - If indoors, stay there and take cover under something heavy or brace yourself
   - If outdoors, move away from trees, buildings, poles, etc.
   - If driving, stop away from trees, power lines, etc, and stay in vehicle
   - Stay away from anything overhead that could break or fall
4) The V-shaped fault we looked at in the structure station.

**Coastal Processes Station**

1) East to West (they may say southwest, but they should have read on the posters that it is WEST) – your call if you want to accept Southwest or not
2) Spit direction
Glaciers Station

1) Loess

2) All along the eastern edge of “the delta”; bluff along the floodplain of the MS River.

3) The people of Vicksburg dug caves into it to live in during the siege.

4) If it is destabilized, it erodes quickly.

Groundwater Station

1) 3 or 4 is OK

2) Fluoride

3) They add it purposely to help strengthen teeth.

PLS Station

1) Public Land Survey

2) Water Tank

3) T3S, R3W, Sec. 26, SE ¼, NW ¼

   OR

   T3S, R3W, Sec. 25, NW ¼, SW ¼
Do the following exercises and hand them in with this week’s lab:

Gradient = \frac{\text{Change in elevation}}{\text{Change in distance}}

Do the following questions for TWO different gradients –
one STEEP and one SHALLOW

NOTE: Your answer will be counted incorrect if you do not include the units!

1) Letter of the steep gradient _____

2) Length of the board (measured along the board) (in m.) ________________

3) Contour interval of the gradient (in cm.) ______________________

4) Elevation at the high end of the gradient (in cm. from the floor) ______________

5) Elevation at the low end of the gradient (in cm. from the floor) ______________

6) Map distance of the gradient (in m.) __________________

7) Gradient (SHOW YOUR WORK – include correct units) ______________________

8) Letter of the shallow gradient _____

9) Length of the board (measured along the board) (in m.) ________________

10) Contour interval of the gradient (in cm.) ______________________

11) Elevation at the high end of the gradient (in cm. from the floor) ______________

12) Elevation at the low end of the gradient (in cm. from the floor) ______________

13) Map distance of the gradient (in m.) __________________
14) Gradient (SHOW YOUR WORK – include correct units) ______________________

15 & 16) Now, draw a contour sketch of the two gradients using the scale: 1in. = .25m.

15

16

17) Compare the two drawings you made. What does the spacing of the contour lines tell you about the gradient?
Prelab for Minerals


Define the following terms:

1) Minerals

2) Rocks

3) Color

4) Clarity

5) Crystal forms

6) Luster

7) Name the two main categories of luster
   a) 
   b) 

Define:

8) Hardness

9) Streak

10) Cleavage
11) Fracture

12) Tenacity

13) Striations

14) Magnetism

15) Specific gravity

**Pre-Lab Volcanoes and Igneous Rocks**

Use Pages 91-96 in the lab manual.

Define the following terms:

1) Igneous Rock

2) Magma

3) Lava

4) Where does an intrusive igneous rock form?

5) Where does an extrusive igneous rock form?

6) Define: Texture of an igneous rock
7) Name the 2 options for intrusive texture:

1) 

2) 

8) Name the 6 options for extrusive texture:

1) 

2) 

3) 

4) 

5) 

6) 

9) Define: Composition of an igneous rock

10) Name the three options for composition:

1) 

2) 

3)
Pre-Lab for Sedimentary Rocks and Depositional Environments

Use Pages 111 - 115 of the lab manual.

Define the following terms:

1) Sedimentary Rock

2) Chemical Weathering

3) Physical Weathering

4) Sediments

5) Aqueous Solution

6) Texture of a Sedimentary rock

See Page 96-

7) What are the 6 options for grain size?

1) 

2) 

3) 

4) 

5) 

6)
8) What are the 3 options for grain shape?

1) 

2) 

3) 

9) What are the 3 options for grain arrangement?

1) 

2) 

3) 

10) What are the three Compositional Classes for Sedimentary rocks and their definitions?

1) 

2) 

3) 

11) What are the three main processes by which sedimentary rocks form?

1) 

2) 

3)
Pre-Lab for Metamorphic Rocks and Glaciers

**Metamorphic Rocks**
Use Pages 133 - 140 of the lab manual.

1) Define Metamorphic Rock:

2) What are the three things that metamorphose a rock?
   1)
   2)
   3)

Define the following terms:

3) Parent Rock:

4) Contact metamorphism:

5) Regional metamorphism:

6) Foliated texture:

List 4 foliated textures:
   1)
   2)
   3)
   4)
7) Nonfoliated texture:

List 4 nonfoliated textures:

1) 

2) 

3) 

4) 

Glaciers:
Use pages 213 – 218 in the lab manual.

Define the following terms:

1) Glacier:

2) Accumulation:

3) Ablation:

4) Terminus:

5) Glacial Retreat:

6) List the 4 main kinds of glaciers:

1) 

2) 

3) 

4) 

7) Loess:
Pre-Lab for Topographic Maps and PLS

Use pages 167 - 180 in the lab manual.

Define the following terms:

1) Topographic Map:

2) Latitude:

3) Longitude:

4) Quadrangle:

5) Contour Lines:

6) Index Contours:

7) Contour Interval:

8) Relief:

9) Total Relief:

10) Gradient:

11) Scale:
12) **List the 4 types of scales:** (Note, you will have to read – one is NOT in bold type)

1)  
2)  
3)  
4)  

**Pre-Lab for Lab #5 – Geologic Structure and Geologic Maps**

Use pages 169-174 in the lab manual.

Define the following terms:

1) Geologic Map:

2) Geologic Cross-section:

3) Block Diagram:

4) Attitude:

5) Strike:

6) Dip:

7) **List the 3 types of stress that create faults:**

1)  
2)  
3)
8) Define Fault:

9) List the 5 types of faults:
   1)
   2)
   3)
   4)
   5)

Define the following terms:

10) Anticline:

11) Syncline:

Pre-Lab for Lab #10 – Streams, Groundwater, and Coastal Processes

STREAMS: Use pages 210 - 216 in the lab manual.

Define the following terms:

1) Perennial Streams:

2) Intermittent Streams:

3) Alluvium:
4) List the 3 types of stream channels:
   1) 
   2) 
   3) 

5) List the 7 stream drainage patterns:
   1) 
   2) 
   3) 
   4) 
   5) 
   6) 
   7) 

Define the following terms:

6) Drainage Basin:

7) Drainage Divide:

8) Name the 3 processes at work in every stream:
   1) 
   2) 
   3) 

Define the following terms:

9) Gradient:
10) Base level:

11) Discharge:

12) Load:


Define the following terms:

13) Groundwater:

14) Water Table:

15) Aquifer:

16) Confining Bed:

17) Well:

18) Artesian Well:

19) Recharge:
DIRECTED-DISCOVERY EXERCISE FOR TOPO MAPS AND PLS
FALL 2005

Worksheet for PLS and Topographic Map Lab - KEY

PLS

1) What does PLS stand for? Public Land Survey

2) Use PLS shorthand to write the location for Point Z (Fig. 9.9 – page 179).
   SW ¼, SW ¼, NE ¼, SE ¼. Sec.11, T1S, R2W.

Contour Box

6) a) What was your contour interval? 1 cm.

   b) Were your contour lines indexes? yes

7) What is the general shape of each contour line? An uneven oval

8) What difference do you notice between contour lines on the steep side and the contour lines on the more gently sloping side of the volcano? The contour lines are closer together on the steep side and farther apart on the gentler side.

9) Elevation change between highest and lowest contour lines (steep side) 6 cm.

   Elevation change between highest and lowest contour lines (gentler side) 6 cm.

10) Map distance (steep side) 6-6.5 cm Map distance (gentler side) 17.5 - 18 cm

11) Gradient (steep side) numbers from 9 and 10 cm elevation change/cm distance

   Gradient (gentler side) numbers from 9 and 10 cm elevation change/cm distance
**Topographic Maps**

12) Point B is located at 40°S 20°W

13) What is the ratio scale of the Mt. Rainier map? 1:50 000

14) What is the contour interval of the Mt. Rainier map? 80 ft

16) Figure on page - no answer needed here.

17) Figure on page – no answer needed here.

18) A: The contour lines on this map are labeled in meters. What is the contour interval of this map?
   20 meters

C: What is the gradient from Y to X? 40m/3km = 13.33m/km (Show your work.)

D: How could you find the areas of this map that have a gradient of 20 meters per kilometer or greater? (*Hint:* Think of the contour interval and how many contour lines of map elevation must occur along one kilometer of map distance.) 60 meters/3 km would give you 20 m/km. Find a spot where the contour lines show this gradient. Then anywhere the lines are closer together than that would be >20m/km.

**Extra Credit Questions**

A) What feature is located at:
   NE ¼, SE ¼, SE ¼, Sec. 32, T15N, R11E? *Kincaid Lake*

B) What feature is located at:
   NE ¼, NE ¼, NW ¼, Sec. 36, T15N, R7E? *Tumtum Peak*

C) Write out the PLS coordinates for *Sweet Peak*

   SW ¼, NE ¼, SW ¼, Sec. 3, T17N, R7E

D) Write out the PLS coordinates for *The Shriner Peak Lookout*

   SE ¼, SE ¼, SE ¼, Sec. 3, T15N, R10E
DIRECTED-DISCOVERY EXERCISES FOR STRUCTURE – FALL 2005

STRUCTURE LAB WORKSHEET - KEY

Part 1 - FUN WITH MODEL MAGIC

Pushing – Compressional force
Step 1: Roll the Model Magic into a ball, and then form it into a fat snake. Hold the snake by the two ends, and slowly push the ends toward each other. Watch carefully and record your observations.

1) What happens to the thickness of the snake as you push the ends slowly?
   It gets thicker toward the center
2) What happens to the length of the snake as you push the ends slowly?
   It gets shorter

Step 2: Roll the Model Magic back into a ball, and then flatten it to form a thick pancake. Hold the pancake at opposite sides and slowly push the sides together.

3) What shape is formed? Is it symmetrical?
   They may just say something like “hill” or “semicircle” or they may say antiform or anticline or syncline or synform. Accept anything reasonable.
   Most will say Yes to symmetrical, but some will not – either way is right.

Step 3: Repeat Step 2 several times.

4) Is the shape always the same?
   Should be Yes or No and hopefully some explanation, but I didn’t specifically ask them to explain – you might want to say it in class.

5) What difference do you see in the shape if you push one side faster or harder than the other side?
   You should get some description of asymmetry.

6) Is there a difference if you push the ends quickly and suddenly?
   Probably not, but if they saw a difference, they should describe it.

Geological Application (refer to pages 200-201 in your lab manual)
Name the geologic structures that result from compressional forces in ductile rocks.

7) Antiform or anticline AND Synform or syncline – they must have both for full credit – the question was clearly plural.
**Pulling – Extensional force**

Roll the Model Magic into a ball again, and reform the fat snake. Hold the snake by the two ends, and slowly pull the ends apart. Watch carefully and record your observations.

8) What happens to the thickness of the snake as you pull the ends slowly?
   - It gets thinner, especially toward the middle.
9) What happens to the length of the snake as you pull the ends slowly?
   - It gets longer.
10) Is there a difference if you pull the ends quickly and suddenly?
    - Maybe NO – Maybe some description of a fault.

**Different directions – Shear force**

Roll the Model Magic into a ball again, and reform the fat snake. Hold the snake by the two ends, and slowly pull one end toward you while you push the other end away from you. Watch carefully and record your observations.

11) What happens to the thickness of the snake as you move one end closer and one end farther from you?
    - They should notice some thinning in the center – along the shear zone.
12) What happens to the length of the snake as you move one end closer and one end farther from you?
    - Overall length shouldn’t change much.
13) Is there a difference if you move the ends quickly and suddenly?
    - Some description of faulting – for sure!

**Part 2 - FUN WITH WOOD BLOCKS**

**Pushing – Compressional force**

Line up the three blocks so that they form a perfectly-aligned rectangle. Pick them up by holding the two end blocks only. Slowly push them together and record your observations. (Hint: The colored stripes are the marker beds.)

14) What happens to the center block as you push the ends slowly?
    - It moves up.
15) What happens to the overall length as you push the ends slowly?
    - It gets shorter.
16) Does the movement occur smoothly or in bursts? Why do think this happens?
    - In bursts – due to friction or hanging up of the blocks against each other – irregularities – something like that.
17) Is there a difference if you push quickly and suddenly?
    - You may get no reaction – or the center block might shoot right out!
18) What happens to the marker beds **on the sides** of the blocks as you push?
    - The get offset.
19) What happens to the marker beds on the tops of the blocks as you push?  
   They are still aligned.

**Pulling – Extensional force**  
Line up the three blocks so that they form a perfectly-aligned rectangle. Pick them up by holding the two end blocks only. Slowly pull them apart and record your observations.

20) What happens to the center block as you pull the ends slowly?  
   It drops down.

21) What happens to the overall length as you pull the ends slowly?  
   It gets longer.

22) Does the movement occur smoothly or in bursts? Why do you think this happens?  
   In bursts – due to friction or hanging up of the blocks against each other – irregularities – something like that.

23) Is there a difference if you pull quickly and suddenly?  
   The center block should drop right out.

24) What happens to the marker beds on the sides of the blocks as you pull?  
   They get offset.

25) What happens to the marker beds on the tops of the blocks as you pull?  
   They are still aligned.

**Different directions – Shear force**  
For this one, use the center block and only one of the end blocks. Align them and then pick them up. Pull one end toward you as you push the other end away from you and record your observations.

26) What happens to the marker beds on the sides as you slowly move the blocks?  
   They are still aligned.

27) What happens to the marker beds on the tops as you slowly move the blocks?  
   They get offset.

28) Does the movement occur smoothly or in bursts? Why do you think this happens?  
   Either one is right – depends on the force they use.

29) Is there a difference if you pull and push quickly and suddenly?  
   Probably not – but if they see a difference, they should describe it.
Geological Application (refer to page 199 in your lab manual)
Name the geologic structure that results from each force in brittle rocks:

30) Compressional force Reverse Fault and/or Thrust Fault
31) Extensional force Normal Fault
32) Shear force Strike slip Fault and/or Right Lateral and/or Left Lateral

What happens in real rocks in the earth is similar to what you observed in all of the questions above.

33) What catastrophic event can be related to the motion you observed in Questions 16, 22, and 28? An earthquake

Part 3 - FUN WITH CARDBOARD MODELS

Tear out the page labeled “Cardboard Model 2” from the back of your book.

CAREFULLY follow the instructions on page 207 in the block titled “Forming the Structure Models” Do all the steps. When you have completed all 9 steps, look carefully to see how the layers line up on the top of the model and on the side and end of the model. Use the colored pencils to fill in the layers on the two blank sides of the model. Label each layer with the proper letter.

NEATNESS COUNTS!

Part 4 - FUN WITH GEOLOGIC MAPS

For this exercise, you will use the colored geologic map you get from your TA. DO NOT remove the map from the sleeve or write on it.

29) What geographic location does this map represent? Mississippi
30) What is the name of the oldest rock unit on this map? Mississippian Devonian
31) What is the name of the youngest depositional unit on this map? Alluvium Coastal Deposits
32) What are the names of the rock units that make up Oktibbeha County, MS? **Selma, Midway, and Wilcox**

33) What rock unit does MSU sit upon? **Selma**  
    HINT: MSU is in the eastern half of Oktibbeha County.

34) In what geologic period did the rock unit in question #41 form? **Cretaceous**

When you have completed all 4 parts, flatten out your cardboard model, staple it to these answer sheets, and turn them in.

There is an extra-credit assignment available and a Pre-lab for next week. Pick these up before you leave.

Please leave your desk tidy for the next class.
DIRECTED-DISCOVERY EXERCISES FOR STREAMS AND GROUNDWATER – FALL 2005

STREAMS AND GROUNDWATER LAB KEY

Flume Experiment #1

1) Width of flume end ___about 10.5______ cm

2) Depth of water __between 6 and 10______ cm

3) Area = A = Width x Depth = ______cm x _______cm = __________cm²

4) Distance between marks ____50_______ cm

5) Time for ball to travel between marks _______________ sec

6) Velocity = V = distance/time = ______cm / _____sec = ______________cm/sec

7) Discharge = Q = VA = _______cm/sec x ________cm² = ____________cm³/sec

Flume Experiment #2

8) Does adding ice to and salt to the water make it lighter or heavier? heavier
   How do you know (what is the evidence)?
   It traveled along the bottom of the flume – the clear water floated on top of it

If there were other pollutants in a natural stream (like factory or agricultural runoff), they would act the same way the cold salt water did in your flume.

9) If you were fishing from a boat, what would the water look like on the surface of the river you were in?
   clean – clear – blue – etc.

10) Based on this experiment, what might the water be like at the bottom of the river?
    Polluted – dirty – full of stuff – etc.

11) Where do catfish spend most of their time?
    At the bottom of the river
12) Give one sentence that summarizes the significance of the experiment and the previous 3 questions.
   Even though the water may look clean and unpolluted at the surface, you can’t be sure that there are not pollutants in the water that will be picked up by the plants and animals that live in and near the river.

**Rio Grande River Meander Evolution (Part 11D)**

Read “River Valley Forms and Processes” (p. 215-216). Then answer the following questions:

p. 222 (using Fig. 11.11 on page 225)

Q21) Study locations H and I.
   a) In what country were H and I located in 1936?  
      Mexico
   b) In what country were H and I located in 1992?  
      USA
   c) Explain a process that probably caused locations H and I to change from meanders to oxbow lakes.
      River cut through the closest part of the meander

Q22) Based on your answer to Question 21c, predict how the river will change in the future at locations J and K.

Will eventually be oxbow lakes

Q23) What are the features L, M, and N, and what do they indicate about the historical path of the Rio Grande?

Oxbow lakes – where the river used to run, but cut off to take shorter path

Q25) Explain the steps how a meander evolves from the earliest stage of its history as a broad slightly-sinuous meander to the stage when an oxbow lake forms.

Meanders – pointbar buildup/cutbank incision – meander cut-off
Groundwater – NOTE: NO POINTS for these questions – but don’t tell the students ahead of time

Answer the next two questions BEFORE opening your lab manual:

13) If a person drilled a well to get groundwater, from where would this water come? (choose all that apply)
   a. river  f. spigot or faucet
   b. sand layer  g. solid/fractured rock
   c. underground pool  h. underground stream
   d. water tower  i. lake
   e. soil  j. city water supply

14) On the back of the next page, draw a detailed diagram that shows how groundwater occurs and moves. Something like the diagram on p.241.

Groundwater Exercise (Part 12C)

Read “Land Subsidence Hazards Caused by Groundwater Withdrawal” (p. 239 – 242). Then answer the following questions:

Refer to Figure 12.10 on page 241.

14) Is the well drilled at Y an artesian well? Explain your answer.
   No – in an unconfined aquifer

15) Is the well drilled at X an artesian well? Explain your answer.
   Yes – in confined aquifer with higher recharge area than the well’s aquitard

16) Which well would you rather have at your home? Why?
   Artesian – cleaner and no pump necessary

Refer to Fig. 12.11 and 12.13 on page 242 and 243.

Q. 14. In Figure 12.11, where are the areas of greatest subsidence in the Santa Clara Valley? **Explain your reasoning.**
   Santa Clara and San Jose – both at 8 ft. below original surface.

Q15. What was the total subsidence at San Jose (Figure 12.13) from 1934 to 1967? **SHOW YOUR WORK!**
   
   \[12.7 - 4.6 = 8.1 \text{ feet}\]
Q16. What was the average annual rate of subsidence for the period 1934 to 1967 in feet per year?  **SHOW YOUR WORK!**

\[
8.1 \text{ feet/33 yrs} = 0.245 \text{ ft.}
\]

Q17. At what place in the Santa Clara Valley would subsidence cause the most problems?  **Explain your reasoning.**

In larger towns – problems with cracking of foundations, etc.

In towns close to the bay – saltwater intrusion

Q25. Subsidence stopped by 1971.  What measures might have been taken to accomplish this?

Refilling of aquifer; Water budgeting or rationing; Reduction of overpumping etc
WEEKLY QUIZZES – SPRING 2006

QUIZ #1 – SEISMISCITY

VERSION A

1) You have just won the lottery and your friends tell you, “California is the place you ought to be” so you load up the truck and move to Beverly (as in Los Angeles). You must decide on which property to build your mansion. Which land would you choose to make your home as safe as possible from the devastating effects of an earthquake?

A) Lush wetlands  
B) Compacted sediment (not lithified into rock)  
C) Loose, uncompacted sediment  
D) Granite Rock  
E) An old landfill now covered with dirt and grass

2) Seismic activity occurs most often:

A) in the middle of a tectonic plate.  
B) at the boundary between tectonic plates.  
C) far away from the edges of a tectonic plate.  
D) where there are no tectonic plates.

3) An undersea earthquake may cause:

A) a city to sink into the sea.  
B) a volcano to erupt under the ocean.  
C) a tsunami.  
D) all the fish to die.

4) Which type of seismic waves are the first to arrive at the station after an earthquake?

A) Pressure waves  
B) Love waves  
C) Shear waves  
D) Tsunami waves
5) How many seismic stations are needed to locate the epicenter of an earthquake?
   A) 1
   B) 3
   C) 5
   D) All that can detect the wave

6) A shear wave will not travel through which medium?
   A) Fluids
   B) Continental crust rocks
   C) Oceanic crust rocks
   D) Lithosphere

7) The trip from Starkville to Birmingham is 150 miles. You drive it in 3 hours. Your average velocity in metric units is:
   **NOTE:** 1mi = 1609.39 meters; 1 hour = 3600 seconds
   A) 50 miles/hour.
   B) 0.0139 miles/sec.
   C) 22.35 m/sec.
   D) 80,469.5 m/sec.

8) Which statement is true about seismic waves?
   A) All of the waves from a quake travel at the same speed.
   B) P waves travel faster than S waves.
   C) S waves travel faster than P waves.
   D) We cannot tell how fast waves travel.

9) We don’t have bedrock here in Mississippi, just deep buildups of sediments. Based on your experiment, which is the best sediment to build upon?
   A) Uncompacted sediments
   B) **Compacted sediments**
   C) Saturated sediments

10) Liquifaction is:
    A) erosion of the land surface because of rivers.
    B) another word for a flood.
    C) **land near a water body becoming like quicksand after an earthquake.**
    D) what happens to students who spend too long at bars on Friday nights.
QUIZ #2 – MINERALS

NAME ___________________  

VERSION A

1. A mineral is:
   A) formed by changing from one form to another by intense heat, intense pressure, or the action of hot watery fluids.
   B) formed by cooling of molten rock (magma or lava).
   C) an inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline structure.
   D) formed from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation.
   E) None of the above.

2. A mineral is also:
   A) the basic building-block of all rocks.
   B) useful only as part of a larger rock.
   C) useful only when processed by man.
   D) useless.

3. Is Talc hard or soft?
   A) Hard (>5 on Moh’s scale)
   B) Soft (<5 on Moh’s scale)

4. Which one of the following is not one of the 6 common properties we used to identify minerals?
   A) Color
   B) Reaction to hydrochloric acid
   C) Luster
   D) Cleavage
   E) Streak

5. Which tool(s) is/are used to identify mineral hardness?
   A) Glass plate
   B) Iron Nail
   C) Penny
   D) Fingernail
   E) All of the above
6. The cleavage of Biotite Mica is:
   A) Excellent to Good.
   B) Fair to Poor.
   C) Absent.
   D) Ugly.

7) Color is **not** a good diagnostic property for:
   A) Graphite.
   B) Pyrite.
   C) Quartz.
   D) Sulfur.
   E) any mineral.

8) Which property can be detected by “hefting” a mineral sample?
   A) Color
   B) Luster
   C) Hardness
   D) **Specific Gravity**
   E) Streak

9) The hardness on Moh’s scale of the glass plates in the lab is:
   A) 2.5.
   B) 3.5.
   C) 4.5.
   D) **5.5**.
   E) 6.5.

10) Which mineral has a non-metallic luster?
    A) Calcite
    B) Magnetite
    C) Hematite
    D) Graphite
    E) Pyrite
QUIZ #3 – IGNEOUS ROCKS AND VOLCANOES

VERSION A

1. An igneous rock is:
   A) formed by changing from one form to another by intense heat, intense pressure, or the action of hot watery fluids.
   B) formed by cooling of molten rock (magma or lava).
   C) an inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline structure.
   D) formed from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation.
   E) None of the above
   An igneous rock is:

2. What type of composition does an igneous rock have if it is composed mainly of light colored minerals?
   A) Felsic
   B) Intermediate
   C) Mafic
   D) Ultramafic

3. What texture below indicates an igneous rock as intrusive in origin?
   A) Phaneritic
   B) Aphanitic
   C) Porphyritic
   D) Glassy
   E) Vesicular

4. What is the texture called if it has a lot of holes in it?
   A) Phaneritic
   B) Aphanitic
   C) Porphyritic
   D) Glassy
   E) Vesicular
5. Felsic magmas are formed by the partial melting of which type of crust?
   A) Oceanic crust
   B) Continental Crust
   C) Island Crust
   D) Bread Crust

6. Porphyritic texture is a result of:
   A) Fast cooling at the surface.
   B) Slow cooling below the surface.
   C) Slow cooling at first, followed by fast cooling later.
   D) Instantaneous cooling under the sea.

7. The equivalent of an intrusive rock is:
   A) any other intrusive rock.
   B) the extrusive rock with the same composition.
   C) an intrusive rock with the opposite composition.
   D) the rock that formed from the same magma in the same cooling environment.

8. Which type of volcano is the largest?
   A) Cinder cone
   B) Composite volcano
   C) Shield volcano

9. Which of the following is not an igneous texture?
   A) Aphanitic
   B) Phaneritic
   C) Glassy
   D) Microcrystalline
   E) Porphyritic

10. Lava is:
    A) molten rock below the surface of the earth.
    B) molten rock above the surface of the earth.
    C) solid rock on the sides of a volcano.
    D) solid rock under a volcano.
QUIZ #4 – SEDIMENTARY ROCKS AND DEPOSITIONAL ENVIRONMENTS

VERSION A

1. A sedimentary rock is:

   A) formed by changing from one form to another by intense heat, intense pressure, or the action of hot watery fluids.
   B) formed by cooling of molten rock (magma or lava).
   C) an inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline structure.
   D) formed from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation.
   E) None of the above

An igneous rock is:

2. What compositional category does coal belong to?

   A) Detrital
   B) Biochemical
   C) Chemical

3. Sandstones are formed in which sedimentary environment(s)?

   A) Beach
   B) Reef
   C) Mountains
   D) Desert
   E) A and D

4. What is the grain arrangement of a conglomerate?

   A) Poorly sorted
   B) Moderately sorted
   C) Well sorted

5. What is the depositional environment of rock salt?

   A) Subaerial
   B) Subaqueous
   C) Subsurface
   D) Subsandwich
6. The presence of fossils indicates which type of rock?

A) Igneous
B) Sedimentary
C) Metamorphic
D) Mineral

7. Which sedimentary rock is formed by the precipitation of dissolved silica from solution (ocean water)?

A) Breccia
B) Sandstone
C) Chalk
D) Chert
E) Coquina

8. The only difference between conglomerates and breccias is that conglomerates have **rounded** gravel-sized sediments and breccias have **angular** gravel-sized sediments. What does the shape of the sediments reveal about these two sedimentary rocks?

A) The sediments in the breccia traveled much farther from their source than the sediments in the conglomerate.
B) The sediments in the conglomerate traveled much farther than the sediments in the breccia.
C) The conglomerate sediments were transported by a small stream, while the breccia sediments were transported by a large river.
D) The sediments in the conglomerate came from igneous rock, while the sediments in the breccia came from metamorphic rock.
E) The shape of the sediment grains doesn’t reveal anything

9. Where does the sedimentary rock coal form?

A) Beaches
B) Deep Ocean
C) Streams
D) Swamps
E) Mountains

10. Where does the sediment that forms sandstone come from?

A) Mechanical/chemical weathering of pre-existing rock
B) Secretions from reef-dwelling creatures
C) Swamps (decaying plant life)
D) Precipitation from seawater
E) Fossil remains
QUIZ #5 – RELATIVE AGE DATING

VERSION A

1) What is relative age dating?

A) Determining when something happened in exact units of time  
B) Determining when something happened in relation to other things  
C) Using a formula to determine the age of rock units  
D) Determining the age of your relatives

Match the Law to its definition (Questions 2-6). Each letter will be used only once.

A) Law of Inclusions  
B) Law of Cross-Cutting  
C) Law of Superposition  
D) Law of Original Horizontality  
E) Law of Lateral Continuity

2) Anything that cuts across a stratum or flow must be younger than the bed it cuts. B

3) Sedimentary strata and lava flows are laid down horizontally. Any variation happened after they were initially deposited. D

4) The oldest layer is at the bottom, younger layers on top. C

5) An inclusion is older than its surrounding matrix. A

6) Strata and lava flows extend laterally in all directions until they pinch out or reach the edge of their depositional basins. E

7) What law is used to determine that an igneous intrusion is younger than a sedimentary rock layer?

A) Law of Inclusions  
B) Law of Cross-Cutting  
C) Law of Superposition  
D) Law of Original Horizontality  
E) Law of Lateral Continuity
8) What law is used to determine that one sedimentary rock layer is older than another sedimentary rock layer?

   A) Law of Inclusions
   B) Law of Cross-Cutting
   C) Law of Superposition
   D) Law of Original Horizontality
   E) Law of Lateral Continuity

9) What are mappable rock units called?

   A) Rocks
   B) Stratigraphic markers
   C) Formations
   D) Groups

10) An unconformity is:

    A) a fold or fault.
    B) a zone where the rocks are “cooked” by the igneous intrusion.
    D) a gap in the rock record (represents missing time).
    D) a sequence of rock layers.
**QUIZ #6 – GEOLOGIC STRUCTURE AND GEOLOGIC MAPS**

**VERSION A**

Match the tectonic stress to the geologic structure it creates (Questions 1-4). Letters may be used more than once.

A) Shear stress  
B) Compressional stress  
C) Tensional stress

**T1)** Which stress causes reverse or thrust faults to occur? **B**

**T2)** Which stress causes normal faults? **C**

**T3)** Which stress causes folds such as anticlines and synclines? **B**

**T4)** Which stress causes left or right lateral faults? **A**

5) A Geologic Map shows the following information:

A) Distribution of rocks seen at the surface  
B) Distribution of rocks just below the soils  
C) The locations of Walmarts  
D) The geographic extent of populations

6) These faults can be seen on a map view, but not on a cross-sectional view:

A) Normal faults  
B) Reverse faults  
C) Strike-slip (lateral) faults  
D) Thrust faults  
E) It’s-all-my faults

7) Which letter best approximates the shape of an anticline?

A) lower case u  
B) lower case n  
C) lower case c  
D) lower case o
8) Which of the following is a type of unconformity?

A) Disconformity  
B) Nonconformity  
C) Erosional conformity  
D) A and B only  
E) All of the above

9) Synclines have their youngest beds:

A) in the center.  
B) on the outside edges.  
C) anywhere they want.  
D) on the bottom.  
E) none of the above.

10) How do you determine the age of a particular rock formation on the map?

A) The lighter colors are always older  
B) The darker colors are always older  
C) They are color-coded in the legend – oldest on the top  
D) They are color-coded in the legend – oldest on the bottom
QUIZ #7 – TOPOGRAPHIC MAPS AND PLS

VERSION A

1) On a topographic map, a contour line represents:
   A) points of equal elevation.
   B) roads.
   C) points of equal temperature.
   D) streams.
   E) points of equal horizontal distance.

2) The contour interval is the:
   A) map distance between each contour line.
   B) slope of the side of the hill.
   C) difference between true north and magnetic north.
   D) elevation change between each contour line.

3) Index contours are:
   A) contour lines used to locate important features on the map.
   B) heavy brown contour lines with elevations printed on them.
   C) blue contour lines that indicate the presence of a glacier.
   D) contour lines that show the position of the highest point.

4) The contour lines on a topographic map are very close together. This area is:
   A) a beach.
   B) a broad plain.
   C) a steep cliff.
   D) sea level.
   E) rolling hills.

5) A concentric series of closed contours represents:
   A) a valley.
   B) sea level.
   C) a depression.
   D) a stream channel.
   E) a hill.
6) Where is elevation assumed to be 0 feet or meters?
   
   A) Prime Meridian
   B) Sea level
   C) North Pole
   D) Equator
   E) The top of the highest hill

T1) The North and South Poles are:
   
   A) Unrelated to latitude or longitude
   B) Minimum longitude
   C) Maximum longitude
   D) Minimum latitude
   E) Maximum latitude

T2) What is another name for 0° latitude?
   
   A) 180° Meridian (International Dateline)
   B) Equator
   C) Prime Meridian
   D) North Pole
   E) South Pole

9) The fractional scale on a map is 1:25,000. This means:
   
   A) 1 inch on the map = 25,000 feet on the earth’s surface
   B) 1 inch on the map = 25,000 inches on the earth’s surface
   C) 1 mile = 25,000 inches on the earth’s surface
   D) 1 inch on the map = 25,000 miles on the earth’s surface

10) PLS Stands for:
    
    A) Public Land Survey
    B) Public Library System
    C) Private Land Survey
    D) Private Lakes and Streams
    E) None of the above
**QUIZ #8 –STREAMS AND GROUNDWATER**

** VERSION A**

Match each stream term to its definition (Questions 1-4). Each letter may be used only once.

A) Intermittent  
B) Drainage basin  
C) Perennial  
D) Base level

1) Flows year-round. Represented by a solid blue line on a topo map. **C**

2) Does NOT flow year-round. Represented by a dashed or dotted line on a topo map. **A**

3) The entire area of land that is drained by one stream or one system. **B**

4) The lowest elevation to which a stream can erode. **D**

5) To calculate the discharge of a stream, you must have:

   A) Ice cubes  
   B) Velocity  
   C) Area  
   D) Salt  
   E) B & C

6) What is the best reason to avoid using a river as a border?

   A) Because the river will flood  
   B) Because the river will eventually dry out  
   C) Because the river will change course over time  
   D) Because you can’t drive across the river  
   E) Because it is easy for immigrants to cross the river

7) An artesian well is:

   A) a well drilled into an unconfined aquifer that rises to the water-pressure surface.  
   B) a well drilled into a confined aquifer that rises to the water-pressure surface.  
   C) a well drilled into an unsaturated aquifer that rises to the water-pressure surface.  
   D) a well drilled into a vadose aquifer that rises to the water-pressure surface.
8) You time a stick floating down a stream, and determine that it takes 100 seconds for it to travel 10 meters. What is the velocity of the stream?
   A) 10 meters/second
   B) 10 meters/minute
   C) 0.10 meters/second
   D) 0.10 seconds/meter

9) The stream from the previous question is 5 meters wide and 2 meters deep. What is the discharge (Q) of the stream? (Hint: Remember from the lab Q=VA)
   A) 1 meter³/second
   B) 10 meter³/second
   C) 100 meter³/minute
   D) There is not enough information to calculate discharge

10) Which statements are true about pollution in a river?
    A) Because it is heavier, pollution usually travels along the bottom of the water.
    B) The river might look clean at the surface but actually be polluted below.
    C) Catfish, being bottom feeders, are exposed to the pollutants in a river and might pass them on to the animals and people who eat the catfish.
    D) All the above.
QUIZ #9 – COASTAL PROCESSES

VERSION A

T1) Exposed marine terraces, wide beaches, and salt marshes are features of what type of coastline?

A) Gulf coast
B) River coast
C) Submergent coast
D) Emergent coast

T2) A submergent coastline can be caused by:

A) Sea level lowering
B) Sea level rising
C) The land sinking (subsidence)
D) Both A and C
E) Both B and C

T3) What natural coastline feature can be used to determine the direction of the longshore current?

A) Estuary
B) Spit
C) Salt marsh
D) Wave-cut cliff
E) Stack

4) If you live in a coastal town, what should you do if a Hurricane is on the way?

A) Follow evacuation instructions if issued.
B) Ignore evacuation instructions, ride it out.
C) Nuke it.
D) Stroll down to the beach bar for margaritas.

5) What coastal process can have a negative effect on buildings near the coast?

A) Sea level rise
B) Storm surge
C) Beach erosion
D) All of the above
Match each coastal structure to its definition (Questions 6-9). Each letter may be used only once.

A) Sea wall
B) Groin
C) Jetty
D) Breakwater

6) Built parallel to the shoreline and offshore (in the ocean) to reduce wave energy D

7) Built parallel to the shoreline and against the beach to prevent erosion A

8) Built perpendicular to the shoreline to trap sand or build up a beach B

9) Built perpendicular to the shoreline, usually in pairs, to keep a harbor open C

T10) What is the biggest problem associated with building jetties and groins?

A) They are not attractive and harm the tourism business
B) They are dangerous to sea creatures
C) They are dangerous to humans
D) They disturb the natural sediment transport and cause erosion
E) Both B and C
QUIZ #10 – GLACIERS

VERSION A

Match each glacial term to its definition (Questions 1-4). Each letter may be used only once.

A) Accumulation  
B) Terminus  
C) Ablation  
D) Retreat

1) The bottom end or nose of the glacier. B
2) Addition of snow and ice to the glacier. A
3) Loss of snow and ice from the glacier. C
4) The glacier is melting and the terminus is moving up the valley. D

5) Most of the world's glaciers are currently retreating.
   A) True
   B) False

6) What is (are) the reasons we study glaciers?
   A) They can be good indicators of global warming
   B) They are responsible for a lot of North American topography
   C) They are the reason we have good farm land in America
   D) They covered large areas of America in the past
   E) All of the above

7) Wind transported glacial deposits are known as what?
   A) Glacial Rock
   B) Horn
   C) Loess
   D) Till
8) Where in the world today are ice sheets still present?

A) Antarctica  
B) Cascade Mountain Range  
C) Andes Mountains  
D) Greenland  
E) Both A and D

9) What useful information can we get from measuring the extent of a glacier over many years (such as a century)?

A) Changes in the amount of pollution in the atmosphere  
B) Changes in climate in the glacial area  
C) Changes in land use in the glacial area  
D) Changes in the animal life in the glacial area

10) From the glacier lab we did, we learned that:

A) mean global temperature is constant  
B) mean global temperature is always rising  
C) mean global temperature is always falling  
D) mean global temperature fluctuates (sometime rises and sometimes falls)

Random Question (No points, just for fun!)
What are the ingredients for slime?

A) Glue, water, and sand  
B) Glue, water, and Comet  
C) Glue, water, and Borax  
D) Glue, water and snot

PowerPoint Presentations available from researcher upon request.
APPENDIX D

FOLLOW-UP STUDY
EARTH SCIENCE LAB FOLLOW-UP STUDY

Conducted Monday, November 14, 2005

For students who completed the lab in May or August, 2005
1) The only difference between a conglomerate and a breccia is that conglomerates have **rounded** gravel-sized sediments and breccias have **angular** gravel-sized sediments. What does the shape of the sediments reveal about these two sedimentary rocks?

A) The sediments in the breccia traveled much farther from their source than the sediments in the conglomerate.

B) The sediments in the conglomerate traveled much farther than the sediments in the breccia.

C) The conglomerate sediments were transported by a large river, while the breccia sediments were transported by a small stream.

D) The sediments in the conglomerate came from igneous rock, while the sediments in the breccia came from metamorphic rock.

E) The shape of the sediment grains doesn’t reveal anything.

2) Where does the sediment that forms sandstone come from?

A) Mechanical/chemical weathering of pre-existing rock.

B) Secretions from reef dwelling creatures.

C) Swamps (decaying plant life).

D) Precipitated from seawater.

E) Fossil remains.

3) In Metamorphic rocks, what does the parent rock refer to?

A) A rock that has undergone regional metamorphism.

B) The original rock before it underwent a metamorphic change.

C) A metamorphic rock that exhibits banding (stripes).

D) A rock that has undergone contact metamorphism.

E) A rock that has undergone a metamorphic change by hot fluids (hydrothermal)

Matching: Choose **one** of the following for the questions below. Each letter can only be used **once**.

A) Sedimentary Rock

B) Mineral

C) Igneous, Sedimentary, and Metamorphic Rock

D) Metamorphic Rock

E) Igneous Rock

4) What type of rock can be changed by a metamorphic event? **C**
5) Forms from weathered (chemical or mechanical) fragments of rock, consisting of remains or secretions of plants/animals, or precipitation. A

6) Forms from molten rock (magma or lava). E

7) An inorganic, naturally occurring substance that has a characteristic chemical composition, distinctive physical properties, and crystalline structure. B

8) Forms by changing from one form to another by intense heat, intense pressure, or the action of watery hot fluids. D

**Match the tectonic stress to the geologic structure it creates. Letters may be used more than once.**

A) Compressional Stress
B) Tensional Stress
C) Shear Stress

9) Which stress creates folds such as anticlines and synclines? A

10) Which stress causes reverse or thrust faults to occur? A

11) Which stress causes left or right lateral faults? C

12) Which stress causes normal faults? B

13) You have just won the lottery and your friends tell you, “California is the place you ought to be” so you load up the truck and move to Beverly (as in Los Angeles). You must decided on which property to build your mansion. Which land would you choose to make your home as safe as possible from the devastating effects of an earthquake?

A) Lush wetlands
B) Compacted sediment (not lithified into rock)
C) Loose uncompacted sediment
D) Granite Rock
E) An old landfill now covered with dirt and grass
14. From the scenario in question #13, which of these choices would be the worst location to build on?

A) Sandstone rock  
B) Compacted sediment (not lithified into rock)  
C) Gneiss rock  
D) Granite rock  
E) An old landfill now covered with dirt and grass

15) What is another name for 0° latitude?

A) North Pole  
B) South Pole  
C) Equator  
D) Prime Meridian  
E) 180° Meridian (International Dateline)

16) The North and South poles are:

A) Minimum Latitude  
B) Maximum Latitude  
C) Minimum Longitude  
D) Maximum Longitude  
E) Unrelated to latitude or longitude

17) What direction does the stream flow in Diagram L (labeled Question 64)?

A) Northwest to Southeast  
B) Southeast to Northwest  
C) Southwest to Northeast  
D) Northeast to Southwest

18) What feature is Berlson Lake (labeled Z) on Diagram O (labeled Question 67)?

A) Cut Bank  
B) Point Bar  
C) Tombolo  
D) Oxbow Lake  
E) River Spit
19) What type of valley is characteristic of a **straight** stream channel?

A) U-shaped  
B) V-shaped  
C) S-shaped  
D) Y-shaped  
E) L-shaped

20) What is the biggest problem associated with building jetties and groins?

A) They are not attractive and harm the tourism business  
B) They are dangerous to sea creatures  
C) They are dangerous to humans  
D) They disturb the natural sediment transport and cause erosion  
E) Both B and C

21) Exposed marine terraces, wide beaches, and salt marshes are features of what type of coastline?

A) Gulf Coast  
B) River Coast  
C) Submergent Coast  
D) Emergent Coast

22) A submergent coastline can be caused by:

A) Sea level lowering  
B) Sea level rising  
C) The land sinking (subsidence)  
D) Both A and C  
E) Both B and C

23) What natural coastline feature can be used to determine the direction of the longshore current?

A) Estuary  
B) Spit  
C) Salt Marsh  
D) Wave-Cut Cliff  
E) Stack
24) Where in the world today are ice sheets still present?

   A) Antarctica
   B) Cascade Mountain Range
   C) Andes Mountains
   D) Greenland
   E) Both A and D

25) What lab did you like the best? Why? (There is no wrong answer, please write as much as you would like.)

Thank you for your time, your effort, and your help.
APPENDIX E

SPREADSHEET
Spreadsheet containing all data for the study is available from the researcher upon request.

Please e-mail at jgj27@msstate.edu or call the Department of Geosciences at Mississippi State University, Starkville, MS.