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THE USE OF VARIOUS TECHNIQUES TO TEACH WEATHERING AND EROSION

By

Julie S. Crossman

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ABSTRACT

THE USE OF VARIOUS TECHNIQUES TO TEACH WEATHERING AND EROSION

By

Julie S. Crossman

During the 2003-2004 school years, earth science students at Charlotte High School completed a unit on weathering and erosion. The unit was developed to address common issues facing educators. The first issue was the need to align instruction with state and national science standards related to earth science. Secondly, was the need to incorporate a variety of effective teaching strategies into classroom instruction that address a range of learners in a classroom. The following techniques were incorporated within the teaching materials: concept maps, PowerPoint presentations, pictures, student drawings, application projects that allow students options, anticipatory sets and writing. Data were collected using predetermined pretest and post-test questions to measure the effectiveness of the various teaching techniques used. Participants also completed a student survey to reflect on the techniques used throughout the unit.

The data showed considerable improvement by the students in all areas. Student survey results expressed particular value to the use of pictures and drawings as well as concept maps.

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Introduction

This project was developed to address some common issues that face teachers today. The first issue was the need to align instruction with state and national science standards related to earth science. Secondly, was the need to incorporate a variety of effective teaching strategies into classroom instruction that address a range of learners in a class, and to increase student participation, understanding and success.

The Michigan State Board of Education approved a system of academic standards and a framework within which local districts could develop, implement and align curricula. A great deal of professional development time in my district is devoted to the design and implementation of curriculum in each core subject, including earth science. The importance of this curriculum has continued to increase and there is a great deal of pressure on local districts to demonstrate mastery of the state standards. The Michigan Educational Assessment Program (MEAP) tests are based on these content standards and are criterion-referenced, meaning that each student's results are judged and reported against a set performance standard. If a student meets the standard, it means he/she meets expectations on the recommended state curriculum. The MEAP tests have been recognized nationally as sound, reliable, and valid measurements of academic achievement (Watkins, 2004). Students who score high on these tests have demonstrated significant achievement in valued knowledge and skill. Further, the tests provide the only common denominator in the state to measure in the same way, at the same time, how all Michigan public school students are doing on the same skills and knowledge. As a result the MEAP tests are used as the primary measurement tool to assess the year-to year achievement of students and is included in the district's Adequate Yearly Progress

(AYP). AYP is one of the cornerstones of the federal No Child Left Behind Act (NCLB) and reflects school performance (Watkins, 2004). It is no surprise then, that it is important for teachers to not only teach the content of these standards but to have all of their students demonstrate mastery of these standards.

Following the release of state and national standards in late 1995, the focus of educational discussion shifted from the development of standards to their implementation through the curriculum. Educators began asking questions about instructional materials that would help learners master the science content defined in the standards (Bybee, 2003). Therefore, curriculum design and implementation has been a primary focus in education and educators are continually striving to improve instruction so that all students can achieve mastery of the standards.

The first step in the process of alignment and curriculum development is to evaluate the current curriculum. Evaluation of the high school earth science curriculum in my district identified a benchmark that was not being taught. This was the starting point for the project described here: to develop materials to cover the state standard: Strand V Using Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts, and High School Benchmark 1, Explain the surface features of the Great Lakes region using the Ice Age theory. From this benchmark, the following objectives were defined for this work, based on the overall topic of glaciers:

- *Describe the climatic cycles that exist during an ice age.*
- *Explain the surface features of the Great Lakes region using Ice Age Theory.*
- *Describe how glaciers form.*
- *Explain two processes by which glaciers move.*

- *Describe the landscape features that are produced by glacial erosion and deposits.*
- *Determine the impact on sea level by the melting of existing glaciers due to Global Warming.*

These objectives were incorporated into an existing unit on weathering and erosion.

The second step is to design instructional units that adequately address the objectives. Providing instruction so that all students can achieve mastery of the objectives is a challenge to all educators. Many classrooms represent diverse student academic levels. Instruction must challenge high-level students without losing low level and special education students. To meet this challenge, teachers must first recognize the range of individual strengths of their students and than design classroom instruction that utilizes these strengths. This can be accomplished by introducing a variety of effective teaching strategies that address a range of learners in class.

Every student is a unique individual. They bring their own ideas, beliefs and background into the classroom. Each student is also intelligent in his or her own right. Dr. Howard Gardner (1983) defines intelligence as "the ability to produce a product that is valued in a culture or society." Gardner's definition acknowledges that everyone has unique talents and can contribute to society. Therefore a student who scores an A on a math test is smart, just as the student who plays Gershwin's Rhapsody in Blue is smart. By identifying and acknowledging the differences and strengths of our students, we can recognize the unique qualities of every individual (Silver and Hanson, 2000). Teachers that recognize this can help students use their strengths in learning and incorporate them into their daily lessons.

Gardner's Multiple Intelligences model identifies different types of intelligence and different ways that people learn. "Differentiated instruction is a teaching approach that provides a variety of learning options to accommodate differences in how students learn. Some differences that impact learning are related to the student's prior knowledge and experience, learning preferences and modality, cognitive level, and personal interest" (Skowron, 2001). Every classroom contains a community of learners with a wide range of abilities and interests. Research supports teaching practices that honor the individuality of students in terms of their experiences, interests and prior knowledge (Skowron, 2001). Expert teachers are attentive to students' varied learning needs. To differentiate instruction, then, is to become a more competent, creative, and professional educator (Rule and Hurley, 2003).

The model of multiple intelligences defines the following intelligences: verbal/linguist, musical/rhythmic, logical/mathematical, visual/spatial, naturalist, bodily/kinesthetic, interpersonal and intrapersonal (Gardner, 1983). Visual learners benefit from graphic representations, auditory learners benefit from aural representations, kinesthetic learners benefit from bodily involvement activities, and tactile learners benefit from touching and feeling shapes, forms and textures (Sprenger, 1999). Most traditional instruction caters to verbal/linguistic learners making it difficult for students with other forms of intelligence to be engaged, interested and successful in the classroom.

> "Teachers should create a classroom environment that allows students to process information the way they do in the real world. Outside school, individuals are free to process and learn in their own way. In schools, however, we often ask students to process in only a linguistic or logical-mathematical way. This inhibits students' ability to develop their intelligences. Perhaps more importantly, it

> inhibits their ability to grasp the concepts and skills we want them to learn." (Silver and Hanson, 1998)

To help accommodate different learning styles, I incorporated visual/spatial components in my lessons by replacing traditional lectures with PowerPoint presentations that included diagrams and photographs, notes with concept maps, and asked students to include sketches in their notes and answers.

> "Much of traditional education breaks wholes into parts, and then focuses separately on each part. But many students are unable to build concepts and skills from parts to wholes. These students often stop trying to see the wholes before all the parts are presented to them and focus on the small, memorizable aspects of broad units without ever creating the big picture. We need to see the "whole" before we are able to make sense of the parts." (Brooks and Brooks, 1993).

The essence of this statement emphasizes the need for students to build concepts and see the big picture. It is easier for students when new concepts or concept meanings are subsumed under broader, more inclusive concepts (Novak and Gowin 1984). Students can then be instructed in ways that show how each individual component fits into a larger concept. Concept maps are a type of visual tool that presents information in this form. Organizing content information into concept maps shows connections among ideas and concepts (Hyerle, 1996). Ovals, lines and linking words are used and interrelated within an adaptable yet strictly hierarchical structure. Though the basic graphic design of this thinking-process map is hierarchical, and thus reflects an overarching classification structure, other thinking processes-such as sequencing, cause-effect and part-whole reasoning, and identification of attributes are implicitly integrated into the representation using linking lines and key words (Hyerle, 1996). By presenting content to my students in the form of concept maps I provide a visual representing the whole picture along with the individual components and include instruction across several learning styles.

The common saying, "a picture is worth a thousand words" sums up the need to use visuals in classroom instruction. Simply describing a landform, for example, provides an abstract idea for a student, but actually seeing it or a model of it can make it real to the students. In fact, some students have to see it in order to understand it. Technology allows teachers to easily present information in both a written and visual format. The use of a PowerPoint presentation that includes pictures can make the material more meaningful and interesting. Teachers can make this information even more powerful by asking students to describe and draw the information as well. By using drawings along with writing students access several areas of their brain while learning. A PowerPoint presentation with pictures along with students describing and drawing the information versus a traditional lecture with notes makes the presentation of information more interesting and meaningful for students. Students use their "whole brain" and are able to experience the information. It also allows students another way to communicate what they know. Instead of relying strictly on writing they can draw a picture to communicate their knowledge.

Learners engage in types of thinking that range from a simple literal level to more complex abstract levels. These levels are not distinct but overlap and are used simultaneously by students as they learn. All students need and benefit from learning activities that challenge them to use complex thinking and reasoning. It matters little if we possess vast amounts of knowledge and information if we cannot use and apply that knowledge (Skowron, 2001). It is the goal of most educators to take their students beyond general knowledge to higher order thinking, including the application of information or concepts to the everyday world. A goal in my earth science class is to instill in my students an appreciation and understanding for the world around them and the processes that led to what we see today. To help students reach this level, teachers must develop and use activities that help them see connections to everyday situations and apply what they learn to new situations (Fogarty, 1997). We can often move subject matter to the application level simply by asking students to take something they've learned and find ways to apply it or see it in their everyday lives (Harmin, 1994). When teachers are able to achieve this goal and their students are able to see how learning is relevant to their lives, they will enjoy learning and will be more likely to retain the information.

Oftentimes students that earn low grades have gotten that grade not because they did not learn the information but because they did not complete the work. There can be many reasons why students do not complete class work. Perhaps the work is not challenging enough or is too challenging. Perhaps the material is at the appropriate level but the approach is unappealing. A strategy or technique that increases student involvement in learning is to develop assignments that allow students to select from several options. Designing unit projects or assignments that offer students a choice can inspire students to take charge of their learning and allows an opportunity to individualize instruction by accommodating various learning styles (Harmin, 1994). The teacher can challenge upper level students without loosing others. "A choice invites the bright or interested student to do more." (Harmin, 1994) and can engage all students in some way by capitalizing on personal interests and needs.

Teachers need to present information in ways that gets their students' attention and interest at the start of a lesson and then keeps it throughout the lesson. Educators have commonly called this idea many things: the anticipatory set, the cue set, the hook and hold strategy, etc. This idea is critical because it determines whether students will be hooked into the lesson right from the start. By capturing students' interest in the first few minutes, it will be easier to keep their attention as the lesson proceeds (Silver and Hanson, 1998). This can be accomplished effectively through demonstrations, the presentation of pictures, a story or a thought-provoking question. Once you have their interest, varying instruction techniques throughout the class period and involving students can help hold their interest.

A goal of my school district is to have students develop or improve writing and thinking skills. To accomplish this goal, my district has emphasized writing across the curriculum and has adopted a model: Developing Writing and Thinking Skills Across the Curriculum: A Practical Program for Schools. The program describes five types of writing assignments that can be used in any subject. "The assignments fall on a continuum from Type One to Type Five: Type One writing emphasizes idea generation without attention to the craft of writing, while Type Five emphasizes close attention to all aspects of craft and content. Each type has a different purpose." (Collins, 1992). I incorporated Type Two writing in my unit lessons:

> "Type Two Writing shows that the writer knows something about a topic or has thought about the topic. It is a correct answer to a teacher's prompt. Type two writing assignments ask for definitions, facts, explanations, or opinions supported with details. The only evaluation criterion is that the content must be correct. Type two writing is best used in lieu of individual questions to students in class. For example, rather than ask a few

> students if they know the answer to a question, give a type two assignment that asks all students to answer a question in writing." (Collins, 1992).

This allows the teacher to assess student knowledge and promotes writing and thinking skills.

In summary, the rationale for this project was to ensure that my curriculum was in alignment with the state standards and benchmarks related to weathering and erosion and to use a variety of instructional techniques that address a range of learners and to increase student participation, understanding and success. Recognizing students as unique individuals with different learning styles and abilities defines the need to incorporate a variety of techniques in classroom instruction. The use of concept maps, PowerPoint presentations, pictures, student drawings, application projects that allow students options, anticipatory sets and writing are all ways to increase student participation, understanding and success and I incorporated these techniques throughout the unit.

Science Background

Weathering is a change in the physical form or chemical composition of rock materials exposed at the earth's surface. There are two types of weathering: mechanical and chemical. Mechanical weathering physically breaks materials into smaller pieces. Exfoliation, ice wedging, organic activity and abrasion are types of mechanical weathering processes. Chemical weathering breaks down materials by changing their chemical composition. Water and oxygen are the primary agents of chemical weathering by hydrolysis, carbonation and oxidation. The composition of the material, the amount of time it is exposed, the amount of surface area exposed, the climate and topography can effect the rate at which weathering occurs. The end result of weathering is soil.

Soil is a complex mixture of various size mineral grains from the weathering of rock, and organic material from the decay of vegetation and animals. The proportion of sand, silt, clay and organic matter determines a soil's properties. For example, at one extreme, there is sand, the end result of chemical and physical weathering. At the other end, slow anaerobic decomposition of vegetative matter forms a dark organic soil, such as found in swamps and bogs. The composition of soil varies from place to place, and is controlled by five important factors: climate, parent material, living organisms, topography and time.

Erosion is the process by which the products of weathering are transported. Agents of erosion include glaciers, rivers, wind and gravity.

Rivers are erosional agents. The amount of material a stream can transport depends on the gradient of the stream and the amount of water flowing in the stream.

Faster moving water will erode material and transport it downstream. When the water slows down, it will deposit its sediments forming alluvial fans or deltas.

A glacier is a large mass of moving ice created from the accumulation of snow that compresses into large, thickened ice sheets over many years. A glacier moves like a very slow river eroding and shaping the land beneath it. There are two types of glaciers: valley glaciers and continental ice sheets. A valley glacier is a long narrow, wedge shaped mass of ice that typically develops in high mountainous areas. A continental ice sheet is a large flat ice sheet covering a large landmass up to millions of square kilometers. They are presently found in Greenland and Antarctic. During the last ice age, a Continental Ice Sheet was believed to cover 30% of the earth's land surface including Michigan.

Glaciers flow downward in response to gravity. There are two basic processes that allow the ice to move: basal slip and internal plastic flow. Basal Slip is caused by the weight of overlying ice exerting enough pressure to melt some ice at the base allowing the glacier to slide along the ground. Solid ice crystals slipping over each other create a slow forward motion cause internal Plastic Flow

Glaciers are powerful agents of erosion. As a glacier moves over their bedrock floors, it erodes large quantities of material and transports it. As the ice melts, material is deposited or further transported by the flow of glacial melt water streams. Moraines are an accumulation of rock, sand, and clay riding on the ice or left on the ground after the ice melts. Ground Moraine is a mantle of till deposited underneath the ice, which is often very rocky and a Terminal Moraine marks the farthest advance of the glacier and is composed of hilly ridges of heterogeneous rock fragments, sand, and clay. Glacial melt water forms rivers and lakes transporting the sand, pebbles, mud and fine rock material eroded by the ice. All of this deposited material is referred to as glacial drift. The flow of the melt water can sort and deposit glacial till called outwash. The outwash can sometimes form small hills, or Kames, where sand and gravel accumulated. Some melt water streams flow in tunnels along the bottom of a melting glacier. The stream sorts and deposits its sediment as a long, narrow ridge called an esker. Both kames and eskers are a present day source for sand and gravel.

Glaciers melt back unevenly, sometimes leaving behind immense, isolated blocks of ice that melt slowly over time and may become partly buried in outwash sand. If the created depression were deep enough that its bottom laid below the water table, as the ice block melted a lake would form, called a kettle lake. If the depth is not as deep, it leaves a steep sided depression known as a kettle.

The Great Lakes of Michigan are the result of a combination of erosion and deposition by continental ice sheets. Glacial erosion widened and deepened broad river valleys covered by the ice sheets. Moraines to the south blocked off the ends of the valleys. As the ice melted, the melt water flowed into the valleys and was held there by the moraines to form lakes. After the ice age, the land slightly uplifted. The lakebeds were also uplifted and slowly shrank to their present size.

The Ice Age is a long period of climatic cooling during which continental ice sheets cover large areas of the earth's surface. It is believed that the world has gone through several periods of glacial ice age advancement and retreat The last glacial retreat occurred 10,000 years ago. The Milankovitch Theory states that small, regular changes in Earth's orbit and in the tilt of the earth's axis causes glacial advancement that can create an Ice Age.

Demographics of School and Student Participants

I implemented this unit on weathering and erosion at Charlotte High School, a suburban/rural high school of approximately 1,000 students in grades nine through twelve. The community is fairly conservative. Residents of Charlotte are primarily employed as factory workers at General Motors or Spartan Motors, or are farmers and small business owners. Charlotte is the county seat for Eaton County and offers many support programs for low-income families. The socioeconomic status of the community is diverse. The ethnic diversity in the school and community is low, with the primary population being Caucasian.

Charlotte High School is on a 4 x 4 block schedule. Students have four 90-minute classes each day for 18 weeks. After 18 weeks, they begin new classes, completing eight different courses a year. All of the science courses offered are 18 weeks long.

Students participating in the study were in two separate Earth Science classes. Earth Science is a science elective with the only prerequisite course being biology, a graduation requirement normally taken in ninth grade. Students in the classes ranged from tenth through twelfth grade. A total of 53 students agreed to participate in the study, 24 females and 29 males, by returning their consent form [Appendix A-1]. The students have a diverse level of abilities, skills and motivation. Many students were encouraged to take this class as a preparation for the High School MEAP test. As a result, the classes consist of students ranging from the top of their class to special education students and a diverse level of ability is represented.

Earth Science is divided into four primary units: Astronomy, Weather, Hydrology and Geology. The first nine weeks addresses Astronomy and Weather and the second nine weeks addresses Hydrology and Geology. This unit on weathering and erosion fits into the Hydrology unit and serves as a basis for studying rock types in the Geology unit. The Hydrology unit begins with the study of water and its properties and then studies groundwater. I developed the beginning of the Hydrology unit during an earlier course in this Master's program and included the properties of water and groundwater. My project is essentially a continuation of that unit, beginning with weathering. The lessons emphasized the role that water and the environment play on the weathering of objects. Soil is included at the end of weathering because it is the end result of weathering. The end of the unit focused on erosion by rivers and glaciers.

Unit Outline and Implementation

An outline of the unit is summarized below. Each numeric item corresponds to the items planned for a 90-minute class period and * items were newly developed or modified for this project.

1) Introduction to Weathering and Erosion
   a) *Weathering and Soil Pretest
   b) Demonstrations
      1. *Day One set up for Ice Bomb
      2. Acid Rain
   c) *PowerPoint Presentation: Weathering
   d) *Concept Map
   e) Lab Set Up:
      1. *Acid Rain
   f) Introduce *Weathering Picture Project
2) Mechanical Weathering
   a) Day Two Observation of Ice Bomb Demonstration
   b) *Mechanical Weathering Abrasion Lab
   c) *Rates of Weathering: Temperature and Surface Area Lab
   d) Day One Acid Rain Observations
3) Chemical Weathering
   a) Conclude Acid Rain Lab
   b) Identifying Types of Weathering Review Questions
   c) Weathering Picture Project
4) Soil
   a) *Concept Map
   b) *Where is Alice Springs? Soil Lab
      1. Set up Density Columns
      2. Begin Soil Analysis
5) Soil
   a) Complete Where is Alice Springs? Soil Lab
   b) Weathering and Soil Review Questions
6) a) *Weathering and Soil Post Test
   Erosion: Streams and Rivers
   b) *Pre Test
   c) Flood Pictures
   d) Notes
   e) Review Questions
7) Levees and Floods
   a) Levee Discussion
   b) Nova © Flood Video

c) Type Two Writing on Levees

8) Erosion: Streams and Rivers
   a) Review
   b) *Streams and Rivers Post Test

   Erosion: Glaciers

   c) Glacier Lab Set up

9) Erosion: Glaciers
   a) *Pre Test
   b) Video Clip: Ice Age
   c) *Glaciers PowerPoint Slides 1-16 with students filling in notes

10) Erosion: Glaciers
   a) *Valley Glaciers: PowerPoint Review of Slides 1-8
   b) *Valley Glacier Assignment
   c) *Pressure Melting Lab

11) Erosion: Glaciers
   a) Set up *Stream Table Demonstration
   b) *Glaciers PowerPoint Conclusion
   c) *Kettles and Clay Striation Lab Activities

12) Erosion: Glaciers
   a) *Stream Table Observation and *Type Two Writing
   b) *Sea Level Lab

13) Erosion: Glaciers
   a) *Unit Review Questions and Game
   b) *Glaciers Post Test

Description, Evaluation and Reflections of the Unit Activities

The activities and lessons developed for this project are essentially three smaller units: Weathering and Soil, Erosion by Rivers and Streams and Erosion by Glaciers. The topics are related and the types of activities used were consistent throughout the unit. Knowledge about each topic was assessed individually with a pretest and post-test. I will describe and evaluate the different types of activities individually by topic.

Demonstrations: Weathering

At the beginning of the unit on weathering, students were introduced to the topic with two demonstrations as the anticipatory set. They were used to get students interested in the topics we would be studying throughout the unit and the day's lesson. The first demonstration, the Ice Bomb [Appendix C], spanned two days. The purpose of this demonstration was to show students how powerful the expansion of freezing water could be. The students initially were to predict what would happen when a steel flask was filled with water, sealed and placed in the freezer. The following day, the students saw that the water had frozen and expanded with a force great enough to break the steel flask. The second demonstration illustrated how acid rain is formed [Appendix C]. As I was doing the demonstration, we discussed that the electricity in Charlotte is generated from the burning of coal. Sulfur is often an impurity contained in low-grade coal and can be released as that coal is burned to drive the production of electricity. The end result is acid rain. Both of these demonstrations served as a cue set for mechanical and chemical weathering.

The ice bomb and acid rain demonstrations were very effective at getting the students' attention, as demonstrated by their interest level and questions. I passed the broken steel flask around the room and the students made comments on how neat it was. The acid rain demonstration elicited a good class discussion on the power source for electricity in our community and provided a solid link to their lives.

Demonstrations: Glaciers

The Glacier Stream Table Demonstration [Appendix C] was used to model the different landforms created by glaciers. Basically, one end of a stream table was filled with a mixture of sand and fine and course aquarium gravel in different colors and a bag of ice was placed on the top quarter of the mixture. Students were asked to observe the contents of the stream table initially and then the following day after the ice had completely melted. Several features were labeled and students were assessed using Glaciers Type Two Writing [Appendix C]. The type two writing asked students to describe the appearance of four features from the stream table.

The purpose of the Glacier Stream Table Demonstration was to illustrate three dimensionally what glacial landforms look like. In evaluating student responses on the type two writing their responses reflected their knowledge of the appearance of the glacial landforms modeled with the stream table.

Unit Project: Weathering

To conclude weathering, students completed a Weathering Picture Project [Appendix C]. The purpose of the project was to have students demonstrate a clear understanding of the different processes of weathering and to make a connection to the world around them. The project asked students to find and identify their own examples of the different weathering processes that occur around them. To help students get started on this, I used the Identifying Types of Weathering questions [Appendix C] as an idea base for the project. We completed the identification as a class and spent some time in the computer lab working on the picture project. Students could utilize the Internet for pictures or do the formatting for photos they had taken. Those choosing the video option could shoot footage, edit footage already taken or write their script.

The weathering picture project was a success. The projects were assessed using a grading rubric [Appendix C] and most of the students received a high score. Students seemed to enjoy this activity. The class period devoted to work on this project fell the Wednesday before Thanksgiving break. This is often a difficult day to keep students focused and on task. My students were engaged for the entire class period. I feel they enjoyed the use of technology as well. Many students made a PowerPoint presentation, a few took photographs and two students made a video for the project. I showed the video to the class as a review of the processes of weathering. They were entertained because their peers had made the video and it was an effective review instrument. I will implement this project again but with a few changes. I would expand the written portion or clarify that they need to explain each of the weathering processes illustrated in the assignment. I would also require that they illustrate each of the weathering types that we studied and that they present them to the class. As a time restraint, I may need to have them work in pairs, especially if they are presenting them. With these small changes, I feel this project will be even better.

PowerPoint Presentations and Concept Maps: Weathering and Soil

Students completed two different concept maps during the unit: Weathering Concept Map [Appendix C] and Soil Concept Map [Appendix C]. The concept maps served as the notes for these unit topics. Students completed the Weathering Concept

Map as I presented a PowerPoint with pictures and descriptions for each type of weathering. We completed the Soil Concept Map together using the overhead projector.

I liked the use of concept maps versus traditional notes. They allowed me to present the big picture to students and then describe individual components. Another advantage is that they do not require as much writing as traditional notes taking less class time.

PowerPoint Presentations and Concept Maps: Glaciers

All of the information for glaciers was presented through a PowerPoint slide show. It included a description of glacial landforms and pictures of them as well. Students were asked to fill in a description and sketch for each landform on the Glacier Unit Vocabulary Chart [Appendix C]. We progressed through the slide show over several days with lab activities included each day.

The glacier unit vocabulary chart and questions contained the primary information for the unit. I really liked the drawing aspect of this. Students also had visuals through the PowerPoint. I thought this helped students understand the concepts. The only draw back, it was hard to break up the notes and was a little boring for students at times.

Activities: Weathering

The weathering portion of the unit included the following activities: Mechanical Weathering Abrasion Lab, Rates of Weathering: Temperature and Surface Area Lab, Chemical Weathering Acid Rain Lab, and Where is Alice Springs? Soil Lab.

The purpose of the Mechanical Weathering Abrasion Lab [Appendix C] was to first demonstrate that abrasion results in rocks with a smooth, rounded surface and also that different substances weather at different rates. Students filled two small containers with water and pieces of sandstone in one and granite in the other, shook the containers and made observations. The activity, Rates of Weathering: Temperature and Surface Area Lab [Appendix C], compares factors that impact the rate of weathering. The students placed whole and ground up Alka seltzer © antacid tablets in hot and cold water and compared the rates at which they dissolved. The purpose of the lab is to show students that hotter temperatures and increased surface area accelerates weathering. Both of these activities include questions that connect these lab models to mechanical and chemical weathering processes.

I used the Abrasion Activity and Factors Affecting Weathering: Temperature and Surface Area lab together. They worked well as a productive use of class time. By looking at their lab answers, I thought students understood the abrasion activity fairly well. They realized that the point of the activity was to show that different materials/rocks vary in their degree of weathering. However, in The Factors Affecting Weathering: Temperature and Surface Area activity students did not make the connection to the weathering application. The lab was supposed to show that warmer climates have increased weathering. Many students made this connection but also thought that the whole piece of antacid had more surface area than the crushed piece creating a misconception. The next connection that they needed to make was that mechanical weathering broke things into pieces, increasing their surface area making them more susceptible to chemical weathering. Many students did not make the connection between mechanical and chemical weathering. Next time, I will emphasize this more and I will include a simple pre lab activity on surface area. This concept is included in the lab, but the students just needed a better understanding before they began the work.

The Chemical Weathering Acid Rain Lab [Appendix C] models Hydrolysis, Carbonation and Oxidation, all forms of chemical weathering. The lab required time during three class periods. On the first day, students recorded the initial appearance and mass of various materials and then placed them in individual cups filled with either water or vinegar. The cups were left overnight and the contents described and massed the following day. The objects were then left to dry overnight and were described and massed again on the final day. The purpose of the lab was to demonstrate the different types of chemical weathering and the impact chemical weathering has on different types of materials. The lab also asked students to consider how weathering impacts the type of materials used in the construction of buildings and structures.

I have used a version of the chemical weathering lab in years past. For this unit I added a lot more depth and included both conclusion and application questions. Overall, I thought this activity worked very well. Students did well on their lab questions and the results were in line with the principles illustrated. There were a few unexpected results on the mass of objects. Some of the objects gained mass. The steel wool, when wet, had gained water mass. Students would need to wait a day to mass this. The skill of the students in massing objects may account for a gain in mass in the other objects. Students were instructed to analyze the loss of mass in the limestone and concrete only. The primary objective demonstrating how chemical weathering affects different objects was illustrated.

The primary activity and instruction on soil was the Where is Alice Springs? Lab [Appendix C]. The crime scene scenario from the lab was the basis for a discussion on how soil may be a useful clue in solving crimes. The purpose of the lab was to have students analyze and compare various characteristics of soil. To accomplish this, students are given a scenario of a crime where the primary evidence is from soil taken from the suspect's vehicle. The students are asked to compare eleven different soil samples taken from the vehicle and various locations. To complete the lab, students were divided into small groups and assigned two different soil samples of the eleven samples to analyze. Each group analyzed different samples and data from all the groups were compiled and used to compare samples involved in the crime scenes.

The preparation for the Where is Alice Springs? Lab was very time consuming. Now that it is all set-up, I can focus on some of the details. In implementing the lab, different groups tested and observed various samples of soil and shared the results with the class. This allowed us to get through the lab quickly. If not organized this way, student groups would need to look at many (a minimum of 5) samples. Unfortunately, many of the observations are subjective and the groups analyzing samples that were the same described them very differently. This made it difficult for students to determine that they were the same sample. In some cases, groups had similar data down for different samples and very different information down for the same sample. The actual forensic aspect of the lab did not work very well, but the objective for students to look at characteristics of different soils was met. I would do this activity again because it is a way to make the study of soil interesting. I will need to experiment with different ways to eliminate the large variation in student observations and I will have each group analyze all the samples individually next time.

Activities: Glaciers

Creating Glacial Landforms: Kettles, Glacial Erosion and Pressure Melting [Appendix C] are a combination of three small lab activities. In the pressure melting activity, students took two blocks of ice and placed them in small foil pie pans. A brick was placed on top of one ice block and they were set aside to melt. After 20 minutes students measured the amount of ice melt created by both ice blocks. The brick causes the ice to melt more rapidly than the one without the brick. This simulates the effect the overlying weight of a glacier has on the bottom portion. The next activity demonstrates the formation of kettles. Students fill a small plastic shoebox with sand and place 4 ice cubes in the sand buried progressively deeper into the sand. Once the ice cubes melt, students will see a small depression for the ice cube buried the deepest, representing a kettle. To simulate the ability of a glacier to transport and deposit material, students used three ice blocks, one plain, one containing sand and the third containing aquarium gravel. They rolled out some clay and pushed the ice blocks across the surface. The plain ice block left water behind, the second left sand and striations in the clay and the final block left pieces of gravel and deep grooves in the clay. The ice blocks will also pick up clay and sand from the clay surface.

Student scores on Creating Glacial Landforms: Kettles, Glacial Erosion and Pressure Melting labs were good. There are only a few changes that I would recommend. The kettle formation activity required melt time and needs to be set up at the very beginning of the class to melt before the end of class. The only difficulty students had with the concepts involved in the lab were in the kettle formation portion of the lab as well. The part that students struggled with regarded a question about whether a kettle would be a lake or not. The correct answer involved the depth to which the ice block was buried. To answer this question correctly students had to recall information on the water table taught in an earlier unit and apply it to this lab. There weren't very many that made the connection that the ice block had to be buried to the water table in order to be a lake. Some students also did not know how an ice block left behind from a retreating glacier would get buried. I went over both ideas when I returned the lab. Next time, I might discuss both of these things before hand to prepare students to answer the questions. Since this was the first time doing these activities, I didn't know what areas would present trouble for students.

To study changes in sea level associated with glaciers, students did the <u>Glaciers and Sea Level Lab</u> [Appendix C]. Students create a simulated shoreline, island, ocean and glacier. They made several measurements and then placed the glacier on the side of the box containing the sand. The box is placed at an angle and left overnight to melt. Students then made new measurements and observed the new water levels and their effects on the shore and island.

The <u>Glaciers and Sea Level lab</u> activity required some flexibility. I had initially set aside only one class period for the lab but the ice blocks did not melt during the 90-minute class, especially since students needed some time to set the lab up. We had to let them sit over night for the entire ice block to melt. It may melt during the 90 minutes if I use heat lamps. There were a few errors in the results since the activity was out all night and moved. For example, the land slid into the water. The primary objective that the melting of glaciers will increase sea level, was shown. The answers given by students on the lab demonstrated that they understood the connection between global warming, glacial ice melt and sea levels. I believe that students were aware of this problem prior to the lab but not the severity of the problem. With the few modifications indicated, I think the exercise will be even more powerful at demonstrating this concept.

Erosion by Streams and Rivers

I introduced this part of the unit by showing photographs of the flooding of the Mississippi that occurred in 1996. Notes were given over the topic and the students completed some questions over the notes [Appendix C]. This part of the unit lays the foundation for the information they will need over streams and rivers. The following day focused on the power of erosion by rivers. I began by discussing levees and dams and then showed a Nova video on the flood of the Mississippi. Students are then asked to complete Type Two Writing: Levėes [Appendix C] to assess what they learned.

I have used the materials and activities for Erosion by Streams and Rivers in previous years. This part of the unit is only a small portion of the many concepts related to streams and rivers. It could be expanded but presently I have time constraints on covering the amount of topics needed for the course. The notes are formatted so that students fill in key words, which are left out as I go through them on the overhead. I will develop a concept map to replace the note fill-in for next year. I would also like to include a stream table demonstration or lab.

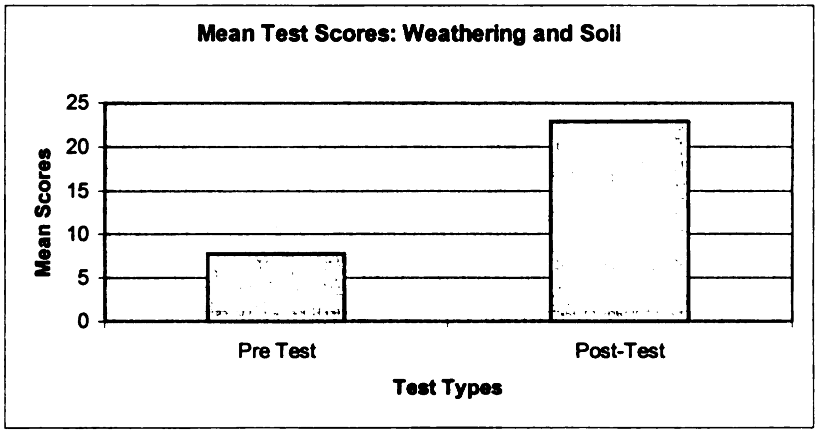
Student Assessment Results

Each topic: Weathering and Soil, Erosion by Rivers and Erosion by Glaciers were assessed individually with a pretest and post-test. The pretest served two purposes: to determine prior knowledge and misconceptions of the topic and also as a baseline for comparison to the post-test results. The questions were designed to assess the objectives developed for this unit and many have open-ended responses. The pre and post-tests as well as the teacher versions are found in Appendix B.

Weathering and Soil

The weathering and soil portion of the unit went well. I feel students grasped the concepts as reflected by their post-test scores. For this portion, the pre and post-tests were the same instrument. The students showed a significant improvement in their knowledge of weathering and soil (Figure 1). The class-mean score for the pre test was 7.8 out of 24 possible points, with a range from 2 to 16. The class-mean score for the post-test was 22.9 out of 24 possible points, with a range from 18 to 24. The t value was –27.1 with 48 degrees of freedom. A paired t-test was performed to focus on the difference between the paired student data and the probability of this result was 0.000.

Figure 1

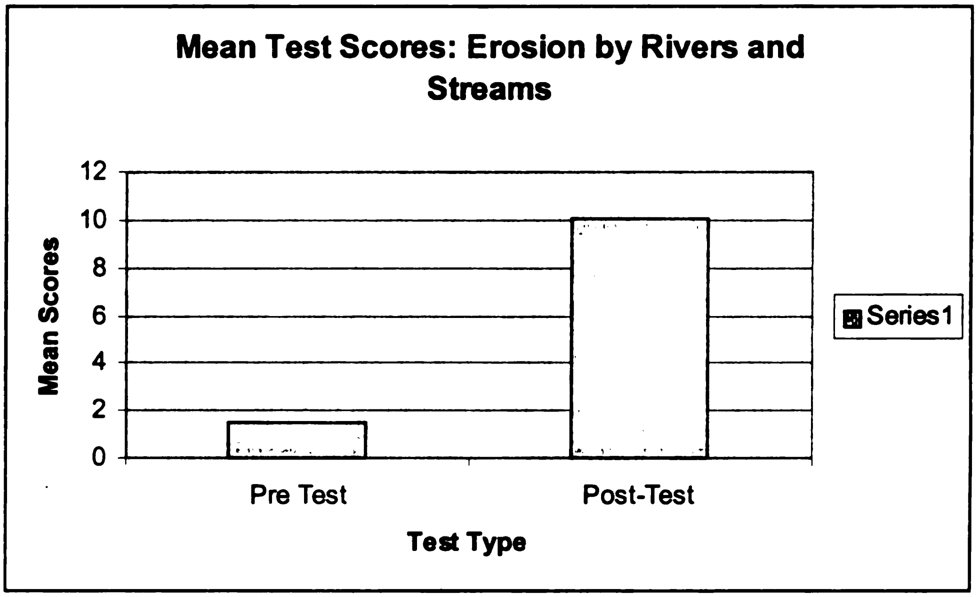


I also analyzed the pre and post-tests from students representing a high, average and low achievement level. I found that the high achieving student typically had the true/false and short answer questions correct on both the pre and post-test. They also were on the right track on the written responses for the pre test but were able to expand their answers and explain them better on the post-test. For example, the pretest question that asked students to identify a factor that would increase the rate of weathering was answered with "how extensive or strong the type is, like strong winds, or heavy falling rain" to a posttest response of "humid climate, a large surface area of materials and water". The average and low-level students improved the number of correct responses on the true/false and fill-in questions from one to three correct to nearly perfect scores on that portion of the test. They also improved their written responses from the pre test and were able to answer them correctly on the posttest. For example, on a question asking them to describe the type of weathering that occurs to form a pot hole on the highway, a pre test response was "from rain and weight" to "ice wedging, water gets into a small hole and freezes and expands the hole". The pretest scores for this part of the unit were varied but most students demonstrated some prior knowledge on the topic. It is worth noting that all students passed the post-test with the lowest score being 18 out of 24.

Erosion by Rivers and Streams

The pre and post-test over Erosion by Streams and Rivers contained the same questions but the post-test was expanded to include more questions. Only the questions that covered the same topics were compared between the pre- and post-tests. The students showed a significant improvement in their knowledge of erosion by rivers and streams (Figure 2). The class-mean for the pretest was 1.5 out of 11 possible points and scores ranged from 0 to 9. The class-mean for the post-test was 10.1 out of 11 possible points and the scores ranged from 7 to 11. The t value was –27.2 with 52 degrees of freedom. A paired t-test was performed to focus on the difference between the paired data and the probability of this result was 0.000.

Figure 2



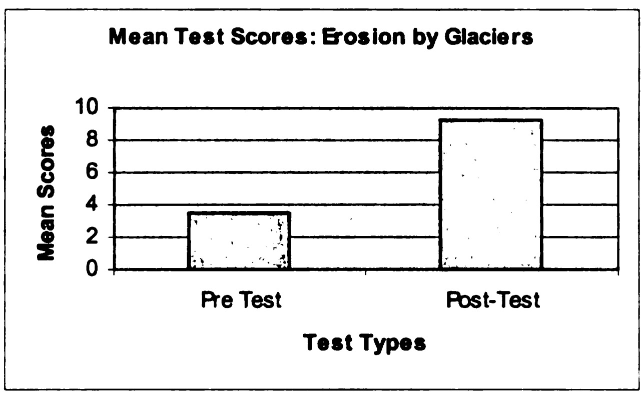
A comparison of the pre and posttests from students representing a high, average and low achievement level was made as well. The pretest scores for two high achieving students went from +2 and +4 on the pretest to +10 and +11 out of 11 on the post test. On a written response asking students to describe two effects of a man-made levee on a river, a high achieving student responded with "I don't know what a levee is" on the pretest to "it prevents annual flooding and it traps water so the nutrients collect at the bottom of the river which causes the river level to rise". The student's answer demonstrates a clear understanding of what a levee is and the effects of its construction on a river. The pretest scores for two average and two low achieving students were three +0 and a +2 out of 11. They all improved their posttest scores to two perfect scores of

+11 for the average students and a +10 and +9 for the lower level students. On a question asking for the definition of erosion, the two average level students who had not answered the question on the pretest to state: "materials being carried away" and "weathering being transported" on the posttest. One of the low level students responded with "weathering change the soil" [sic] to "when fast moving water starts to take away land". All students showed improvement and demonstrated a much clearer understanding as illustrated in some of their written responses and the lowest posttest score of +7 out of 11.

Erosion by Glaciers

For the glacier portion of the unit, the pre and post-test addressed the same information but the post-test was expanded to include more questions. Only the questions that covered the same topics were compared between the pre and post-tests. The students showed a significant improvement in their knowledge of erosion by glaciers (Figure 3). The class-mean for the pre test was 3.5 out of 11 possible points and scores ranged from 0 to 8. The class-mean for the post-test was 9.2 out of 11 possible points and the scores ranged from 5 to 11. The t value was –17.9 with 48 degrees of freedom. A paired t-test was performed to focus on the difference between the paired student data and the probability of this result was 0.000.

Figure 3



Pre and post-test answers were compared for several students representing various academic levels. Students at all levels demonstrated a basic understanding that glaciers are massive pieces of ice and are found in colder climates like Alaska and Antarctica. Students did not include the fact that glaciers move on their pre test but most included that fact on the post-test. One of the primary concepts for this portion of the unit was the landforms created by glaciers during the last ice age that are present in Michigan today. The pre and post-test question asked students to draw and label or describe pictures of landforms found in Michigan that occur as a result of glaciers. The most common correct response on the pretest was the Great Lakes. Post-test answers included kettle lakes, gravel pits, erratics, drumlins, kames and eskers. The upper level and average students gave the most extensive answers and lower level students had at least one landform correct when answering the question. The question allowed students to include drawings in their answers. Since a component of instruction included drawings of each landform I expected many to complete the question with drawings. 76 % of the post-test responses included drawings. All students correctly answered a post-test question regarding the effects on sea level if there was an increase in the amount of solar energy reaching the earth's surface. The last objective asked students to describe what an ice age is and to identify factors that contribute to their occurrence. The most common error on both pretest and posttest answers were failing to identify factors. Most answers were improved from the pre to post test. A pretest answer for an upper level student was "An ice age was when the earth was cooler. All over the earth huge glaciers covered parts of the ocean and land. Animals lived with great coats of fur," compared to their posttest answer "An ice age is where glaciers cover land and are present around the world where it is cold enough. The little change in the earth's tilt, axis and orbit play a part in the climate change." shows a dramatic improvement to the second part of the question. All in all, students improved on all unit objectives tested.

Student Survey Results

At the conclusion of the unit, students were asked to complete a survey to assess their perceptions of the unit [Appendix B]. The survey asked students to rate each activity on its degree of difficulty, if it helped them understand the material and if they liked the activity by completing a chart that listed each activity. Students assigned each category for each activity with a value of 1 to 5 with 5 representing strongly agree. I don't think the format was easily understood by the students and they did not take a lot of time on the chart. Most filled in the same number for all of the activities. The survey also included some questions about their overall thoughts on the unit and the use of visuals. Most students provided excellent feedback through their comments and responses.

One aspect of my project was to include concept maps and pictures in my instruction. Students were asked specifically about the use of concept maps and pictures. Most students indicated that both were a beneficial part of their learning and understanding of the information. Regarding concept maps, students were asked "Do you like the use of concept maps versus traditional notes? Explain." The following were typical student responses:

- Yes, because it is straight forward.
- Yes, they are easier to follow and visualize.
- Yes, because notes are sometimes hard to understand, concept maps help put things in order.
- Yes I do because I am a visual learner.
- It organizes things and is easier to understand.
- Yes, it shows how the unit and the concepts will flow.
- Yes, because they spread out the info and it helps me understand the info.

Regarding the use of drawings and pictures, the students were asked "Did the use of drawings help you understand or remember the material? Explain." The following student responses were given:

- Yes, the drawings gave me a good visual on what it really is.
- Yes, because when I see things I remember them better.
- Yes, I am a visual learner.
- Yes, extremely, especially those notes on glaciers.
- Yes, that way you can picture what it looks like.
- Yes, because I learn better with pictures than words.
- Yes, because it helped me see a real life situation of what we were learning.
- Yes, because I always had a picture in my head to remember.
- Yes, because even though I don't remember a lot of things seeing a picture helps.

I felt that these responses clearly indicate that the students thought they benefited from concept maps and visuals throughout the unit.

Another aspect of my project was to include a variety of activities to meet the needs of all students. As a result, I feel that more students were involved on a day-to-day basis and enjoyed the unit. I also tried to make solid connections to the everyday world so that the students would understand things that they see around them. The following comments support my ideas on this:

- I thought this unit was fun.
- I liked all of the different labs.
- All the examples and labs could be related to what happens in real life.
- I found it fun doing all the labs and they helped. The labs made it easy, because I could see what happened.
- I honestly liked this; it helped me learn a lot I didn't know.

- I liked all the "hands on" stuff
- We learned the material in many different ways.
- I liked the way this class is set up because of a variety of different learning skills.

Conclusion and Discussion

This project was developed to address two issues: to align instruction with state and national science standards and the need to incorporate a variety of effective teaching strategies into classroom instruction to address a range of learners in a class, increase student participation, understanding and success. I accomplished the first goal by developing the unit. To determine if the unit was successful in helping my students correctly answer questions over the content covered in this unit on the MEAP test is not known yet. The results for the MEAP for the 2003-2004 school year have not been released but it is assumed that students would be more likely to correctly answer questions covering the content now than they would have prior to participating in this study based on student improvement from their pre to post-test scores.

The weathering and soil portions of this unit were developed and expanded from existing materials. One of the goals of this project was to use a variety of effective teaching strategies to address a range of learning abilities and styles. I was able to do this through the use of demonstrations, a PowerPoint presentation, concept maps, unit project and lab activities. From the first day, I felt like I got the students' attention with the use of demonstrations. I was able to maintain that interest by teaching to various learning styles. I used a PowerPoint presentation on the types of weathering to introduce the material. It provided pictures of weathered objects that are similar to things they may see in their everyday lives. I believe that this provided a connection to the world around them versus an abstract concept. Replacing traditional notes with a concept map offered instruction in the verbal and linguistic realm of learning but with a visual twist. The lab activities allowed for active hands-on learning and lastly, the unit project offered options to meet various student needs at an application level of learning. I really enjoyed teaching these topics with the new activities and my students seemed to enjoy them as well. They participated during the presentation of information and were engaged in the activities. As a result, their post-test scores showed significant improvement indicating that the students had successfully demonstrated mastery of the content.

The glacier portion of this unit was completely developed for this project. I have never taught or studied glaciers before this unit; therefore, the material was also new for me. My first task in developing the lessons for glaciers was to learn the information myself. I have found that when I teach a topic for the first time that I tend to fall back on more traditional teaching practices. As I continue to teach the topic and my comfort level increases, I am able to develop more activities that deviate from the traditional format. My initial reaction to teaching this portion of the unit is a direct reflection of this phenomenon. I felt that the students were not as engaged, particularly on the presentation of the information as they were in the other portions of the unit. The PowerPoint presentation was more engaging than traditional note taking, but it was time consuming and students had difficulty staying focused for the entire presentation even though I broke it up into smaller segments.

I was able to incorporate various activities into the unit. The lab activities went fairly well and were effective in adding variation to the lessons. There are some obstacles in activities related to glaciers. Most involved ice and required extended waiting time for the ice to melt. This presented a challenge to keep students engaged. I combined activities and also had students set up labs at the beginning of class, presented portions of the slide show and then had students return to the labs at the end of class.

Having done the activities once with students will improve my instruction the next time I teach the unit because I can anticipate and address areas that presented problems to students and eliminate down time during activities by rearranging the daily order of the lessons. As I continue to teach this unit, my confidence with the material and activities will improve and the unit will more smooth. It will also allow me to be more creative and expand the activities and presentation of the information further.

Although all of the student performances on the post-tests showed an improvement compared to the pretest, the glacier portion showed a smaller improvement than the others. I feel this is due to my comfort level. Since I had never taught the subject before it didn't run as smoothly as the others. Perhaps, this is reflected in the smaller amount of student improvement.

The activities and material on Erosion by Rivers and Streams were not newly developed for this project. They had been taught as a small stand alone unit in my past earth science courses. For this project, they became part of a larger cohesive unit where the topics were connected together. The smooth transition from weathering to erosion made this material more relevant and instruction more effective. As a result, students still showed significant improvement from the pre to post-test scores even though the instruction was more traditional.

The students who participated in this project were a nice mix of student abilities, interests, and personalities. As a whole, the classes were successful throughout the earth science course. The primary difference during this unit was an increase in student scores for my average and lower level students. I feel the unit met the needs of these students better than other units taught throughout the course. I also felt the atmosphere was more positive. I had fewer student complaints about the assignments and activities and more student participation as compared to other units. There were very few students who did not complete the work and as a whole the group was very cooperative and willing to give their best. It is my feeling that this is due to the variety of effective teaching strategies used that addressed each individual learner.

I feel that the data obtained from the pre and post tests scores, individual analysis of these tests and student survey responses indicate that my students understand the material presented in this unit. The majority of my students completed all of the activities and assignments and improved their test scores throughout this project. Over all I am pleased with this unit and will continue to use the materials created for this project.

APPENDICES

APPENDIX A

September 2, 2003

Dear Students/Parents/Guardians,

I would like to take this opportunity to welcome you back to school and inform you about a project that will be included in Earth Science this semester. I have been working on a Masters of Science degree through the Division of Science and Mathematics Education at Michigan State University. This past summer I designed a new unit on weathering and erosion as part of my thesis. This unit includes assignments, laboratory experiments and activities, a student survey, and assessments. These items were created with the intent to improve the student's comprehension and retention of the material covered in this course. The unit will begin in late October early November and will take 3-4 weeks to complete.

An important requirement for obtaining the Master's degree is to write and submit a thesis explaining the work and activities completed by students and its implementation into the curriculum. To accomplish this task, I will be collecting data from pre- and post-tests, surveys on the students' reflections and opinions, as well as pulling essay and short answer questions from the labs, homework, and assessments. With your permission, I would like to use this data in my research thesis. The names of students will not be used in the thesis paper, as it will only include statistics and anonymous samples of written work. Your privacy will be protected to the maximum extent allowable by law. You and your child's participation in this research study is completely voluntary.

The requirements for the course will remain the same for all students. The research data will only consist of those who agree to have their work included. At any time throughout the course, you may request that your student's work not be included in the data analysis. There is no penalty for not giving consent or for revoking consent in the future.

If you have any questions regarding this research project, please contact me at 517-541-5649. If you have any questions or concerns regarding the role or rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact the University Committee for Research Involving Human Subjects Chairperson, Ashir Kumar, 202 Olds Hall, Michigan State University, East Lansing, MI 48824; the telephone number is (517) 355-2180 and the e-mail is ucrihs@msu.edu .

Please complete and return the attached consent form by September 5, 2003. Thank you for your time.

Sincerely,

Julie S. Crossman

The Use of Student Activities and Drawings to Teach Weathering and Erosion
Parent/Student Consent Form

Name of Student ________________________________

Please read the following permission statements carefully and check all that apply:

Parental Permission
Data Use:

_______I volunteer to give Mrs. Crossman permission to use my child's work collected from the Weathering and Erosion unit. Mrs. Crossman will not use my child's name in her thesis and all student data will remain confidential to the maximum extent allowable by law.

_______ I do not wish to have my child's work from the Weathering and Erosion unit included in Mrs. Crossman's thesis. There is no penalty for choosing to withhold my data.

Photography Use:

_______I give Mrs. Crossman permission to use my child's photograph, taken during laboratory experiments and activities, in the presentation of her thesis defense. The pictures will not be used for any other purposes or presentations and will be disposed of following the presentation.

_______ I do not wish Mrs. Crossman to use my child's photograph in the presentation of her thesis defense.

Signatures:

Parent/Guardian Name (Printed) ______________________________

Parent/Guardian Signature ____________________________ Date _________

The Use of Student Activities and Drawings to Teach Weathering and Erosion
Parent/Student Consent Form

Name of Student ________________________________

Please read the following permission statements carefully and check all that apply:

Student Permission
Data Use:

_______I volunteer to give Mrs. Crossman permission to use my work collected from the Weathering and Erosion unit. Mrs. Crossman will not use my name in her thesis and all student data will remain confidential to the maximum extent allowable by law.

_______ I do not wish to have my work from the Weathering and Erosion unit included in Mrs. Crossman's thesis. There is no penalty for choosing to withhold my data.

Photography Use:

_______I give Mrs. Crossman permission to use my photograph, taken during laboratory experiments and activities, in the presentation of her thesis defense. The pictures will not be used for any other purposes or presentations and will be disposed of following the presentation.

_______ I do not wish Mrs. Crossman to use my photograph in the presentation of her thesis defense.

Student Name (Printed) _____________________________

Student Signature ___________________________ Date _________

APPENDIX B

Weathering and Soils Pre Test

Name ________________________

Block ________ Date ___________

Complete the following to the best of your ability. You will not be penalized for wrong answers. This will be used as a way to identify prior knowledge, misconceptions and as a baseline for your learning.

State whether the following are true or false. Please write out the whole word.

1.______________All rocks are equally susceptible to weathering processes.

2.______________When water freezes it constricts.

3.______________Rainfall is naturally acidic.

4.______________Acid weathers objects more effectively than water.

5.______________Soil is a product of weathering.

Short Answer and Fill In the Blank

1.__________________ is a change in the physical form or chemical composition of rock materials exposed at the earth's surface.

2.__________________ is a complex mixture of minerals, water, gases, and the remains of dead organisms.

3.What is the difference between Mechanical and Chemical Weathering?

4.The following are the end result of weathering. Identify the type of weathering and explain how each formed.

a. Pot Holes on the Highway

b. Rust on your car

c. Round, Smooth Rocks

5. Identify a factor that would increase the rate of weathering.

6. You are consulted on whether a limestone building or a quartzite building would better withstand the effects of acid rain. What would be your response and why?

7. Compare the difference of a 50 year old highway running through the desert versus a humid continental climate like Florida.

8. Why does a whole piece of limestone remain intact longer than a crushed piece of limestone?

9. Describe two characteristics used to compare soils in determining a common origin.

10. Define Humus and give a reason it is essential for fertile soil.

Weathering and Soils Post Test

Name ______________________
Block _______ Date __________

State whether the following are true or false. Please write out the whole word.

1.______________All rocks are equally susceptible to weathering processes.

2.______________When water freezes it constricts.

3.______________Rainfall is naturally acidic.

4.______________Acid weathers objects more effectively than water.

5.______________Soil is a product of weathering.

Short Answer and Fill In the Blank

1.__________________ is a change in the physical form or chemical composition of rock materials exposed at the earth's surface.

2.__________________ is a complex mixture of minerals, water, gases, and the remains of dead organisms.

3.What is the difference between Mechanical and Chemical Weathering?

4.The following are the end result of weathering. Identify the type of weathering and explain how each formed.

a. Pot Holes on the Highway

b. Rust on your car

c. Round, Smooth Rocks

5. Identify a factor that would increase the rate of weathering.

6. You are consulted on whether a limestone building or a quartzite building would better withstand the effects of acid rain. What would be your response and why?

7. Compare the difference of a 50 year old highway running through the desert versus a humid continental climate like Florida.

8. Why does a whole piece of limestone remain intact longer than a crushed piece of limestone?

9. Describe two characteristics used to compare soils in determining a common origin.

10. Define Humus and give a reason it is essential for fertile soil.

Weathering and Soils Pre Test Answer Key Name ______________________
Block ________ Date ___________

Complete the following to the best of your ability. You will not be penalized for wrong answers. This will be used as a way to identify prior knowledge, misconceptions and as a baseline for your learning.

State whether the following are true or false. Please write out the whole word.

1. ____FALSE____ All rocks are equally susceptible to weathering processes.
2. ____FALSE____ When water freezes it constricts.
3. ____TRUE____ Rainfall is naturally acidic.
4. ____TRUE____ Acid weathers objects more effectively than water.
5. ____TRUE____ Soil is a product of weathering.

Short Answer and Fill In the Blank

1. ___WEATHERING___ is a change in the physical form or chemical composition of rock materials exposed at the earth's surface.

2. ___SOIL___________ is a complex mixture of minerals, water, gases, and the remains of dead organisms.

3. What is the difference between Mechanical and Chemical weathering?

Mechanical weathering physically breaks rock into smaller pieces.

Chemical weathering breaks rock down by changing its chemical composition.

4. The following are the end result of weathering. Identify the type of weathering and explain how each formed.

   a. Pot Holes on the Highway

   Mechanical – Ice Wedging
   Water seeps into small cracks in the road when temperatures are above freezing. Later when the temperature drops below freezing, the water freezes and expands. It expands the crack and then later thaws. This creates a gap in the pavement. As heavy trucks travel over the pavement crumbles.

   b. Rust on your car

   Chemical – Oxidation
   Metallic elements combine with oxygen to form iron oxide (rust). Water and/or acid accelerates the formation.

   c. Round, Smooth Rocks

   Mechanical – Abrasion
   Collision of rocks with one another creating smooth surfaces.

5. Identify a factor that would increase the rate of weathering.

   1) Rock Composition
   2) Amount of Time Exposed
   3) Amount of Surface Area
   4) Climate
   5) Topography

6. You are consulted on whether a limestone building or a quartzite building would better withstand the effects of acid rain. What would be your response and why?

   Quartzite is made from Quartz. Quartz resists chemical weathering, whereas the calcite in Limestone is chemically weathered by carbonic acid. Therefore, Quartzite is more resistant to acid rain.

7. Compare the difference of a 50 year old highway running through the desert versus a humid continental climate like Florida.

   Desert – Hot, dry climate; weathering takes place slowly in this environment
   Warm, Humid Climate – Weathering is fairly rapid; constant moisture is highly destructive to exposed surfaces and hot temperatures increases the weathering rate.

8. Why does a whole piece of limestone remain intact longer than a crushed piece of limestone?

   A crushed piece of limestone has greater surface area; weathering can only occur on the surface.

9. Describe two characteristics used to compare soils in determining a common origin.

   1) General Appearance
   2) Color
   3) Acidity (pH)
   4) Particle Size
   5) Density

10. Define Humus and give a reason it is essential for fertile soil.

   Humus - decaying remains of plants and animals. It provides nutrients to the soil and helps the soil retain moisture.

Streams and Rivers Pre-Test

Name ______________________
Block ________ Date _________

1. What is erosion?

2. Using the words listed below, complete the following statement:

Deposition	Discharge
Divides	Erosion
Meanders	Salinization

As a general rule, ________________ occur(s) with fast moving water and

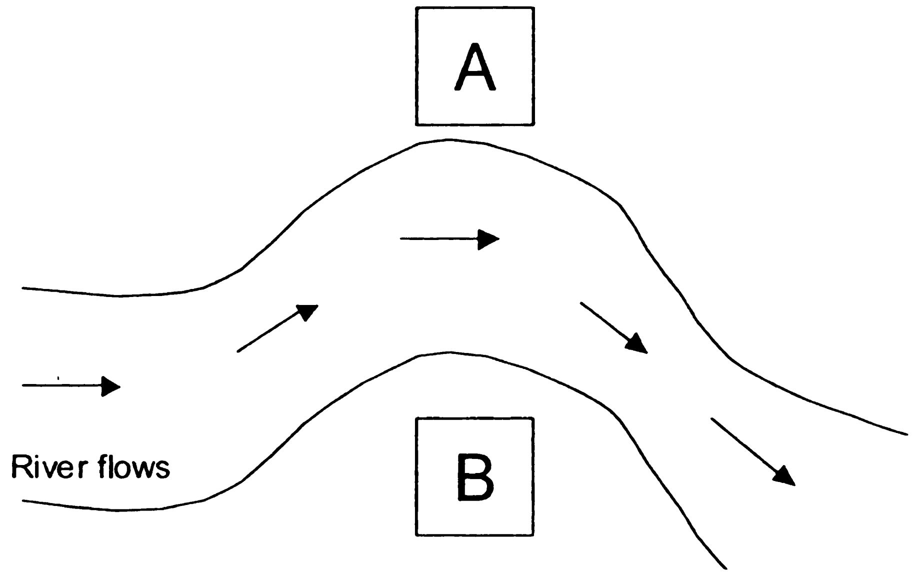
______________________ occur(s) with slower moving water.

3. The ability of a stream to transport sediment is determined by (check all that apply)
_______ A. velocity of the stream
_______ B. gradient of the stream
_______ C. amount of water
_______ D. amount of fish and aquatic organisms
_______ E. wind speed

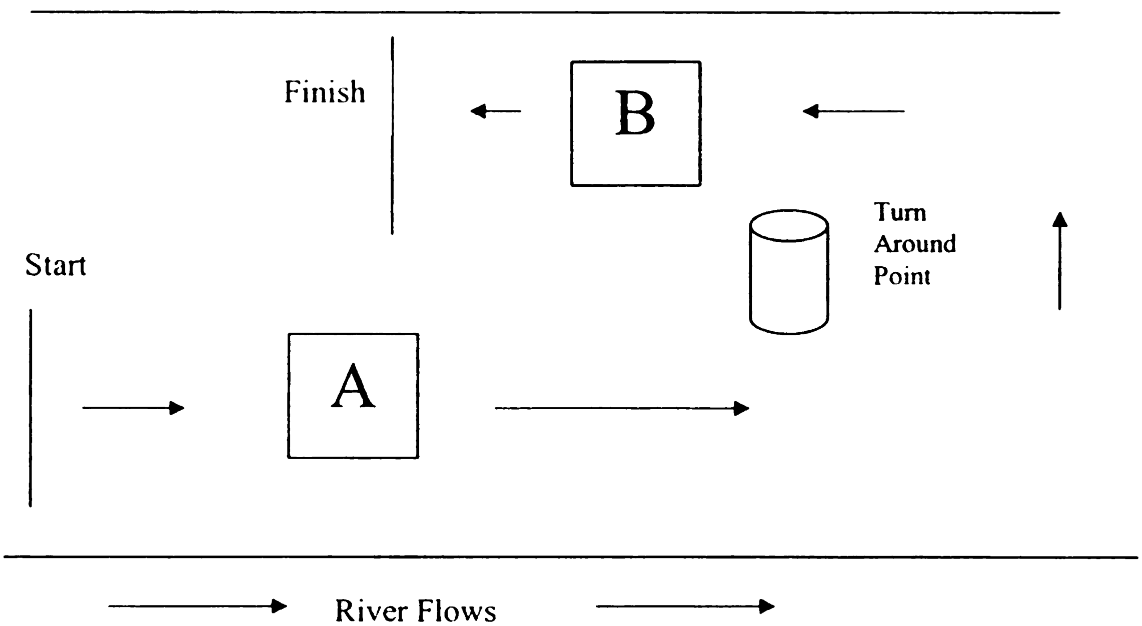
4. Describe 2 affects of a man made levee on a river.

5. Draw a side profile of a river and label the following parts:
   Banks
   Bed
   Channel
   Flood Plain

6. On the diagram of the stream below, circle the location you would build a house (A or B) and explain why you would build it there. Include in your answer what processes occur at the curves of a river and why.



7. You are in a canoe race. The course of the race is diagrammed below; it starts and travels downstream to a turn around point and then requires canoes to travel upstream to the finish line. Canoes in the race can travel at any location in the river. State your strategy for the points marked A and B, will you keep the canoe in the middle or near the banks and why?



Streams and Rivers Post Test

Name ______________________
Block ________ Date ________

1. Define erosion.

_____ 2. Which of the following are agents of erosion?
A. Animals B. Wind
C. Water D. Gravity
E. Glaciers F. B and C Only
G. All of the Above H. None of the Above

_____ 3. The term "watershed" refers to...?
A. the entire area that drains runoff into a stream.
B. a river and its banks.
C. the lake a river flows into.
D. the mouth of a river.

_____ 4. The continental divide separates a continent according to the ocean that the area on the divide drains into, in the U.S., the continental divide is the
A. Mississippi River
B. Rocky Mountains
C. Smoky Mountains
D. 30^{th} parallel

5. Using the words listed below, complete the following statement:

Deposition	Discharge
Divides	Erosion
Meanders	Salinization

As a general rule, ________________ occur(s) with fast moving water and

______________________ occur(s) with slower moving water.

6. The ability of a stream to transport sediment is determined by (check all that apply)
_______ A. velocity of the stream
_______ B. gradient of the stream
_______ C. amount of water
_______ D. amount of fish and aquatic organisms
_______ E. wind speed

Streams and Rivers Post Test

_____ 7. The fastest moving water in a straight portion of a stream is along the?
   A. Banks
   B. Levee
   C. Middle of the Channel
   D. Sides of the Channel

_____ 8. During annual flooding, the river overflows its channel and deposits sediments which
   A. Form a Natural Levee.
   B. Form Banks.
   C. Rejuvenates the flood plain soil.
   D. All of the above.

_____ 9. A fan shaped deposit of sediments where a river enters a lake or ocean is called a?
   A. Alluvial Fan
   B. Delta
   C. Sand Bar
   D. Oxbow Lake

10.

Formula:
Discharge = Channel Width (m) X Channel Depth (m) X Velocity (m/sec)

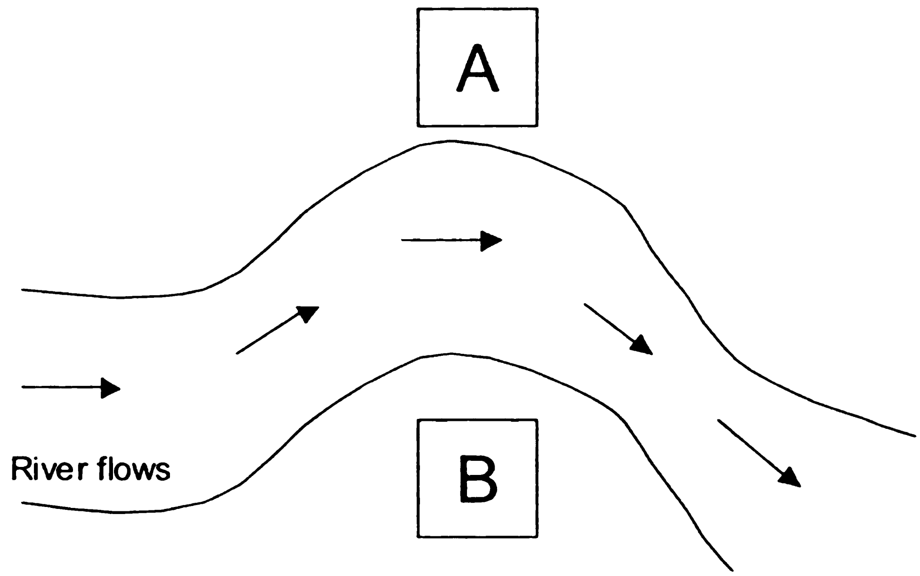
Calculate the discharge of a stream that is 50 meters wide, 20 meters deep with a velocity (speed) of 7 m/sec. Include units in your answer.

11. Describe 2 affects of a man made levee on a river.

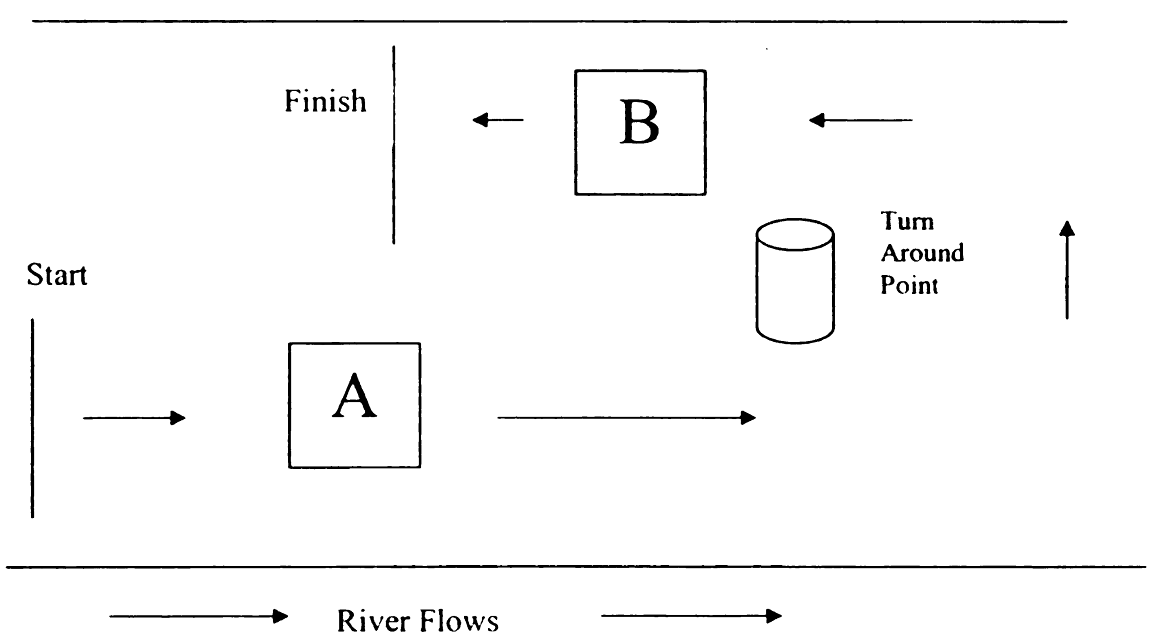
12. Draw a side profile of a river and label the following parts:
    Banks
    Bed
    Channel
    Flood Plain

Streams and Rivers Post Test

13. On the diagram of the stream below, circle the location you would build a house (A or B) and explain why you would build it there. Include in your answer what processes occur at the curves of a river and why.



14. You are in a canoe race. The course of the race is diagrammed below; it starts and travels downstream to a turn around point and then requires canoes to travel upstream to the finish line. Canoes in the race can travel at any location in the river. State your strategy for the points marked A and B, will you keep the canoe in the middle or near the banks and why?



Glaciers Pre-Test

Name ____________________
Block _______ Date _________

1. What are glaciers? (What do they look like? How big are they? Where are they found?) Write at least 5 Lines

2. Glaciers/Continental Ice Sheets once covered Michigan. Describe or draw labeled pictures of landforms found in Michigan that occur as a result of glaciers. Write at least 5 Lines

3. What is an Ice Age? Include in your answer factors that contribute to the occurrence of an ice age. Write at least 5 Lines

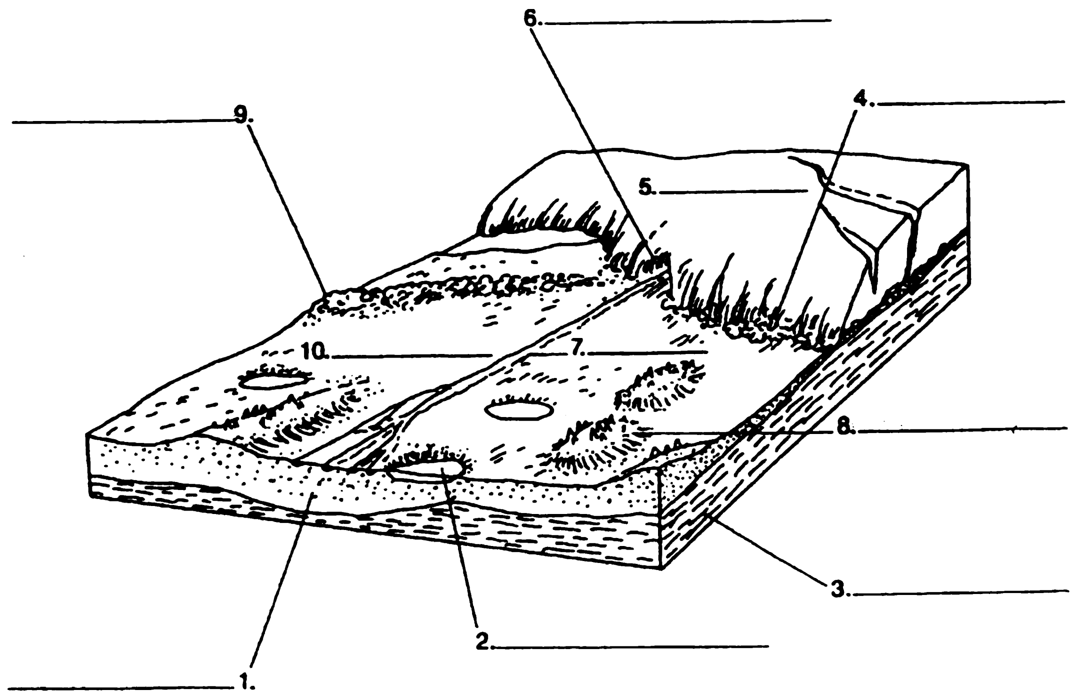
4. How would an increase in the amount of solar energy reaching the earth's surface most likely affect sea level along the coastline of the United States?

5: *Match the numbered item from the diagram to the correct feature.*

______ Kettle Lake

______ Drumlin

______ Moraine



Glacier Post Test

Name ____________________
Block ______ Date __________

Part 1: Matching: Match *the letter of the definition or description to the term listed.*

_______ 1. Aretes
_______ 2. Cirque
_______ 3. Drumlin
_______ 4. Erratic
_______ 5. Esker
_______ 6. Firn
_______ 7. Hanging Valley
_______ 8. Kames
_______ 9. Kettle
_______ 10. Moraines

A. Grainy ice created from the compacting of snow; gives the glacier a blue color.
B. A bowl shaped depression formed from a valley glacier pulling blocks of rock from the floor of a mountain valley.
C. A sharp jagged ridge between cirque. Can join to form a horn.
D. Creates a waterfall.
E. The shape of a valley after a glacier scrapes away the floor and walls of a V-shaped valley.
F. Streams of water flowing from the retreating, melting glacier.
G. Ridges of unsorted rock material on the ground or on the glacier.
H. Small hills of sand and gravel formed from out wash.
I. Long, narrow ridges of sand and gravel in the middle of a moraine. Formed from melt water streams flowing in tunnels along the bottom of the melting glacier.
J. A large depression resulting from a large ice block being left behind as a glacier recedes.
K. Long, low tear shaped mounds of till formed from the ice sheet molding ground moraine.
L. Material that has been sorted and layered by flowing melt water streams.
M. A mass of moving ice.
N. Boulders found in glacial till or lying free on the surface.

Part 2: Multiple Choice Place *the letter of the best choice on the line.*

______ 1. Basal Slip in a glacier occurs when water melted by the weight of the glacier acts as a lubricant between the glacier and the underlying rock.
A. True
B. False

______ 2. Ice flows faster along the sides of the glacier than the middle.
A. True
B. False

______ 3. The type of glacier that forms in mountainous areas is called a
A. Continental Ice Sheet
B. Valley Glacier

______ 4. Which of the following feature is NOT the result of Valley Glaciers?
A. Cirque
B. Aretes
C. Drumlin
D. Hanging Valley

______ 5. Which of the following features would have a layered or stratified deposition?
A. Drumlin
B. Moraine
C. Esker
D. Kettle

______ 6. Embedded material in a glacier may gouge long scratches and grooves called __________ in the bedrock as the ice passes over.
A. Striations
B. Crevasses
C. Moraines
D. Till

______ 7. Which of the following most likely caused large rock and gravel deposits near the Great Lakes?
A. Wind blown Sediments
B. Kettle Lakes
C. Rotation of the Earth
D. Retreating Glaciers

______ 8. Examination of fossils found in moraine rocks can yield misleading results if you assume that the fossils reveal the local biological history, Why?
A. The fossils will only be those of sea creatures.
B. The rock may have been moved a large distance.
C. The fossils will all be younger that the last ice age.
D. The rock will have an unusually folded sedimentation pattern.

______ 9. During Earth's history, changes in climate have caused
A. Periods of glaciation.
B. Shifting of tectonic plates.
C. Shifting of Earth's magnetic poles.
D. Periods of increased volcanic activity.

______10. A particular area has several gravel pits, which of the following is NOT a likely landform for the site of the gravel pit?

A. Kames
B. Eskers
C. Moraine

Part 3: Short Answer

1. What are glaciers? (What do they look like? How big are they? Where are they found?)

2. Glaciers/Continental Ice Sheets once covered Michigan. Describe or draw labeled pictures of landforms found in Michigan that occur as a result of glaciers. (Include at least 2)

3. What is an Ice Age? Include in your answer factors that contribute to the occurrence of an ice age.

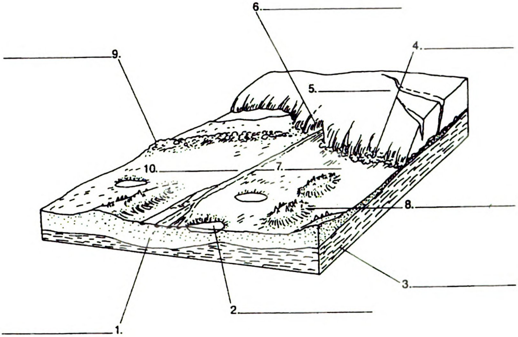
4. How would an increase in the amount of solar energy reaching the earth's surface most likely affect sea level along the coastline of the United States?

Part 4: *Match the numbered item from the diagram to the correct feature.*

______ Kettle Lake

______ Drumlin

______ Moraine



Reshaping the Crust: Weathering and Erosion
Student Survey

Rate each of the following activities used during this unit from 5 (Strongly Agree) to 1 (Strongly Disagree). Please include comments.

Activity Description	The activity was difficult; I didn't understand it.	The Activity helped me understand the material	Enjoyment – I liked the activity
Weathering			
• Concept Map and PowerPoint			
• Picture Assignment			
• Chemical Weathering Lab			
• Ice Wedging Demo and Mini Lab			
• Abrasion Mini Lab			
• Rates of Weathering Lab			
• Weathering Review Questions			
Soils			
• Soil Concept Map			
• Soil Profile Activity			
• Where is Alice Springs? Lab			
Streams			
• Stream Concept Map			
• Stream Table Activity			
• Nova Floods Video			
• Stream Review Questions			

Activity Description	The activity was difficult; I didn't understand it.	The Activity helped me understand the material	Enjoyment – I liked the activity
Glaciers			
• Glacier Vocabulary with Drawings and PowerPoint			
• Glacier Stream Table Simulation			
• Topographic Map Activity			
• Kettle Formation Mini Lab			
• Clay Striation Mini Lab			
• Pressure Melting Mini Lab			
• Sea Level Lab			
• Glacier Video			
• Glacier Review Questions			

Please answer each of the following.

1. What did you like the best about this unit?

2. What did you like the least about this unit?

3. Do you feel like the material was easy to learn and understand? Explain.

4. Do you like the use of concept maps versus traditional notes? Explain.

5. Did the use of drawings help you understand or remember the material? Explain.

6. Please provide any additional feedback or comments on the unit.

APPENDIX C

Weathering

A change in the physical form or chemical composition of rock materials exposed at the earth's surface.

2 types

Mechanical

Physically break rock into smaller pieces

Types

- **Exfoliation**
  Pressure release causing rocks to expand and crack.
- **Ice Wedging**
  Water seeps into cracks in a material, freezes and expands widening the crack
- **Organic Activity**
  Activity of plants and animals
- **Abrasion**
  Collision of rocks with one another

Chemical

Breaks rock down by changing its chemical composition

- **Hydrolysis**
  Material reacting with water
- **Carbonation**
  CO_2 from the air dissolves in water creating carbonic acid; speeds up the process of hydrolysis
- **Oxidation**
  Metallic elements combine with oxygen

Factors Affecting the Rate of Weathering:

- Rock Composition
- Amount of Time exposed and Surface Area
- Climate
- Topography

Mechanical Weathering Lab Name______________________________
Ice Wedging – Steel Flask Demonstration Block _________ Date ______________

Background

Mechanical weathering is the process of physically breaking rock into smaller pieces. A common kind of mechanical weathering is called ice wedging. Ice wedging occurs when water seeps into cracks or joints in rock and freezes. When the water freezes, its volume expands by about 10 percent, creating pressure on the rock. Every time the ice thaws and refreezes, it wedges farther into the rock, and the crack widens and deepens. This process eventually will split the rock apart increasing the amount of surface area exposed to other agents of weathering like wind and water.

Objective: To observe the effects of ice wedging mechanical weathering. To demonstrate that freezing water causes rock movement.

Materials:

- Galvanized Steel Flask
- Freezer
- Water

Procedure

1. Boil the water to remove any air. Let it cool.
2. Fill the flask completely with the water and seal it tightly.
3. Place the flask in the freezer.
4. Remove the flask after the water has frozen and observe the ends.

Conclusion

1A. Describe what happened to the steel flask.

B. Explain.

2. Explain how ice wedging forms pot holes on Michigan roads.

Mechanical Weathering Lab Name________________________________

Ice Wedging – Steel Flask Demonstration Block __________ Date _______________

ANSWER KEY

Background

Mechanical weathering is the process of physically breaking rock into smaller pieces. A common kind of mechanical weathering is called ice wedging. Ice wedging occurs when water seeps into cracks or joints in rock and freezes. When the water freezes, its volume expands by about 10 percent, creating pressure on the rock. Every time the ice thaws and refreezes, it wedges farther into the rock, and the crack widens and deepens. This process eventually will split the rock apart increasing the amount of surface area exposed to other agents of weathering like wind and water.

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Materials:

- Galvanized Steel Flask
- Freezer
- Water

Procedure

1. Boil the water to remove any air. Let it cool.
2. Fill the flask completely with the water and seal it tightly.
3. Place the flask in the freezer.
4. Remove the flask after the water has frozen and observe the ends.

Conclusion

1A. Describe what happened to the steel flask.

The flask split into two pieces and ice was spread out and embedded in the box it was in It appears that when it cracked open that the ice was ejected outward with force.

B. Explain.

When the water froze it expanded applying pressure to the inside of the flask with enough force to crack open the flask.

2. Explain how ice wedging forms pot holes on Michigan roads.

Mechanical – Ice Wedging
Water seeps into small cracks in the road when temperatures are above freezing. Later when the temperature drops below freezing, the water freezes and expands. It expands the crack and then later thaws. This creates a gap in the pavement. As heavy trucks travel over the pavement crumbles.

Acid Rain Demonstration

Goals: To demonstrate that sulfur oxides are a source of acid rain.

Background: Many areas in the United States rely on the burning of fossil fuels for their primary energy source. Car exhaust emits carbon dioxide in the atmosphere and burning low-grade coal, which contains sulfur impurities, releases sulfur oxides into the atmosphere. Both products combine with moisture in the air to form carbonic and sulfuric acid creating acid rain.

Materials:

- 1-liter glass flask
- Rubber stopper with a single hole
- Aim-n-Flame
- Bromcresol Purple Indicator
- 1 or 2 grams of Sulfur
- 200 – 300 ml Distilled Water
- 3 small beakers

Bromcresol Purple ph Indicator	
Yellow	5.5 or less
Purple	7.0 or greater

Procedure:

1. Set up the beakers as pH examples: acid, base and water. Add several drops of bromcresol purple indicator to each and place them on the overhead. The acid should be yellow, the base purple and water gray - purple.
2. Fill the 1-liter flask with approximately 200 ml of distilled water. Add several drops of bromcresol purple indicator. The solution should be purple.
3. Feed the handle of the deflagrating spoon through the hole in the stopper.
4. Scoop 1 to 2 grams of sulfur into the spoon and apply a flame to get the sulfur to burn.
5. Once the sulfur begins to glow and melt, place the spoon into the flask and secure the stopper on the top. Do not submerge the sulfur. Let it burn and release smoke. The smoke will contain sulfur.

Caution: Sulfur dioxide gas is poisonous. Use fume hood or make sure there is adequate ventilation.

6. After the sulfur has finished burning or the flask is filled with smoke, swirl the solution to dissolve the gas.
7. The solution should turn yellow.

* *It may be helpful to have a white paper behind the flask to make the color change more visible.*

* Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises. 47 pp.

Mechanical Weathering Lab Name________________________________
Abrasion Block __________ Date ________________

Background

Mechanical weathering is the process of physically breaking rock into smaller pieces. The collision of rocks with one another, resulting in the breaking and wearing away of the rocks, is a form of mechanical weathering called abrasion. Agents of abrasion include gravity, running water and wind. Gravity causes loose soil and rocks to move down the slope of a hill or mountain. Rocks break into smaller pieces as they fall and collide. Running water or wind also can carry particles of sand or rock. These particles scrape against each other and against other stationary rocks, thus abrading the exposed surfaces. The end result of abrasion is smooth rounded rocks.

There are several factors that contribute to the rate at which rock weathers including: rock composition, amount of exposure, climate and topography. The composition of rocks is a major factor in the rate of weathering. Often, igneous and metamorphic rocks on the earth's surface remain almost unchanged after all the surrounding sedimentary rock has weathered away. Of the minerals in igneous and metamorphic rock, quartz is the least affected by chemical weathering. Because quartz is one of the hardest minerals, it also resists mechanical weathering and retains its structure in tiny grains of sand. Among sedimentary rocks, limestone and other rocks containing calcite are most rapidly weathered. Although these rocks resist mechanical weathering, they are easily weathered by carbonation. Mainly mechanical weathering processes affect many other sedimentary rocks. The rate at which these rocks weather depends on the material that holds the fragments of the sediments together. For example, shales and sandstones that are not firmly cemented together gradually break up into clay and sand particles. However, conglomerates and those sandstones that are strongly cemented by silicates may resist weathering processes even longer than some igneous rocks.

Objective: To observe the effects of mechanical weathering by abrasion. To compare the weathering rates of different rock types.

Materials:

- 2 clear plastic containers with lids
- Several pieces of Sandstone
- Several pieces of Granite
- Water

Procedure:

1. Observe the samples of sandstone and granite. Note any sharp edges and the surface texture. Record on the data table.
2. Place the sandstone in one container and the granite in another.
3. Fill the containers 1/3 full of water and put the lid on tightly.

Adapted from Sager, Robert J., Ramsey, William L., Phillips, Clifford R., and Watenpaugh, Frank M. 1998. Modern Earth Science. Holt, Rinehart and Winston. 220 pp.

4. Shake the containers approximately 100 times in an up and down motion.
5. Gently pour the water and rocks through a strainer. Observe the surface of the rocks, feel the inside of the container and observe the appearance of the water. Record on the data table.

Data

Material	Appearance of rock before shaking	Appearance of rock after shaking	Appearance of water after shaking	Appearance and feel of the inside of the container
Granite				
Sandstone				

Conclusion Questions

1. Which material had the greatest amount of change? (circle your choice)
   a. Granite
   b. Sandstone

2. What type of rock is granite? (circle your choice)
   a. Igneous
   b. Metamorphic
   c. Sedimentary

3. What type of rock is Sandstone? (circle your choice)
   a. Igneous
   b. Metamorphic
   c. Sedimentary

4. Based on your observations, what type of rock is most resistant to weathering?
   a. Igneous
   b. Metamorphic
   c. Sedimentary

5. Describe the surface and shape of rocks after excessive abrasion.

Adapted from Sager, Robert J., Ramsey, William L., Phillips, Clifford R., and Watenpaugh, Frank M. 1998. Modern Earth Science. Holt, Rinehart and Winston. 220 pp.

Mechanical Weathering Lab
Abrasion ANSWER KEY

Name________________________________
Block __________ Date ______________

Background

Mechanical weathering is the process of physically breaking rock into smaller pieces. The collision of rocks with one another, resulting in the breaking and wearing away of the rocks, is a form of mechanical weathering called abrasion. Agents of abrasion include gravity, running water and wind. Gravity causes loose soil and rocks to move down the slope of a hill or mountain. Rocks break into smaller pieces as they fall and collide. Running water or wind also can carry particles of sand or rock. These particles scrape against each other and against other stationary rocks, thus abrading the exposed surfaces. The end result of abrasion is smooth rounded rocks.

There are several factors that contribute to the rate at which rock weathers including: rock composition, amount of exposure, climate and topography. The composition of rocks is a major factor in the rate of weathering. Often, igneous and metamorphic rocks on the earth's surface remain almost unchanged after all the surrounding sedimentary rock has weathered away. Of the minerals in igneous and metamorphic rock, quartz is the least affected by chemical weathering. Because quartz is one of the hardest minerals, it also resists mechanical weathering and retains its structure in tiny grains of sand. Among sedimentary rocks, limestone and other rocks containing calcite are most rapidly weathered. Although these rocks resist mechanical weathering, they are easily weathered by carbonation. Mainly mechanical weathering processes affect many other sedimentary rocks. The rate at which these rocks weather depends on the material that holds the fragments of the sediments together. For example, shales and sandstones that are not firmly cemented together gradually break up into clay and sand particles. However, conglomerates and those sandstones that are strongly cemented by silicates may resist weathering processes even longer than some igneous rocks.

Objective: To observe the effects of mechanical weathering by abrasion. To compare the weathering rates of different rock types.

Materials:

- 2 clear plastic containers with lids
- Several pieces of Sandstone
- Several pieces of Granite
- Water

Procedure:

1. Observe the samples of sandstone and granite. Note any sharp edges and the surface texture. Record on the data table.
2. Place the sandstone in one container and the granite in another.
3. Fill the containers 1/3 full of water and put the lid on tightly.
4. Shake the containers approximately 100 times in an up and down motion.

Adapted from Sager, Robert J., Ramsey, William L., Phillips, Clifford R., and Watenpaugh, Frank M. 1998. Modern Earth Science. Holt, Rinehart and Winston. 220 pp.

5. Gently pour the water and rocks through a strainer. Observe the surface of the rocks, feel the inside of the container and observe the appearance of the water. Record on the data table.

Data

Material	**Appearance of rock before shaking**	**Appearance of rock after shaking**	**Appearance of water after shaking**	**Appearance and feel of the inside of the container**
Granite	***Jagged Edges***	***Jagged Edges***	***Clear***	***Smooth***
Sandstone	***Edges***	***Smoothed Edges***	***Cloudy***	***Gritty***

Conclusion Questions

1. Which material had the greatest amount of change? (circle your choice)
   a. Granite
   b. Sandstone

2. What type of rock is granite? (circle your choice)
   a. Igneous
   b. Metamorphic
   c. Sedimentary

3. What type of rock is Sandstone? (circle your choice)
   a. Igneous
   b. Metamorphic
   c. Sedimentary

4. Based on your observations, what type of rock is most resistant to weathering?
   a. Igneous
   b. Metamorphic
   c. Sedimentary

5. Describe the surface and shape of rocks after excessive abrasion.
   Excessive abrasion results in smooth rounded rocks.

6. Where does abrasion occur on earth's surface?
   Abrasion occurs in moving bodies of water like streams and rivers. It also takes place in the ocean with wave action. Abrasion can also occur as rocks tumble down steep slopes.

Adapted from Sager, Robert J., Ramsey, William L., Phillips, Clifford R., and Watenpaugh, Frank M. 1998. Modern Earth Science. Holt, Rinehart and Winston. 220 pp.

Rates of Weathering Lab Name______________________________
Block __________ Date _______________

Background

The processes of weathering generally work very slowly. For example, carbonation dissolves limestone at an average rate of only about one twentieth of a centimeter every 100 years. At this rate, it could take up to 30 million years to dissolve a 150 m thick layer of limestone. There are several factors that contribute to the rate at which rock or material is weathered including: rock composition, amount of exposure, climate and topography.

The more exposure a rock receives to weathering processes, the faster it will weather. The amount of time the rock is exposed and the amount of surface area available for weathering are important factors. Weathering can only take place on the surface of the rock or material. Fractures and joints break most rocks at the surface of the earth. Fractures also form natural channels through which water flows. Water penetrates the rock through these channels and breaks the rock by ice wedging. These processes usually split the rocks into a number of smaller blocks exposing more of the rock. Fractures and joints increase the surface area of a rock and allow weathering to take place more rapidly.

In general, rainfall and the freezing and thawing produced by alternating hot and cold weather have the greatest effect on the rate of weathering. Climates in which variable weathering conditions exist can cause ice wedging fractures, which help to expose new rock surfaces. Chemical weathering then can attack the fractured rock more quickly. When temperatures raise daily or seasonally, the rate at which chemical reactions occur also accelerates. In hot, dry climates, weathering takes place slowly. The lack of water limits the rate of the many chemical and mechanical weathering processes associated with water, such as carbonation and ice wedging. Weathering is also slow in very cold climates. In warm, humid climates, chemical weathering is fairly rapid. The constant moisture and heat is highly destructive to exposed surfaces.

Objective: To observe the effects of temperature and surface area on the rate of chemical weathering.

Materials:

- 4 250 mL beakers
- 4 Antacid Tablets
- Hot Water
- Cold Water
- Mortar and Pestle
- 4 Stopwatches

Procedure:

1. Fill 2 of the beakers with 100 mL of hot water and 2 of the beakers with 100 mL of cold water.
2. Crush 2 of the antacid tablets using the mortar and pestle. Keep them separated.

3. Add a whole antacid tablet to one hot water beaker and one to the cold-water beaker. Add a crushed antacid tablet to one hot water beaker and the other crushed antacid tablet to the cold-water beaker. All antacid should be added simultaneously and the stopwatches started upon addition.
4. Stop timing when the tablet is fully dissolved. (You do not need to wait for all of the bubbling to stop; wait only for all pieces of the tablet to disappear.)
5. Record the time on the data table.
6. Rinse the contents of the beaker down the drain and thoroughly wash each beaker out.

Data

Beaker	Time (seconds)
Hot Water with Whole Tablet	
Cold Water with Whole Tablet	
Hot Water with Crushed Tablet	
Cold Water with Crushed Tablet	

Conclusion Questions

1. Which beaker dissolved the fastest?
2. Which beakers dissolved faster, the hot or cold? (circle your answer).
3. Based on your observations, what is the relationship between the temperature and the rate of natural chemical weathering reactions?
4. Which beakers dissolved faster, the whole or crushed tablets? (circle your answer)
5. Which tablet had more surface area, the whole or crushed tablets? (circle your answer)
6. Based on your observations, what is the relationship between the amount of surface area and the rate of natural chemical weathering reactions

Application Questions

1. Why does fractured rock weather more rapidly than smooth rock?
2. Compare the rate of weathering of a marble statue in Florida versus Alaska?

3. Michigan has a Humid Continental Climate. Areas with this type of climate are subject to both cold, dry continental polar air masses and warm, moist maritime tropical air masses. Write a short paragraph describing the connection to weathering in Michigan and its climate. Include the following information in your answer.
   a) Explain what type of weathering occurs during fall and spring as temperatures fluctuate around freezing.
   b) How does this impact chemical weathering?
   c) Explain how the moist, hot summer months contribute to the rate of chemical weathering.

Rates of Weathering Lab
ANSWER KEY

Name________________________________
Block __________ Date _______________

Background

The processes of weathering generally work very slowly. For example, carbonation dissolves limestone at an average rate of only about one twentieth of a centimeter every 100 years. At this rate, it could take up to 30 million years to dissolve a 150 m thick layer of limestone. There are several factors that contribute to the rate at which rock or material is weathered including: rock composition, amount of exposure, climate and topography.

The more exposure a rock receives to weathering processes, the faster it will weather. The amount of time the rock is exposed and the amount of surface area available for weathering are important factors. Weathering can only take place on the surface of the rock or material. Fractures and joints break most rocks at the surface of the earth. Fractures also form natural channels through which water flows. Water penetrates the rock through these channels and breaks the rock by ice wedging. These processes usually split the rocks into a number of smaller blocks exposing more of the rock. Fractures and joints increase the surface area of a rock and allow weathering to take place more rapidly.

In general, rainfall and the freezing and thawing produced by alternating hot and cold weather have the greatest effect on the rate of weathering. Climates in which variable weathering conditions exist can cause ice wedging fractures, which help to expose new rock surfaces. Chemical weathering then can attack the fractured rock more quickly. When temperatures raise daily or seasonally, the rate at which chemical reactions occur also accelerates. In hot, dry climates, weathering takes place slowly. The lack of water limits the rate of the many chemical and mechanical weathering processes associated with water, such as carbonation and ice wedging. Weathering is also slow in very cold climates. In warm, humid climates, chemical weathering is fairly rapid. The constant moisture and heat is highly destructive to exposed surfaces.

Objective: To observe the effects of temperature and surface area on the rate of chemical weathering.

Materials:

- 4 250 mL beakers
- 4 Antacid Tablets
- Hot Water
- Cold Water
- Mortar and Pestle
- 4 Stopwatches

Procedure:

1. Fill 2 of the beakers with 100 mL of hot water and 2 of the beakers with 100 mL of cold water.
2. Crush 2 of the antacid tablets using the mortar and pestle. Keep them separated.

3. Add a whole antacid tablet to one hot water beaker and one to the cold-water beaker. Add a crushed antacid tablet to one hot water beaker and the other crushed antacid tablet to the cold-water beaker. All antacid should be added simultaneously and the stopwatches started upon addition.
4. Stop timing when the tablet is fully dissolved. (You do not need to wait for all of the bubbling to stop; wait only for all pieces of the tablet to disappear.)
5. Record the time on the data table.
6. Rinse the contents of the beaker down the drain and thoroughly wash each beaker out.

Data

Beaker	Time (seconds)
Hot Water with Whole Tablet	
Cold Water with Whole Tablet	
Hot Water with Crushed Tablet	
Cold Water with Crushed Tablet	

Conclusion Questions

1. Which beaker dissolved the fastest?
   Hot, Crushed
2. Which beakers dissolved faster, the ***hot*** or cold? (circle your answer).
3. Based on your observations, what is the relationship between the temperature and the rate of natural chemical weathering reactions?
   Hotter temperatures have faster chemical weathering reactions.
4. Which beakers dissolved faster, the whole or ***crushed tablets***? (circle your answer)
5. Which tablet had more surface area, the whole or ***crushed tablets***? (circle your answer)
6. Based on your observations, what is the relationship between the amount of surface area and the rate of natural chemical weathering reactions
   Greater amount of surface area has faster chemical weathering reactions.

Application Questions

1. Why does fractured rock weather more rapidly than smooth rock?
   More surface area. The water can seep into the fractures. It can become even more fractured if there is freezing and thawing resulting in ice wedging.
2. Compare the rate of weathering of a marble statue in Florida versus Alaska?
   It would weather faster in Florida where the weather is warmer, more humid and experiences more rainfall.

3. Michigan has a Humid Continental Climate. Areas with this type of climate are subject to both cold, dry continental polar air masses and warm, moist maritime tropical air masses. Write a short paragraph describing the connection to weathering in Michigan and its climate. Include the following information in your answer.
   a) Explain what type of weathering occurs during fall and spring as temperatures fluctuate around freezing.
   b) How does this impact chemical weathering?
   c) Explain how the moist, hot summer months contribute to the rate of chemical weathering.

   (a) Michigan experiences temperatures which fluctuate around freezing in late fall and early spring. These temperature changes result in ice wedging. When temperatures are mild, water can seep into small fractures. Later when the temperature drops and the water freezes it expands which widens the fracture. Eventually, the object (rock, concrete, etc.) will be in smaller pieces.

   (b) Chemical weathering can only occur on the surface. By increasing the amount of surface area, chemical weathering will occur quickly. Larger objects broken into smaller pieces has more surface exposed (more surface area).

   (c) Michigan also experiences hot, humid conditions in the summer. Hot temperatures accelerate chemical weathering. The humidity and rainfall also provides the water for chemical weathering to occur with.

Chemical Weathering

Name ________________
Block ______ Date ______

The process of weathering changes the landscape and material around you. Mechanical and Chemical weathering work together to break down materials and alter their chemical composition. Chemical weathering occurs when chemical reactions take place between the minerals in the rock or material and water, carbon dioxide, oxygen and acids. These chemical reactions alter the internal structure of the original mineral and lead to the formation of new minerals. As a result, both the chemical composition and the physical appearance of the rock or material undergo changes.

Not all rocks and materials are affected by chemical weathering in the same way. Some rock materials are more susceptible to the agents of chemical weathering. Water plays a crucial role in chemical weathering and an acidic solution enhances the effects of hydrolysis. Carbonic acid is naturally produced in the environment by the combination of Carbon Dioxide gas in the air dissolving in water. Natural rainfall is also naturally acidic. Human activities can exaggerate the formation of acidic rainfall by emitting more carbon dioxide and sulfur into the air.

The purpose of this lab activity is to evaluate how different materials are affected by chemical weathering. It will also allow a comparison between water and acid on the weathering rate. The water is also a control for the experiment.

Purpose: To observe the effects of chemical weathering on common building materials and objects and to compare the effects of chemical weathering of water and acid.

Materials:
- Small cups
- Distilled Water
- pH Paper
- Galvanized and Non-Galvanized Nails
- Various Metals: Aluminum, Steel Wool, Copper
- Vinegar
- Saran Wrap
- Mass Balance
- Different Rock Types: Limestone, Granite, Concrete
- * Object of Student Choices (suggestions: Aluminum Siding Painted Wood)

Procedure

** You will have two complete sets of materials. One set in distilled water and the other in vinegar. You will need to know the pH of the water and vinegar and the mass of each object. This initial information will be recorded on the data table.*

1. Collect the various materials that you will be testing. Describe the physical appearance of the material on the data table. You may include color, texture, size and shape.
2. Mass each piece individually and record the mass on the data table. Be sure to keep the material placed in water separate than those placed in vinegar.

Adapted from Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises.

3. Measure the pH of the water and vinegar and record on the data table.
4. Place the materials individually in small cups. Add enough water to one set to cover the objects and acid to the other set.
5. Cover all the cups with saran wrap and place on a tray with the group members' names on them.
6. Let the cups sit for 24-48 hours.
7. Carefully remove the materials from the cups and place them on paper towel to dry. Observe their appearance and the appearance of the water and acid. Did they change color, texture? Is the water or acid cloudy or have small particles in them?
8. Measure the pH of the water and vinegar from each cup and record on the data table.
9. Once the objects are dry, mass them and record their mass on the data table.
10. Label a piece of paper towel as water and another piece as acid. Place the objects that were in the water on the appropriate towel and those in acid on the other towel. Leave the objects exposed to the air over night.
11. Empty and rinse out the cups and materials.

Adapted from Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises.

Conclusion Questions

1. Compare the objects placed in the water, did any of them show signs of change? If so, which ones?____
2. Compare the objects placed in the acid, did any of them show signs of change? If so, which ones?____
3. Compare the affects observed between objects placed in water and those placed in acid. Which had the greatest impact on the objects? ____________________

   ____
4. Did the pH change after any of the objects were placed and left in the solution? If so, which ones? ____
   a. How can you explain the change in pH? ___________________________

      ____
5. Did the mass of any of the objects change after being placed and left in the solution? If so, which ones? ____
   a. How can you explain the loss of mass? ____________________________

   ____
6. This lab simulates the affect of acid on the chemical weathering of objects; provide a source in the environment that exposes objects to acid? ____________________

   ____
7. Compare the water objects exposed to air, did any of them show signs of change? If so, which ones?____
8. Compare the acid objects exposed to air, did any of them show signs of change? If so, which ones?____
9. What form of chemical weathering affected objects exposed to air?

   ____
10. Based on your results, write a conclusion relating water, acid and oxygen to the weathering of objects. _______________________________________

    ____

    ____

    ____

Adapted from Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises.

Application Questions

11. The materials tested in this lab are common building materials, which metal (copper, aluminum, steel (steel wool and nails) is the most resistant to chemical weathering? Identify a use for that metal in building a house? ______________________________

____

12. Why are steel nails galvanized? ______________________________________

____

13. You are consulted on whether a limestone building or a quartzite building would better withstand the effects of acid rain. What would you recommend and why?

____

____

14. Which do you think would weather faster, a sculpted marble statue or a smooth marble column? Explain your answer. (Hint: Marble is a metamorphic rock formed from the compression of Limestone) ______________________________________

____

15. Pollution occurring in the Lower Peninsula of Michigan travels up into the atmosphere and moves over parts of Canada and the Upper Peninsula causing acid rain to fall in isolated areas. Many lakes have a highly acidic pH and it is decreasing the fish populations found in these lakes. An extensive study of lakes found most to have a highly acidic pH. Several lakes surrounding a limestone quarry were found to have a neutral pH. How can you explain these findings? ______________________

____

16. Explain why bridges are painted. ______________________________________

____

Adapted from Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises.

Physical Appearance Data Table

Material	Describe the physical appearance....				
	Before placing the object in solution	The object and solution in Water	The object and solution in Acid	The water object exposed to air	The acid object exposed to air
Galvanized Steel Nail					
Non-Galvanized Steel Nail					
Aluminum					
Copper					
Steel Wool					
Limestone					
Granite					
Concrete					
Student Choice:					

Adapted from Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises.

pH and Mass Data Table for Objects Placed in Water

Material	Initial pH	Final pH	Initial Mass	Final Mass	Change in Mass
Galvanized Steel Nail					
Non-Galvanized Steel Nail					
Aluminum					
Copper					
Steel Wool					
Limestone					
Granite					
Concrete					
Student Choice:					

Adapted from Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises.

pH and Mass Data Table for Objects Placed in Acid

Material	Initial pH	Final pH	Initial Mass	Final Mass	Change in Mass
Galvanized Steel Nail					
Non-Galvanized Steel Nail					
Aluminum					
Copper					
Steel Wool					
Limestone					
Granite					
Concrete					
Student Choice:					

Adapted from Person, Jane L. 1989. Environmental Science Investigations. J.M. LeBel Enterprises.

Chemical Weathering Answer Key and Teacher Notes

Materials:

- Small cups
- Distilled Water
- pH Paper
- Galvanized and Non-Galvanized Nails
- Various Metals: Aluminum, Steel Wool, Copper

Aluminum Foil is fine

- Vinegar
- Saran Wrap
- Mass Balance
- Different Rock Types: Limestone, Granite, Concrete

The rocks can be purchased at a Landscape company (Hammond Farms)

- * Object of Student Choices

Suggestions: Aluminum Siding and/or Painted Wood

Conclusion Questions

1. Compare the objects placed in the water, did any of them show signs of change? If so, which ones?

   Yes, the galvanized and non-galvanized nails. The water was cloudy from the Limestone and Concrete.

2. Compare the objects placed in the acid, did any of them show signs of change? If so, which ones?

   Yes, the galvanized and non-galvanized nails, the copper, and steel wool. The acid was cloudy from the limestone and concrete.

3. Compare the affects observed between objects placed in water and those placed in acid. Which had the greatest impact on the objects?

   The acid caused a more noticeable change on the objects.

4. Did the pH change after any of the objects were placed and left in the solution? If so, which ones? *The Limestone and Concrete*

   a. How can you explain the change in pH? *Limestone and concrete react and neutralize the acid.*

5. Did the mass of any of the objects change after being placed and left in the solution? If so, which ones? *Yes, the Limestone and Concrete.*

   a. How can you explain the loss of mass? *The mass is lost to the particles left behind in the solution as the acid and water start to cause the limestone and concrete to disintegrate.*

6. This lab simulates the affect of acid on the chemical weathering of objects; provide a source in the environment that exposes objects to acid? *Acid Rain*

7. Compare the water objects exposed to air, did any of them show signs of change? If so, which ones? *Answers may vary depending on the degree of detail noted. The steel wool should show some discoloration and possibly the nails.*

8. Compare the acid objects exposed to air, did any of them show signs of change? If so, which ones? *The steel wool is discolored (rust), the aluminum foil has several black spots, the nails are discolored (rust) and the copper has some green discoloration.*

9. What form of chemical weathering affected objects exposed to air? *Oxidation*

10. Form a conclusion statement relating your weathering with water or acid and air. *Acid had a greater affect on the weathering of materials and exaggerated the effects of oxidation.*

Application Questions

11. The materials tested in this lab are common building materials, which metal (copper, aluminum, steel (steel wool and nails) is the most resistant to chemical weathering? Identify a use for that metal in building a house? *Aluminum is the most resistant. It is used to make aluminum siding. Copper is also fairly resistant and is used for wiring and sometimes for decorative roofing. Copper used in this way does discolor with exposure to rain and air.*

12. Why are steel nails galvanized? *To help protect the steel from rusting.*

13. You are consulted on whether a limestone building or a quartzite (component granite) building would better withstand the effects of acid rain. What would you recommend and why? *In this activity, granite showed no change and is therefore the best building material for an area that has a lot of rain. It is most resistant to weathering.*

14. Which do you think would weather faster, a sculpted marble statue or a smooth marble column? Explain your answer. (Hint: Marble is a metamorphic rock formed from the compression of Limestone) *The sculpted marble statue would weather faster because the sculpting increases the surface area or amount exposed to the elements of weathering. Weathering only occurs on the surface.*

15. Pollution occurring in the Lower Peninsula of Michigan travels up into the atmosphere and moves over parts of Canada and the Upper Peninsula causing acid rain to fall in isolated areas. Many lakes have a highly acidic pH and it is decreasing the fish populations found in these lakes. An extensive study of lakes found most to have a highly acidic pH. Several lakes surrounding a limestone quarry were found to have a neutral pH. How can you explain these findings? *The limestone in the soil neutralizes the acid rain.*

16. Explain why bridges are painted. *Bridges are painted to help protect the steel beams and concrete (or wood) from the effects of rain and air. It is used to slow the weathering process.*

Answers on Data Table

**Answers will vary on physical descriptions, some sample data is given. The pH and mass will only change with the acid and limestone and the acid and concrete. In a trial run of the lab, the pH of the vinegar was 3 before addition to the cups and a 5 after 24 hours. If you are short time to complete the lab, students can mass only the limestone and concrete.*

Physical Appearance Data Table

Material	Describe the physical appearance….				
	Before placing the object in solution	**The object and solution in Water**	**The object and solution in Acid**	**The water object exposed to air**	**The acid object exposed to air**
Galvanized Steel Nail	*Frosty Gray*	*Not as frosted; rust mark in the cup*	*Very little frosted covering left; no marks in the container.*	*No change.*	*The nail is rusted*
Non-Galvanized Steel Nail	*Plain Gray*	*Some discoloration upon drying*	*Some discoloration*	*Small amount of rust.*	*Rust present*
Aluminum	*Shiny, silver*	*No Change*	*No Change*	*No change*	*Black spots*
Copper	*Shiny copper color*	*No change*	*No Change*	*Some green discoloring*	*Some green discoloring*
Steel Wool	*Gray and Wirey*	*Small color change; water yellow*	*Disintegrating; lots of small pieces floating*	*Some rust formation*	*Almost all rust and disintegrating*
Limestone	*Crème Color*	*No change on the surface; particles in water*	*No change on the surface; lots of particles in acid*	*No change*	*No change*
Granite	*Pink and Gray crystals*	*No change*	*No change*	*No change*	*No change*
Concrete	*White, chalky color*	*No change on surface; small particles in water*	*Surface has exposed crystals; particals and bubbles in acid*	*No Change*	*No Change*
Student Choice:					

Weathering Identification

Name ________________
Block ______ Date _______

1. List the 4 Types of Mechanical Weathering:

2. List the 3 Types of Chemical Weathering

Indicate what type of weathering is related to each of the following:

____________________A. creates rounded, smooth shaped rocks

____________________B. rock cracking and forming layers like an onion

____________________C. creates pot holes

____________________D. tree roots

____________________E. freezing and thawing

____________________F. wearing and grinding of rock surfaces by collisions with others

____________________G. large trees can cause cracks in sidewalks

____________________H. main cause for large accumulations of rocks at the base of a cliff or mountain

____________________I. caused by pressure release

____________________J. moles

____________________K. rust on your car

____________________L. old tombstones that are discolored and hard to read because the rock has slowly washed away

____________________M. caves

Weathering Identification
ANSWER KEY

Name ________________
Block ______ Date _______

1. List the 4 Types of Mechanical Weathering:
   Abrasion, Ice Wedging, Organic, Exfoliation

2. List the 3 Types of Chemical Weathering
   Hydrolysis, Carbonation, Oxidation

Indicate what type of weathering is related to each of the following:

Abrasion A. creates rounded, smooth shaped rocks

Exfoliation B. rock cracking and forming layers like an onion

Ice Wedging C. creates pot holes

Organic Activity D. tree roots

Ice Wedging E. freezing and thawing

Abrasion F. wearing and grinding of rock surfaces by collisions with others

Organic Activity G. large trees can cause cracks in sidewalks

Ice Wedging H. main cause for large accumulations of rocks at the base of a cliff or mountain

Exfoliation I. caused by pressure release

Organic Activity J. moles

Oxidation K. rust on your car

Hydrolysis and Carbonation L. old tombstones that are discolored and hard to read because the rock has slowly washed away

Hydrolysis and Carbonation M. caves

Weathering Review Questions

Name ________________

Block _____ Date ________

Directions: Circle the letter of the best choice to complete each question or statement.

1. This type of weathering alters the chemical composition of the material?
    a. Chemical Weathering
    b. Mechanical Weathering

2. This type of weathering physically breaks the rocks into smaller pieces?
    a. Chemical Weathering
    b. Mechanical Weathering

3. This type of weathering is the result of water seeping into cracks and expanding as it freezes?
    a. Abrasion
    b. Exfoliation
    c. Ice Wedging
    d. Organic Activity

4. This type of weathering is the mechanical wearing and grinding of rock surfaces by friction and impact with other rocks?
    a. Abrasion
    b. Exfoliation
    c. Ice Wedging
    d. Organic Activity

5. The end result of this type of weathering is rocks that have a rounded appearance?
    a. Abrasion
    b. Exfoliation
    c. Ice Wedging
    d. Organic Activity

6. The substances that are mainly responsible for chemical weathering in nature are water, carbon dioxide and...?
    a. Oxygen
    b. Nitrogen
    c. Hydrochloric Acid
    d. Frost

7. Which of the following forms acid rain?
    a. Carbon dioxide combining with water vapor in the atmosphere
    b. the burning of sulfur
    c. nitrogen oxides
    d. all of the above
    e. none of the above

8. Acid weathers objects more effectively than water.
    a. True
    b. False

9. Metallic elements combining with oxygen....
    a. is Oxidation.
    b. forms rust.
    c. is a form of chemical weathering.
    d. all of the above
    e. none of the above

10. Which of the following does <u>not</u> affect the rate of weathering?
    a. Amount of Surface Area
    b. Amount of Time Exposed
    c. Climate
    d. Density
    e. Rock Composition
    f. Topography

Short Answer and Fill in the Blank

11. _________________________ is a change in the physical form or chemical composition of rock materials exposed at the earth's surface.

12. Why does a whole piece of limestone remain intact longer than a crushed piece of limestone?

13. Compare the difference of a 50-year-old highway running through the desert versus a humid continental climate like Florida. (Hint: What ~~a~~effect does a dry warm climate have on the rates of weathering? What affect does a humid, hot climate have on the rates of weathering?)

14. The following are the end result of weathering. Identify the type of weathering and explain how each formed.
    a. Rust on your car

    b. Round, smooth rocks

Weathering Assignment

Name ____________________
Block ______ Date ________

DUE DATE ______________________

The purpose of this assignment is to document examples of weathering found in our area.

Types of Weathering
Mechanical Weathering:

- Exfoliation
- Ice Wedging
- Organic Activity
- Abrasion

Chemical Weathering

- Hydrolysis
- Carbonation
- Oxidation

Option 1: Photographs
You will need to take pictures of 4 examples of the 7 types of weathering. The pictures will need to be attached to a sturdy piece of paper and labeled as to which type of weathering is illustrated in the photo. It will also need to include a location of where the picture was taken.

Option 2: Videotape
You will need to take video footage of 4 examples of the 7 types of weathering. The video will need to be narrated and include information of the location of the example and what type of weathering is illustrated.

Option 3: Pictures
You will need to provide pictures of 3 of the 4 types of mechanical weathering examples and 2 of the 3 types of chemical weathering. The pictures will need to be attached to a sturdy piece of paper and labeled as to which type of weathering is illustrated in the photo. It will also need to include a location of where the picture was taken. Possible sources for the pictures include the Internet (provide the internet address for each and the location on earth if given) or magazines (provide the magazine name and issue for each and the location on earth if given).

Ideas discussed in class:

Weathering Picture Assignment **Name** ____________________
Grading Criteria

Option 1: Photographs
You will need to take pictures of 4 examples of the 7 types of weathering. The pictures will need to be attached to a sturdy piece of paper and labeled as to which type of weathering is illustrated in the photo. It will also need to include a location of where the picture was taken.

Photograph 1 – Type of Weathering illustrated ___________________________
______ Photograph illustrating a type of weathering (2 point)
______ Photo is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location photograph was taken (1 point)

Photograph 2 – Type of Weathering illustrated ___________________________
______ Photograph illustrating a type of weathering (2 point)
______ Photo is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location photograph was taken (1 point)

Photograph 3 – Type of Weathering illustrated ___________________________
______ Photograph illustrating a type of weathering (2 point)
______ Photo is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location photograph was taken (1 point)

Photograph 4 – Type of Weathering illustrated ___________________________
______ Photograph illustrating a type of weathering (2 point)
______ Photo is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location photograph was taken (1 point)

_______TOTAL (20 points)

Weathering Picture Assignment **Name** ____________________
Grading Criteria

Option 2: Videotape
You will need to take video footage of 4 examples of the 7 types of weathering. The video will need to be narrated and include information of the location of the example and what type of weathering is illustrated.

Scene 1 – Type of Weathering illustrated ____________________________
______ Video footage illustrating a type of weathering (2 point)
______ Footage is correctly narrated with the type of weathering illustrated; includes a description (2 points)
______ Location footage was taken (1 point)

Scene 2 – Type of Weathering illustrated ____________________________
______ Video footage illustrating a type of weathering (2 point)
______ Footage is correctly narrated with the type of weathering illustrated; includes a description (2 points)
______ Location footage was taken (1 point)

Scene 3 – Type of Weathering illustrated ____________________________
______ Video footage illustrating a type of weathering (2 point)
______ Footage is correctly narrated with the type of weathering illustrated; includes a description (2 points)
______ Location footage was taken (1 point)

Scene 4 – Type of Weathering illustrated ____________________________
______ Video footage illustrating a type of weathering (2 point)
______ Footage is correctly narrated with the type of weathering illustrated; includes a description (2 points)
______ Location footage was taken (1 point)

_______TOTAL (20 points)

Weathering Picture Assignment **Name ____________________**
Grading Criteria

Option 3: Pictures

You will need to provide pictures of 3 of the 4 types of mechanical weathering examples and 2 of the 3 types of chemical weathering. The pictures will need to be attached to a sturdy piece of paper and labeled as to which type of weathering is illustrated in the photo. It will also need to include a location of where the picture was taken. Possible sources for the pictures include the Internet (provide the internet address for each and the location on earth if given) or magazines (provide the magazine name and issue for each and the location on earth if given).

Picture 1 – Type of Weathering illustrated ___________________________

______ Picture illustrating a type of weathering (1 point)
______ Picture is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location picture was taken (web address) (1 point)

Picture 2 – Type of Weathering illustrated ___________________________

______ Picture illustrating a type of weathering (1 point)
______ Picture is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location picture was taken (web address) (1 point)

Picture 3 – Type of Weathering illustrated ___________________________

______ Picture illustrating a type of weathering (1 point)
______ Picture is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location picture was taken (web address) (1 point)

Picture 4 – Type of Weathering illustrated ___________________________

______ Picture illustrating a type of weathering (1 point)
______ Picture is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location picture was taken (web address) (1 point)

Picture 5 – Type of Weathering illustrated ___________________________

______ Picture illustrating a type of weathering (1 point)
______ Picture is correctly labeled with the type of weathering illustrated; includes a description (2 points)
______ Location picture was taken (web address) (1 point)

_______TOTAL (20 points)

Soil

Layers

From Top to Bottom

Humus
Decaying remains of plants and animals; dark, organic material

Soil
A complex mixture of minerals, water, gases, and the remains of dead organisms.

Regolith
A layer of weathered rock fragments covering earth's surface

Bedrock
Solid, unweathered rock

Profile

A cross section in which layers of the soil and bedrock can be seen.

*Soil that rests on top of its parent rock develops distince layers

3 Principle Horizons (layers)

- A – Topsoil
- B – SubSoil
- C – Partially Weathered Bedrock

*Transported soils do not have horizons. They are deposited in sorted layers or unsorted masses.

3 Main Types:

- Clay
- Sand
- Silt

* Amounts determined by the Parent Rock

Leaching

Process by which water carries dissolved minerals to lower layers of rock

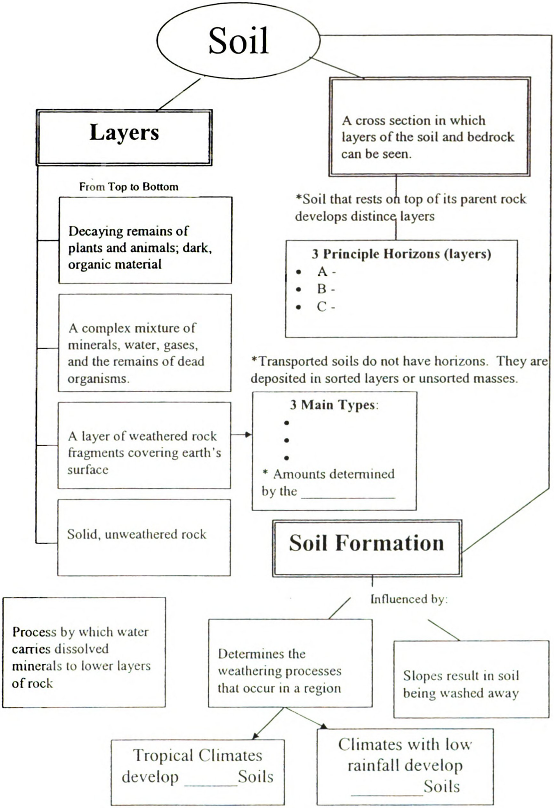
Soil Formation

Influenced by:

Climate
Determines the weathering processes that occur in a region

- Tropical Climates develop Thick Soils
- Climates with low rainfall develop Thin Soils

Topography
Slopes result in soil being washed away


Soil
Layers
From Top to Bottom
Decaying remains of plants and animals; dark, organic material
A complex mixture of minerals, water, gases, and the remains of dead organisms.
A layer of weathered rock fragments covering earth's surface
Solid, unweathered rock
A cross section in which layers of the soil and bedrock can be seen.
*Soil that rests on top of its parent rock develops distince layers
3 Principle Horizons (layers)
A -
B -
C -
*Transported soils do not have horizons. They are deposited in sorted layers or unsorted masses.
3 Main Types:
* Amounts determined by the ________
Soil Formation
Influenced by:
Process by which water carries dissolved minerals to lower layers of rock
Determines the weathering processes that occur in a region
Slopes result in soil being washed away
Tropical Climates develop ______ Soils
Climates with low rainfall develop ________ Soils

Where is Alice Springs?
Soil Lab

Name ______________________________
Block __________ Date _____________

Introduction

Soil is a complex mixture of various size mineral grains from the weathering of rock, and organic material from the decay of vegetation and animals. The proportion of sand, silt, clay and organic matter determines a soil's properties. For example, at one extreme, there is sand, the end result of chemical and physical weathering. At the other end, slow anaerobic decomposition of vegetative matter forms a dark organic soil, such as found in swamps and bogs. The composition of soil varies from place to place, and is controlled by five important factors: climate, parent material, living organisms, topography and time.

The prevalence of soil and the fact that it is easily and inadvertently transferred can make it valuable as forensic evidence. For example, samples of soil and mud can provide associations between a suspect's car, clothing, shoes or other instruments used at a crime scene. As with most forensic physical evidence, the tests are comparative in order to determine a common origin.

There are many characteristics of soils that can be described without sophisticated instrumentation. We will be looking at general appearance under the stereomicroscope, color, acidity, particle size, and density.

Crime Scenario

Thursday, July 18 at 9:38 am: The Springdale County Police received a call from a Mrs. Marshall who was concerned with the whereabouts of her friend, Alice Springs. She was to have had lunch with her the day before, but Alice never showed up. She called her house, but there was no answer. That evening, she called again. Mr. Springs curtly related that Alice's mother was ill and she had gone to Florida to visit her. This was not like Alice, just to leave, without telling her best friend.

The next morning, Mrs. Marshall called their hairdresser since she knew Alice had an early morning appointment. Alice had not appeared and had not called to cancel. This prompted Mrs. Marshall to call the police.

The County Police had received over the years a number of domestic violence complaints about the Springs. Indeed, Alice had appeared bruised and cut on several occasions. No charges were ever pressed, however.

The police stopped by the Springs' house in Martinsville that evening. Rusty Springs brusquely repeated that his wife had left Wednesday to visit her sick mother in Florida and he didn't know when she would be back.

Saturday, July 20 at 11:41 am: After hours of searching, Detective Chernozem found Alice's mother's phone number in Orlando and called her. She stated that Alice was not there and that she was quite well, thank you! A call to the County Seat produced a search warrant and that evening, Detective Chernozem and a colleague descended upon the Springs' home.

A thorough search turned up nothing out of the ordinary. There were several shotguns (Mr. Springs was a duck hunter), but none had been fired recently. As they were leaving through the garage, Detective Chernozem noted a shovel leaning against the wall next to a pair of black, knee-high rubber boots. What had caught his attention was a dark, puddle-like stain on the garage floor emanating from the blade of the shovel. Looking more closely, he noted a small amount of dark soil under the foot ridge of the shovel. He asked Rusty, who had been dogging them ever since they set foot on his property, if he had been digging recently. Rusty remarked that he had been working in the garden in the back yard.

The detective went out back looking for freshly spaded ground. Finding none, he nevertheless took a sample of soil from the garden. Back in the garage, he collected a small amount of dark soil in the back of Rusty's pickup truck. On a whim, he peered at the underside of the rear left fender of the truck and noted a coating of dirt, which he carefully dislodged with his penknife. It was damp so it peeled off as a layer. It looked rather like fudge with a dusting of light brown sugar. He observed the same coatings above the other tires, but not on Mrs. Springs' old Cavalier. Rusty testily denied driving anywhere in the last week other than to work, the bar, and the grocery store. Detective Cherozem impounded the shovel as they finally departed.

Discussion Questions

- What is the significance of the dark, puddle-like stain that apparently came from the shovel? Had Rusty Springs washed it? Why?
- Why did Detective Chernozem collect a sample of soil from the garden?
- What is the significance of what appears to be the same type of dark soil in the truck bed? What about the same type of soil under the fenders of the truck? It had two layers: a thick, dark, inner coating, and a thin, lighter outer layer.
- Why was it damp (a check with the weather bureau confirmed no rain in the area for the past two weeks, but a storm front was expected Tuesday)?
- What significance is there to the fact that Mrs. Springs' car did not have any layers of dirt under the fenders?
- Did the detective look closely at the rubber boots? Would that have been important? Or to look for dark soil in the cab floor of the truck?

Forensic Characterization of Soil

Objective: To study various aspects of soil and use these characteristics to help locate Alice Springs.

Materials:

- Soil Samples
- Petri Dishes or Watch Glasses
- Universal Indicator
- Weighing Paper
- Electronic Scale
- Stereomicroscope
- Sample Vials
- Set of Sieves
- Density Gradient Column

Procedure

1. **Physical Appearance**: The first step in characterizing and comparing soils is a microscopic examination using a stereomicroscope. Spreading the sample out in a Petri dish allows easy viewing and poking around. It is important to note any artifacts in the sample; that is, a man-made or natural material like pits of plastic or metal, parts of insects or vegetation, fibers, etc. Record your observations on the data table.
2. **Color:** The color of a soil is generally related to the presence of particular minerals or organic matter. For example, red soils are associated with highly oxidized iron; black soils, with organic matter. Wet soil is usually darker than the dry soil, so each soil sample should be dried at 100 ^{0} C for an hour. This can be done directly in the petri dish. Crush each sample with your finger to break up aggregates. Once dried, use the paint color panels as a reference for matching and comparing the colors of the samples. Record the color of each on the data table.
3. **Acidity/Alkalinity**: Stir a small amount of the sample into some distilled water in a test tube. Add a drop of Universal Indicator and compare to the chart. Record the pH of the sample on the data table.
4. **Particle Size:** The composition of soil not only determines the color and pH, but also its texture; that is, the range of particle size of the components. If the samples come from the same source, then they should have the same or similar distribution of particle size. Arrange a set of sieves in order with the largest holes (the largest mesh or smallest screen number) on top and the finest screen at the bottom. Weigh 10 grams of dried soil and add it to the top sieve. Rub your fingers over it to break up any remaining clods. Put the cover and bottom base on the set of sieves and shake in an up and down motion for several minutes. Tap the sides, remove the cover, and weight the contents of each sieve. Label and save each fraction of soil for later use. Record on the data table. Calculate the % of each size for the total sample. Repeat this step for each sample.

How to Calculate the % of each size for the total sample:

Example: 2.00 grams of soil was contained in the first sieve.

Total Sample = 10 Grams (amount you added to the sieve system)

2.00 grams/10 grams X 100 = 20 %

5. **Density:** About 300 years ago, Galileo discovered that a ball of wax could be suspended between a layer of salt water and a layer of fresh water. Objects float at the level of their density. This principle will be used to classify soil types. The particles making up soils vary in density as well as in particle size.

If two soils are from the same location, they should contain particles of similar densities. The density distribution of the particles can be determined by adding soil to a tube containing layers of different density liquids. Each particle will "float" at an equidensity point in the column, thereby providing a density profile of the soil sample.

Density gradient columns are used for this experiment. They are made by layering various liquids of different densities. Soil is added to the column and within hours, the individual particles of the soils will settle to their density levels. Size of particles will have no influence on the density level, just on how fast they settle. Why? Quartz (SiO_2) is a common constituent of many soils. Pure Quartz is called silica and has a density of 2.65 g/cc which is a higher density than any of the liquids in the column. Organic matter, on the other hand, has a density of less than 1.00 g/cc. Where would you expect to find each of these components in a density column?

To create a density column

1. Mark the side of a test tube (125 mm) into 2 mL increments.
2. Add 2 mL of each of the following to a test tube and let it settle into layers:
    a. Karo Syrup
    b. Glycerin
    c. Ethylene glycol
    d. Distilled water
    e. cooking oil
    f. alcohol

How to use the density column to determine or compare density of particles

3. For each sample, weigh onto weighing paper about 0.1 g of the dried soil fraction that remains on the **second sieve**.
4. Carefully pour it into a labeled density gradient column. Be careful not to jostle the column.
5. Let the soil settle in the column. (Allow approximately 10 minutes)
6. Observe the layer that contains the soil. Use the following density values for the liquids to determine the density of the soil grains. Record on the data table. If there are particles in several layers, record that information and estimate the amount in each layer.
   **Liquids are listed as they would appear in the density column from bottom to top.*

Material	Density (g/mL)
Alcohol	0.79 g/ml
Cooking Oil	0.90 g/ml
Water	1.00 g/ml
Ethylene Glycol	1.11 g/ml
Glycerin	1.26 g/ml
Karo Syrup	1.36 g/ml

6. **Tabulating Results and Drawing Conclusions**: Each group will share the results from the samples they evaluated. Complete the data tables. What conclusions can be drawn from the results so far? Are the results consistent with the original hypothesis of what may have happened? Are all the dark soil samples the same? Is it consistent with the soil from the garden? How can this information help find Alice? What to do next?
7. **Guidelines to Search for Alice**: Consistent with the detective's theory that Rusty killed Alice; police need to find her body. Chances are that Rusty did not drive far to dump his wife's body. Also keep in mind that Rusty is a duck hunter. Use the information obtained during the lab and the characteristics about soil types to determine potential locations that the samples from the shovel, boots, and truck came from. Look at a topographic map of the area and identify areas that the soil would be found. Are any of these locations out of view from the houses in the area? Create a topographic profile to determine if there is an area that contains the type of soil found that is out of sight from the surrounding houses. Explicit directions must be drawn up so the police know where to look and quickly since rain may destroy vital clues.

Soil Characteristics:

Swampy Soil

- Formed from the decomposition of vegetative matter
- High in organic matter
- Organic matter has a density less than 1.00 g/ml
- Dark colored
- Smaller particles
- Retains or hold water (when wet and formed into a ball it will hold its shape)
- Has an odor when wet

Garden Soil

- A loamy soil: wide variations in particle sizes (sand, clay, silt) and colors
- May contain remains of plant material
- Brown – Gray color
- Holds water

Sandy Soil

- Very little organic material
- Made of Quartz
- Particles are large and have a density around 2.65 g/ml
- Light Colored
- Does not retain water or hold its shape when wet

Data Table

Samples	Physical Appearance	Color	pH	Density of Particles in Second Sieve
Shovel				
Garden				
Back of Truck				
Front Fender/Dark Layer				
Front Fender/Light Layer				
Back Fender/Dark Layer				
Back Fender/Light Layer				
Inside of Truck/Floor Mat				
Rubber Boots				
Unknown Swamp				
Unknown Dirt Road				

Samples	Mass in Top Sieve (Largest Mesh)	Mass in Second Sieve	Mass in Third Sieve	Mass in Bottom Sieve (Finest Mesh)
Shovel				
Garden				
Back of Truck				
Front Fender/Dark Layer				
Front Fender/Light Layer				
Back Fender/Dark Layer				
Back Fender/Light Layer				
Inside of Truck/Floor Mat				
Rubber Boots				
Unknown Swamp				
Unknown Dirt Road				

Conclusion Questions:

1. What type of soil is the most likely source for the samples taken from the shovel, truck and boots? ___________________________

2. Identify an area on the map that the soil may be found. Determine a location that is out of sight to the houses in the area. Mark that location with an X. Draw a straight line from that location to a house and create a topographic profile along that line. This will verify that your selected location is out of sight from the house.
3. What type of soil is the most likely source for the lighter samples taken from the fenders of the truck? ________________________

4. How would that soil have ended up in the fender of Rusty's truck?

5. Identify 5 characteristics used to compare soil samples.

6. Define Soil.

7. Which location: Nevada or Michigan would have the thickest soil and why?

8. Identify 2 reasons that Humus is an important part of soil.

9. What processes occur to form soil?

Topographic Map of the Martinsville-Mount Horeb Area

Map Information:
Contour Interval = 20 Feet
Scale 1:24,000 (1 inch = 2000 feet)

Topographic Profile

460____

440____

420____

400 _______________________________________

Elevation in Feet

Teacher Notes:
The map shows the area where the Springs live. There is only one spot that is swampy, just off Mount Horeb Road. Using map symbols, a swamp, pond, stream, dirt road, and houses can be defined. The pertinent part of the map can be enlarged using a copier, as shown. Is there an area that cannot be seen from any of the houses? The contour interval must be determined by the student (it is 20 feet), then sight lines drawn to define a blind spot, assuming the houses are a standard two floors high. Distances can be estimated form the scale of the original map (1:24,000; therefore, 1 inch equals 2000 feet). A topographic profile could be constructed to verify the blind spot.

Each student investigative team can describe a hypothetical reenactment of disposal of the body. Explicit directions must be drawn up so the police know where to look and quickly since rain may destroy vital clues.

Scenario Continued:
Through the rapid, astute, deductive reasoning of the crime scene investigators, Detective Chernozem and several colleagues are dispatched to the Mt. Horeb swamp road where indeed there is an apparent blind spot running from the road to the creek. The police notice a tire track in the dark muck by the road, but no footprints. After 15 minutes of traversing an area of cattails and saw grass, they find disturbed soil on a slight rise by an old duck blind. It is not long after that they unearth the body of Alice Springs, wrapped in a blanket. A sample of the dark soil in the area is taken as well as a sample from the dirt road leading into the area.

The swamp soil can now be compared to the dark-colored samples from the Springs' house. The sample from the dirt road can be compared to the "light brown sugar" coating of the dark soil under the fender of Rusty's truck.

EROSION INTRODUCTION
STREAMS AND RIVERS NOTES
Reference: Chapter 13

Erosion
The process by which the products of ___***weathering***___ are ___***transported***___.

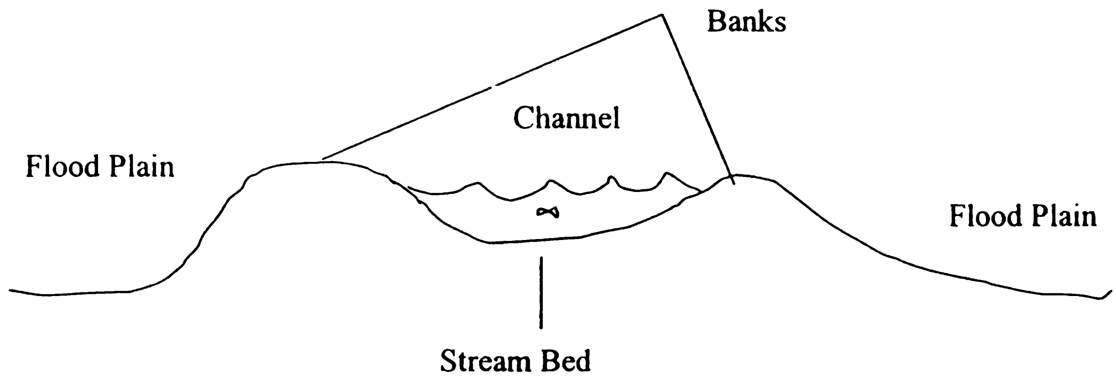
Agents of Erosion:
****wind***
****water = oceans, rivers, lakes***
****gravity***
****ice/glaciers***

River System
___***Tributaries***___ drain the ___***watershed***___ into a ___***river***___ to the ocean.

2 Main Watersheds in the United States

1. Drains to ___***Pacific***___ Ocean → ___***Colorado***___ River
2. Drains to ___***Atlantic***___ Ocean → ___***Mississippi***___ River

Stream Anatomy



Stream Load
___***Materials***___ carried by a stream
(***sand, rocks, leaves***)

3 Types of Stream Load
1. ___***Suspended***___ Load – Particles floating in the water. ****carries the most***
2. ___***Bed***___ Load – Material pushed along the bottom of the stream
3. ___***Dissolved***___ Load – Materials dissolved in the water chemically

Amount of Stream Load Depends on:

- ***Velocity*** which is determined by the ***gradient*** of the stream
- ***Amount of Water*** Stream vs. River

3 Things Affect How a River Erodes it's Path

1. ***Velocity***
2. Its ***stream load*** (How much it is already carrying)
3. Amount of ***water (size)*** .

Delta Formation

Streams ***slow*** down dramatically when they enter still water of a ***lake (or ocean)***. As the current ***slows*** down, the stream is not able to carry all the ***material*** (load) it was carrying at a ***higher*** speed and therefore ***deposits*** its sediment (load) forming a ***Delta*** .

Alluvial Fan Formation

Streams slow down dramatically as they enter a ***flat plain*** from a ***mountain*** . As the current slows down, the stream is not able to carry all the materials (load) it was carrying at a higher speed and therefore deposits its sediment (load) forming an Alluvial Fan.

Discharge is the volume of water flowing downstream per unit time, measured in m^3/sec

Formula:

Discharge = Channel Width (m) X Channel Depth (m) X Velocity (m/sec)

Calculate the discharge of a stream that is 25 meters wide, 10 meters deep with a velocity (speed) of 5 m/sec. Include units in your answer.

25m x 10m x 5m/s = 1250m/s

Erosion

The water in the center of the stream flows faster than the water along the banks, Why?

Less friction – water on the side has friction with the banks of the river, slowing it down.

Erosion occurs from ***moving*** water, the ***faster*** the water the ***more*** it erodes. ***Deposition*** or ***sedimentation*** occurs when water ***slows*** down. Water flowing around a bend or curve in a stream travels _____***fast***_____ on the outside of the curve and ____***slow***___ on the inside of the curve. This causes ___***erosion***___ on the outside of the curve and _________ on the inside of the curve.

Type 2 Writing – Levees

Do you think that Levees should be built to control annual flooding? Explain your position. (Give at least 1 advantage and 1 disadvantage) *Write a minimum of 6 lines.

GLACIER UNIT VOCABULARY

Complete the following columns for the terms associated with glaciers. Use your textbook, Modern Earth Science, Chapter 15 pages 276-295 and classroom resources (PowerPoint).

TERM	**Description**	**How did it form?**	**Sketch**
GLACIER		2 Major Requirements: -Low Temperatures -Adequate amounts of snow	
FIRN			
VALLEY GLACIER		**Where do they form? Provide an example of a valley glacier.**	

CONTINENTAL GLACIER ICE SHEET		Where do they form? Provide the location of the only 2 present continental glaciers.	
CIRQUE			
ARETES AND HORN			
HANGING VALLEY			

U-SHAPED VALLEY			
MELTWATER/ MELTWATER STREAM			
MORAINE			
TYPES OF MORAINES: **LATERAL AND MEDIAL MORAINE**			
GROUND MORAINE			

TERMINAL MORAINE			
KAME			
ESKER			
KETTLE/ KETTLE LAKE			
DRUMLINS			

ERRATIC			
TILL -			
STRATIFIED DRIFT / OUTWASH			

GLACIER UNIT VOCABULARY

Complete the following columns for the terms associated with glaciers. Use your textbook, Modern Earth Science, Chapter 15 pages 276-295 and classroom resources (PowerPoint).

TERM	Description	How did it form?	Sketch
GLACIER	A mass of moving ice.	Accumulation of snow that is compressed into glacial ice from overlying weight. 2 Major Requirements: -Low Temperatures -Adequate amounts of snow	
FIRN	Grainy ice	Created from the partial melting and refreezing of snow crystals.	
VALLEY GLACIER	Long, narrow, wedge shaped ice moving down a valley.	**Where do they form? Provide an example of a valley glacier.** Forms in mountainous areas like coastal Alaska, Andes, Alps, New Zealand or Himalayas	

CONTINENTAL GLACIER ICE SHEET	A glacier covering a large land mass.	**Where do they form? Provide the location of the only 2 present continental glaciers.** Form near the poles. Presently found in Greenland and Antarctica.	
CIRQUE	A bowl shaped depression	Form from a valley glacier pulling blocks of rock from the floor of the upper valley.	
ARETES AND HORN	A sharp jagged ridge between cirque Several aretes joined to form a sharp, pyramid peak.		
HANGING VALLEY	A small tributary glacial valley suspended on a higher portion of a mountain. Ice melt flowing over the edge creates a waterfall.	Formed when a smaller tributary glacier merges with a larger glacier. The tributary glacier has less erosional power so its U-shaped valley is not cut as deep. When the ice melts, this valley is left suspended on the mountain high above the main valley.	

U-Shaped Valley	The shape of a valley after a glacier retreats.	The glacier scrapes away the valley floor and walls of a V-shaped valley.	
Meltwater/ Meltwater Stream	Streams or water flowing from the retreating, melting glacier.	Formed from a melting glacier.	
Moraine	Ridges of unsorted rock material on the ground or on the glacier.	Formed from material accumulated by the glacier.	
Types of Moraines: **Lateral and Medial Moraine**	A long ridge on the side or between two glaciers that merge together.	Deposited along the sides of a valley glacier; when two or more glaciers join the lateral moraines remain between them creating medial moraines.	
Ground Moraine	Unsorted material left beneath a melting glacier. Often very rocky.	Formed when the material trapped within glacial ice is deposited as the glacier melts.	
Terminal Moraine	Belts of small ridges of till with many depressions containing lakes or ponds.	Till deposited in front of a melting glacier.	

KAME	Small hills of sand and gravel	Formed from outwash	
ESKER	Long, narrow ridges of sand and gravel in the middle of a moraine.	Form from melt water streams flowing in tunnels along the bottom on the melting glacier.	
KETTLE/ KETTLE LAKE	A large depression sometimes filled with water.	The result of a very large block of ice being left behind as a glacier recedes. The block may become partially buried; if buried to the depth of the water table it will become a lake.	
DRUMLINS	Long, low tear shaped mounds of till.	Formed from the ice sheet molding ground moraine into the tear shape as it passes over. The long axes is parallel to the direction of glacial movement.	
ERRATIC	Large boulder, generally of a different rock type than the area it is found	Transported by a moving glacier and deposited when the glacier melts and retreats.	

TILL	Unsorted deposits left from a glacier	Deposited from sediments scraped off by the base of the glacier or is left behind when the glacier melts.	
STRATIFIED DRIFT / OUTWASH	Material that has been sorted and layered	Sorted and layered by flowing streams from the glacial meltwater.	

Glacier Unit Questions

1. **Provide two reasons that Glaciers are studied.**

2. **What are the two types of Glaciers? How are they categorized?**

3. **How do Glaciers move? Explain Basal slip and Internal Plastic Movement.**

4. **The Milankovitch Theory provides a rational for the advancement and retreat of continental ice sheets. What are the 3 periodic changes identified in the theory?**

5. **Describe how glacial lakes form, specifically the Great Lakes.**

Application

1. **You just built a house and are planting grass for the yard. As you work the soil, you find lots of rocks of many different sizes. Explain how all of these rocks ended up in your yard.**

2. **While looking at a topographical map of the Charlotte area, you count several gravel pits. What 2 glacial landforms are often exploited as gravel pits?**

Glacier Unit Questions

1. Provide two reasons that Glaciers are studied.

Potential answers:

1. *Glaciers are the second largest reservoir of water on earth.*
2. *A slight increase in global average temperature would likely cause all glaciers to melt, raising sea level by 50-70 m.*
3. *Glaciers represent ice – reflecting climatic conditions, not variations in weather.*
4. *Glaciers are an important agent of erosion; formed much of the landscape of Michigan.*
5. *An ice age will likely occur again.*

2. What are the two types of Glaciers? How are they categorized?

Types:
Continental Glacier or Ice Sheet
Valley Glacier

Categorized by:
Size
Where they formed

3. How do Glaciers move? Explain Basal slip and Internal Plastic Movement.

Basal Slip – The weight of overlying ice exerts enough pressure to melt some ice at the base of the glacier. The melting ice creates a slippery surface for the overlying glacier to slide over.

*Internal Plastic Flow – Solid ice crystals throughout the glacier slipping over each other creating a slow forward motion. *Provides a way to transport material within the glacier to the terminal moraine for deposit.*

4. **The Milankovitch Theory provides a rational for the advancement and retreat of continental ice sheets. What are the 3 periodic changes identified in the theory?**

1. ***A more elliptical orbit carrying earth father from the sun.***
2. ***A variation in the degree of earth's tilt.***
3. ***Circular motion of precession.***

5. **Describe how glacial lakes form, specifically the Great Lakes.**

Lateral and Terminal Moraines can block existing streams causing a lake to form.

The Great Lakes formed from a combination of erosion and deposition by continental ice sheets. Glacial erosion widened and deepened broad river valleys covered by the ice sheets. Moraines to the south blocked off the ends of the valleys trapping melting glacial waters.

APPLICATION

1. **You just built a house and are planting grass for the yard. As you work the soil, you find lots of rocks of many different sizes. Explain how all of these rocks ended up in your yard.**

Michigan is covered by glacial deposits, which contain unsorted material of various sizes, including lots of larger rocks.

2. **While looking at a topographical map of the Charlotte area, you count several gravel pits. What 2 glacial landforms are often exploited as gravel pits?**

Kames and Eskers

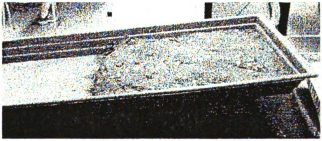
Assume you are hiking in the mountains. You suspect that the area was glaciated in the past. Describe some of the features you would look for to confirm your suspicion.

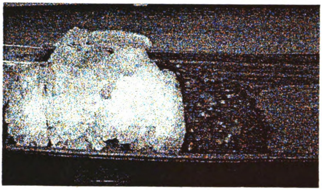
Stream Table Demonstration

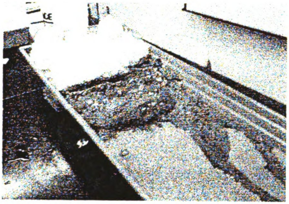
Objective: To demonstrate how a glacier erodes and deposits material to create landforms present today.

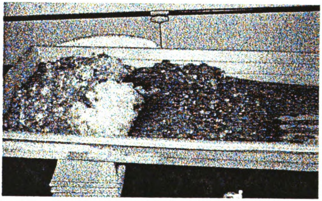
Materials:
- ♦ Stream Table
- ♦ Course Sand
- ♦ Fine Sand
- ♦ Aquarium Gravel
- ♦ Bag of Ice

Procedure:
1. Mix the sand and gravel together, add water to moisten it.
2. Pour the mixture into one end of the stream table and pat it down so it forms a fairly flat surface.
3. Prop the sand/gravel filled side of the stream table up so that the table forms a gradual slope to the opposite end.
4. Pile the ice up at the end of the stream table on top of the gravel mixture. Pick out some large pieces to place near the front edge, piling smaller pieces of ice behind it and on top of it. Once in place, push the front edge down into the gravel and push it forward slightly and then back. If any pieces of ice fall further down the gravel area, push them into the gravel. This will form nice kettles.
5. After the ice is in place gently pour some water over the ice. It will form a meltwater stream with some outwash.
6. As the ice melts, periodically push down and backward on the ice to help give the end result of a retreating glacier.









GLACIERS **Name** ________________

TYPE 2 WRITING

Observe the stream table. Describe at least 4 glacial features formed from the movement of a continental ice sheet that is represented on the stream table model. Include in your description what it looks like on the stream table and characteristics of that feature. Use your glacier vocabulary definitions given in class as a reference.

Creating Glacial Land Forms

Name ____________________
Block ______ Date __________

A glacier is a large moving mass of ice. Glaciers are responsible for shaping many of the earth's natural features seen today. As a glacier advances it changes the landscape, eroding the surface over which it passes, and incorporating material in the ice. The material carried by a glacier can gouge out grooves called striations in the landscape that it passes over. Different materials have varying effects on the landscape...As glaciers recede; they leave huge amounts of accumulated rock material behind. Sometimes receding glaciers form moraines by depositing some of the rock material in ridges. At other times, glaciers leave chucks of ice that form depressions called kettles. These depressions may form ponds or lakes. All of these things are a result of the powerful force of glaciers.

Part 1:

In this activity you will discover how glacial activity forms large depressions, kettles.

Materials:

- Plastic box
- Sand
- 4 Ice Cubes of Various Sizes

Procedure:

1. Fill the tub three-quarters full of sand.
2. Evenly place the ice cubes across the surface of the sand.
3. Leave the first ice cube resting on the surface, push the next ice cube so that half of it is below the sand, the third so that three-quarters is below the sand and the fourth bury so that only the top surface is visible and at sand level.
4. Set the sand filled box aside and proceed to Part 2 while you wait for the ice cubes to melt.
5. Observe the sand after the ice cubes have melted.

Data

Ice Cube	Description after the Ice Cube Melts *(Things to include: Did it leave a depression, how deep, was there water in it? Etc.)*
Ice Cube on the Surface	
Half Buried Ice Cube	
Three Quarters Buried Ice Cube	
Buried Ice Cube	

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001

Conclusion Questions:

1. Which ice cube(s) formed a depression?

2. Explain how a large chunk of ice abandoned by a glacier could become partially or fully buried.

3. What glacial feature was formed in this model?

4. Some kettles are filled with water creating a kettle lake. Why would some kettles become lakes and others just remain a depression? *(Hint: What is a possible water source? Was each ice cube buried to the same depth? How deep could an ice block be buried?)*

5. This model represents the formation of a kettle. Using this activity as a guide, describe how a receding glacier forms a kettle.

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001

Part 2

In this activity, you will create a model glacier to demonstrate the effects of glacial erosion by various materials.

The downslope movement and the extreme weight of glaciers cause them to scrape and plow (push) rock materials that they encounter. They pluck rock material by freezing around it and ripping it from bedrock, incorporating it into the glacial ice. This rock debris then can be transported many kilometers by a glacier. The debris also gives glacial ice its great abrasive power. As the heavy rock-filled ice moves over the land, it scrapes surfaces like a giant sheet of sandpaper.

Materials:

- 3 Ice Blocks: Gravel, Sand, Plain
- Clay
- Paper towel

Procedure:

1. Flatten the clay into a square piece.
2. Hold the plain ice block firmly with a towel, and press as you move it along the length of the clay. Do this three times. Sketch and describe the appearance of the clay.
3. Repeat step 2 with the Sand ice block and then with the Gravel ice block.

Data

Appearance of the Clay after the Plain Ice Block	
Appearance of the Clay after the Sand Ice Block	
Appearance of the Clay after the Gravel Ice Block	

Conclusion Questions:

1. Compare the surface of the clay after each ice block, which one caused the most striations?

2. Compare the surface of the clay after each ice block, which one caused the deepest grooves?

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001

3. Was any material deposited on the clay surface? If so, what?

4. Observe the bottom of the ice blocks, did any material from the clay become mixed with the material in the ice blocks? If so, What?

5. This is a model of how a glacier can erode and deposit materials. Using this model as a guide, describe how a glacier erodes and deposits materials.

6. A geologist discovers an area of bedrock that contains deep grooves and striations on its surface running north and south. Based on this activity, what can you conclude about the direction the glacier traveled?

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001

Part 3:

As the layers of ice build up and the glacier begins to accumulate in size the overlying weight causes the bottom of the glacier to begin to melt. The water from the melted ice allows the glacier to move forward. In this activity you will learn about the effect of pressure on the melting rate of a glacier.

Materials:

- 2 Plain Ice Blocks
- 1 Brick
- Collection Container
- Graduated Cylinder

Procedure:

1. Place an ice block upside down in each collection container.
2. Place 1 brick on top of one of the ice blocks. Leave the other ice block alone.
3. After 20 minutes, remove the brick from the ice block.
4. Measure the amount of water that has melted from each ice block using the graduated cylinder. Record your findings.

Data

	Amount of Water Accumulated
Ice Block with 1 Brick	
Ice Block	

Conclusion

1. Which ice block produced the most water?

2. What did the brick represent?

3. What part of the ice block melted first? Why?

4. What effect does pressure have on the melting rate of ice?

5. What force causes a glacier to flow downward?

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001

Creating Glacial Land Forms **Teacher's Guide**

A glacier is a large moving mass of ice. Glaciers are responsible for shaping many of the earth's natural features seen today. As a glacier advances it changes the landscape, eroding the surface over which it passes, and incorporating material in the ice. The material carried by a glacier can gouge out grooves called striations in the landscape that it passes over. Different materials have varying effects on the landscape...As glaciers recede; they leave huge amounts of accumulated rock material behind. Sometimes receding glaciers form moraines by depositing some of the rock material in ridges. At other times, glaciers leave chucks of ice that form depressions called kettles. These depressions may form ponds or lakes. All of these things are a result of the powerful force of glaciers.

Part 1:
In this activity you will discover, how glacial activity forms large depressions, kettles.

Data

Ice Cube	**Description after the Ice Cube Melts** *(Things to include: Did it leave a depression, how deep, was there water in it?)*
Ice Cube on the Surface	No Depression or water; sand is damp.
Half Buried Ice Cube	Very shallow depression, no water accumulation.
Three Quarters Buried Ice Cube	Small depression, no water accumulation.
Buried Ice Cube	Depression the size of the ice cube, no water accumulation.

Conclusion Questions:

1. Which ice cube(s) formed a depression?

    The ice cubes which were embedded or buried in the sand.

2. Explain how a large chunk of ice abandoned by a glacier could become partially or fully buried.

    As the glacier is retreating it is also melting, meltwater can transport and deposit sediment that could cause some burial.

3. What glacial feature was formed in this model? A Kettle

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001
ISBN 0-03-051953-5

4. Some kettles are filled with water creating a kettle lake. Why would some kettles become lakes and others just remain a depression? *(Hint: What is a possible water source? Was each ice cube buried to the same depth? How deep could an ice block be buried?)*

   An ice block buried to the depth of the water table will form a kettle lake; the ground water is the water source.

5. This model represents the formation of a kettle. Using this activity as a guide, describe how a receding glacier forms a kettle.

   As the glacier begins to retreat, chunks of ice may fall or break away from the main glacier body. This ice may then become buried and slowly melt, leaving behind a depression where the ice once existed.

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001
ISBN 0-03-051953-5

Part 2

In this activity, you will create a model glacier to demonstrate the effects of glacial erosion by various materials.

The downslope movement and the extreme weight of glaciers cause them to scrape and plow (push) rock materials that they encounter. They pluck rock material by freezing around it and ripping it from bedrock, incorporating it into the glacial ice. This rock debris then can be transported many kilometers by a glacier. The debris also gives glacial ice its great abrasive power. As the heavy rock-filled ice moves over the land, it scrapes surfaces like a giant sheet of sandpaper.

- Let the ice blocks begin to melt before passing them over the clay. This allows some of the material to come off the ice.

Data

Appearance of the Clay after the Plain Ice Block	**Some water remains, relatively smooth.**
Appearance of the Clay after the Sand Ice Block	**Some sand and water remain on the clay, small, shallow grooves in the clay**
Appearance of the Clay after the Gravel Ice Block	**Gravel and water remain on the clay, larger, deeper grooves in the clay.**

Conclusion Questions:

1. Compare the surface of the clay after each ice block, which one caused the most striations?

   Gravel ice block

2. Compare the surface of the clay after each ice block, which one caused the deepest grooves?

   Gravel ice block

3. Was any material deposited on the clay surface? If so, what?

   Gravel, Sand, Water

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001
ISBN 0-03-051953-5

4. Observe the bottom of the ice blocks, did any material from the clay become mixed with the material in the ice blocks? If so, What?

    Yes, some clay was transferred to the ice block.

5. This is a model of how a glacier can erode and deposit materials. Using this model as a guide, describe how a glacier erodes and deposits materials.

    As a glacier advances across an area, it continually plucks rocks and material from the land surface incorporating it within the ice. This material is like sandpaper, scratching the material it passes over. Once the glacier begins to recede and melt, the material once held within the ice is deposited on the area.

6. A geologist discovers an area of bedrock that contains deep grooves and striations on its surface running north and south. Based on this activity, what can you conclude about the direction the glacier traveled?

    The glacier was traveling north and south.

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001
ISBN 0-03-051953-5

Part 3:

As the layers of ice build up and the glacier begins to accumulate in size the overlying weight causes the bottom of the glacier to begin to melt. The water from the melted ice allows the glacier to move forward. In this activity you will learn about the effect of pressure on the melting rate of a glacier.

Data

	Amount of Water Accumulated
Ice Block with 1 Brick	**40 ml**
Ice Block	**20 ml**

Conclusion

1. Which ice block produced the most water? The one with the brick on it.
2. What did the brick represent?

   The overlying weight of the glacier and accumulating snow.

3. What part of the ice block melted first? Why?

   The bottom, it had the most pressure exerted on it.

4. What effect does pressure have on the melting rate of ice?

   Pressure increases the melting rate of ice.

5. What force causes a glacier to flow downward? Gravity

Adapted from Earth Science Lab Book by Holt Science and Technology, 2001
ISBN 0-03-051953-5

Glaciers and Sea Level

Name ________________
Block ____ Date __________

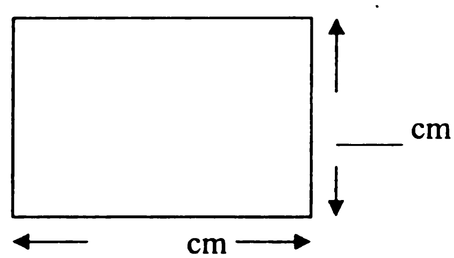
The total volume of ice on earth today contains about 2.2% (25,000,000 km^3) of the earth's water. What if 25,000,000 km^3 of water now tied up in ice were to melt? The change in sea level would be catastrophic for the melting of all existing ice would raise the oceans by about 65 m (210 ft). This would inundate many major cities of the world such as Tokyo, London and New York. A climatic change could alter the amount of glacial melt that occurs, think of the implications!

In this investigation, you will construct a model to stimulate what would happen if the Antarctic ice sheet melted.

Pre Lab Preparation:

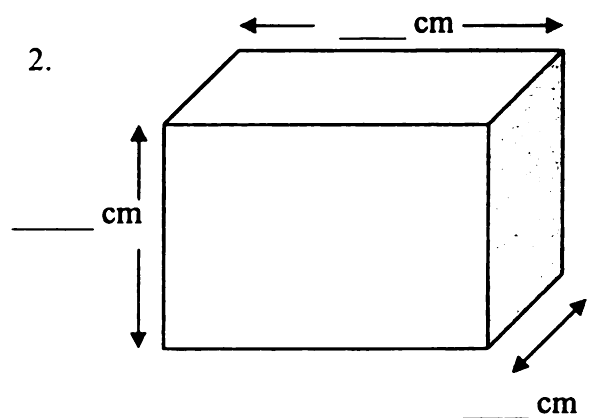
Area (A) is calculated by multiplying length (l) times width (w) [A = l x w]. Area is expressed in square units. Volume (V) is calculated by multiplying length (l) times width (w) times height (h) [V = l x w x h]. Volume is expressed in cubic units. Calculate the area and the volume of the shapes shown below.

1.



Area = ____________

2.



Volume = ____________

3. If the total area of an object is 450 cm^2 and 65 cm^2 is covered by ice, what percent of the object is covered in ice?

Materials

- Metric Ruler
- Sand and Small Pebbles
- Small block of ice
- Wooden Block
- Calculator
- Water
- Plastic Shoe Box
- Clay

Adapted from Modern Earth Science by Sager, Ramsay, Phillips, Watenpaugh. Holt, Rhinehart & Winston, 1998.

Procedure

1. Measure and record the length and width of the bottom of the plastic shoebox. Calculate the area and record on the data table.
2. Moisten the sand and small pebbles and add them to the pan so they cover about half the area of the pan, sloping toward the middle. Elevate this end of the pan using the wooden block as shown in the figure below.
3. Slowly add water to the opposite end of the pan. Be sure that the water does not cover the sand, but only touches the edge of it.
4. Measure and record the following:
    a. Distance from the end of the box covered with sand to the point where the sand touches the water.
    b. Distance from the end of the box covered with water to the point where the water touches the sand.
    c. Distance across the side of the box.
    d. The depth of the water at the deepest point.
5. Make a small island out of clay and place it in the water. Make sure that a portion of it is above the water.
6. Remove the ice block from the plastic container. Measure and record the length, width and height. Calculate and record the overall volume and the area of one side of the ice block.
7. Place the block of ice lengthwise in the box on top of the sand as shown in the figure above.
8. As the ice begins to melt, pick up the ice block. Note the appearance of the bottom of the ice block and of the sand under the ice. What is happening to the ice block? What is happening to the sand under the ice block? Place the ice block back on the sand.
9. While the ice is melting, calculate the expected rise in the box's water level using the following formula:

$$\text{Rise in Water Level (cm)} = \frac{\text{Volume of water in ice block (cm}^3\text{)}}{\text{Area of box covered with water (cm}^2\text{)}}$$

10. When the ice is completely melted, measure and record the depth of water at the deepest point in the box.
11. Measure and record the distance from the end of the box covered with sand to the point where the sand touches the water.
12. Clean up all lab materials as directed by the teacher.

Adapted from Modern Earth Science by Sager, Ramsay, Phillips, Watenpaugh. Holt, Rhinehart & Winston, 1998.

Data

Object	Length	Width	Height	Calculation
Bottom of Plastic Box				Area =
Ice Block				Volume =
Ice Block				Area =
Amount of box covered with water				Area =
Percent of Total Area of Box Covered by Ice				
Initial Depth of Water				
Final Depth of Water				
Initial Distance from edge of pan to sand/water boundary				
Final Distance from edge of pan to sand/water boundary				
Calculated Rise in Water Level				
Actual Rise in Water Level				

Analysis and Conclusion

1. What effect did the melted ice block have on the water depth and the sand-water boundary?

2. What happened to the island?

3. Compare the calculated value for the expected rise in water level with the actual rise in water level value. Provide an explanation for any differences in the values.

4. This activity is a physical model to simulate what would happen if the Antarctic ice sheet melted. What would happen physically if the Antarctic ice sheet melted?

Adapted from <u>Modern Earth Science</u> by Sager, Ramsay, Phillips, Watenpaugh. Holt, Rhinehart & Winston, 1998.

5. A mathematical model can also be used to calculate the effects. Complete the following mathematical model: The total area of the earth is approximately 511,000,000 km^2. About 70% of the earth's surface is covered with water. The volume of water locked as ice in the Antarctic ice sheet is approximately 17,900,000 km^3. Show your work.
   a. Calculate the area of the earth, in square kilometers, that is covered with water.

   b. Find the average worldwide rise in sea level that would occur if the Antarctic ice sheet melted. (Use equation given in procedure).

   c. Convert your answer to meters.

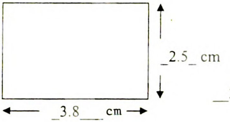
6. Explain how human activities may affect the worldwide average temperature (Global Warming).

7. Glaciers contain a large quantity of fresh water. Scientists are currently developing ways to utilize the fresh water locked in polar ice sheets. Discuss with your group ways that this source of freshwater may be utilized and record some of your ideas.

Adapted from <u>Modern Earth Science</u> by Sager, Ramsay, Phillips, Watenpaugh. Holt, Rhinehart & Winston, 1998.

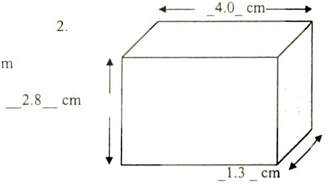
Glaciers and Sea Level
Teacher's Guide and Answer Key

1.



Area = ___9.5 cm^2_____

2.



Volume = __14.56 cm^3__

3. If the total area of an object is 450 cm^2 and 65 cm^2 is covered by ice, what percent of the object is covered in ice?

$$65 \text{ cm}^2 / 450 \text{ cm}^2 \times 100 = 14 \%$$

Data *Answers will vary, the following is a sample.

Object	Length	Width	Height	Calculation
Bottom of Plastic Box	30 cm	15.7 cm		Area = 471 cm^2
Ice Block	8.2 cm	8.0 cm	5.1 cm	Volume = 335 cm^3
Ice Block	8.2 cm	8.0 cm		Area = 65.6 cm^2
Amount of box covered with water	19 cm	15.7 cm		Area = 298.3 cm^2

Percent of Total Area of Box covered by Ice	14 %
Initial Depth of Water	3.9 cm
Final Depth of Water	4.9 cm
Initial Distance from edge of pan to sand/water boundary	10.6 cm
Final Distance from edge of pan to sand/water boundary	9.4 cm
Calculated Rise in Water Level	1.1 cm
Actual Rise in Water Level	1.0 cm

Adapted from Modern Earth Science by Sager, Ramsay, Phillips, Watenpaugh. Holt, Rhinehart & Winston, 1998.

Analysis and Conclusion

1. What effect did the melted ice block have on the water depth and the sand-water boundary?

   The water depth should have increased.
   The distance to the sand-water boundary should have decreased as the water level should have rose. Some sand may have washed into the water as the ice melted also.

2. What happened to the island?

   It may have been covered with water; minimally the amount located above the water level should have decreased.

3. Compare the calculated value for the expected rise in water level with the actual rise in water level value. Provide an explanation for any differences in the values.

   Errors in measuring the area and volume of the box, ice. They may not be perfectly square; have rounded corners, etc.

4. This activity is a physical model to simulate what would happen if the Antarctic ice sheet melted. What would happen physically if the Antarctic ice sheet melted?

   The sea level would increase significantly causing water levels to rise along shore lines, submerging coastal cities and islands.

5. A mathematical model can also be used to calculate the effects. Complete the following mathematical model: The total area of the earth is approximately 511,000,000 km^2. About 70% of the earth's surface is covered with water. The volume of water locked as ice in the Antarctic ice sheet is approximately 17,900,000 km^3. Show your work.
   a. Calculate the area of the earth, in square kilometers, that is covered with water.

      511,000,000 km2 x .70 = 357,700,000 km2

Adapted from <u>Modern Earth Science</u> by Sager, Ramsay, Phillips, Watenpaugh. Holt, Rhinehart & Winston, 1998.

b. Find the average worldwide rise in sea level that would occur if the Antarctic ice sheet melted. (Use equation given in procedure).

17,900,000 km3 / 357,700,000 km2 = 0.050 km

c. Convert your answer to meters.

50 m

6. Explain how human activities may affect the worldwide average temperature (Global Warming).

An increase in the amount of CO2 being added to the atmosphere through the burning of fossil fuels can cause an exaggeration to natural global warming.

7. Glaciers contain a large quantity of fresh water. Scientists are currently developing ways to utilize the fresh water locked in polar ice sheets. Discuss with your group ways that this source of freshwater may be utilized and record some of your ideas.

Possible suggestions may include towing icebergs to water poor areas to provide a source for freshwater.

Adapted from <u>Modern Earth Science</u> by Sager, Ramsay, Phillips, Watenpaugh. Holt, Rhinehart & Winston, 1998.

Glacier Questions

Name ____________________
Block ______ Date __________

Part 1: Matching: Match *the letter of the definition or description to the term listed.*

_______ 1. Aretes		_______ 8. Kames	
_______ 2. Cirque		_______ 9. Kettle	
_______ 3. Drumlin		_______ 10. Moraines	
_______ 4. Erratic		_______ 11. Stratified Drift	
_______ 5. Esker		_______ 12. Till	
_______ 6. Firn		_______ 13. U-Shaped Valley	
_______ 7. Hanging Valley			

A. Grainy ice created from the compacting of snow; gives the glacier a blue color.
B. A bowl shaped depression formed from a valley glacier pulling blocks of rock from the floor of a mountain valley.
C. A sharp jagged ridge between cirque. Can join to form a horn.
D. Creates a waterfall.
E. The shape of a valley after a glacier scrapes away the floor and walls of a V-shaped valley.
F. Streams of water flowing from the retreating, melting glacier.
G. Ridges of unsorted rock material on the ground or on the glacier.
H. Small hills of sand and gravel formed from out wash.
I. Long, narrow ridges of sand and gravel in the middle of a moraine. Formed from melt water streams flowing in tunnels along the bottom of the melting glacier.
J. A large depression resulting from a large ice block being left behind as a glacier recedes.
K. Long, low tear shaped mounds of till formed from the ice sheet molding ground moraine.
L. Material that has been sorted and layered by flowing melt water streams.
M. A mass of moving ice.
N. Boulders found in glacial till or lying free on the surface.

Part 2: Multiple Choice Place *the letter of the best choice on the line.*

______ 1. Which of the following is the most commonly accepted theory for the last glacier advance creating an ice age?
A. Changes in the amount of heat produced by the sun.
B. Blockage of the sun's rays by volcanic dust.
C. Movements of continents affecting warm ocean currents.
D. Small changes in the earth's orbit, tilt, and precession.

______ 2. Basal Slip in a glacier occurs when water melted by the weight of the glacier acts as a lubricant between the glacier and the underlying rock.
A. True
B. False

______ 3. Ice flows faster along the sides of the glacier than the middle.
A. True
B. False

______ 4. Which of the following is NOT the site of present day continental ice sheets?
A. Antarctica
B. Iceland
C. Greenland

______ 5. The type of glacier that forms in mountainous areas is called a
A. Continental Ice Sheet
B. Valley Glacier

______6. Which of the following feature is NOT the result of Valley Glaciers?
A. Cirque
B. Aretes
C. Drumlin
D. Hanging Valley

______7. Which of the following features would have a layered or stratified deposition?
A. Drumlin
B. Moraine
C. Esker
D. Kettle

______8. Travel over the top of a glacier is dangerous due to the presence of deep cracks called
A. Kettles
B. Crevasses
C. Iceberg
D. Esker

______ 9. Embedded material in a glacier may gouge long scratches and grooves called __________ in the bedrock as the ice passes over.
A. Striations
B. Crevasses
C. Moraines
D. Till

______10. Which of the following most likely caused large rock and gravel deposits near the Great Lakes?
A. Wind blown Sediments
B. Kettle Lakes
C. Rotation of the Earth
D. Retreating Glaciers

______11. Examination of fossils found in moraine rocks can yield misleading results if you assume that the fossils reveal the local biological history, Why?
A. The fossils will only be those of sea creatures.
B. The rock may have been moved a large distance.
C. The fossils will all be younger that the last ice age.
D. The rock will have an unusually folded sedimentation pattern.

______ 12. During Earth's history, changes in climate have caused
A. Periods of glaciation.
B. Shifting of tectonic plates.
C. Shifting of Earth's magnetic poles.
D. Periods of increased volcanic activity.

______13. A particular area has several gravel pits, which of the following is NOT a likely landform for the site of the gravel pit?
A. Kames
B. Eskers
C. Moraine

Part 3: Short Answer

1. A(n) ________________ is a thick mass of ice that forms over land from the accumulation, compacting and recrystalization of snow.

2. How would an increase in the amount of solar energy reaching the earth's surface most likely affect sea level along the coastline of the United States?

3. What features would you look for in a region to determine if the area had been glaciated by a continental ice sheet? (include at least 3 in your answer)

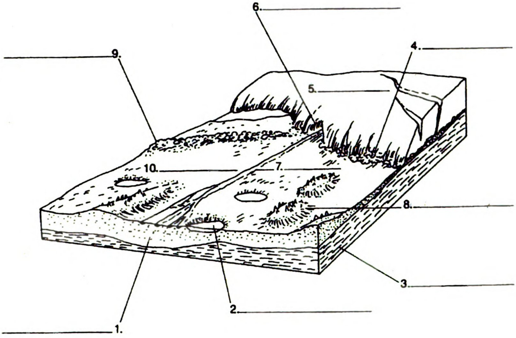
4. Describe how the Great Lakes formed.

Part 4: *Match the numbered item from the diagram to the correct feature.*

______ Kettle Lake

______ Drumlin

______ Moraine



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