Name:

LABORATORY MANUAL

FOR

EARTH SCIENCES 1100

PLANET EARTH: HOW IT WORKS

EDITION FOR OSU LIMA CAMPUS

The Ohio State University
School of Earth Sciences

A Note to the Student

It is hoped that this manual will provide a satisfactory medium to introduce you to some of the principal aspects of geology/earth sciences. This manual has been compiled at The Ohio State University Lima to be used in conjunction with Earth Sciences 100. This laboratory program is largely the result of the research and work of W. C. Sweet, R. L. Bates, and J. A. Maccini, who developed the program and original manual with financial assistance from the National Science Foundation. The revised manual draws heavily on the original work. Modifications have been made as a result of experience gained in using the manual and are based largely on the comments and suggestions of students. The lecture program of this course, and the laboratory work that supports and augments it, have both profited greatly from student suggestions in the past. Therefore I solicit your continued comments and suggestions.

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UNIT 1

MINERALS

AND

THEIR

PROPERTIES

A **MINERAL** is a naturally occurring inorganic solid that has an orderly internal structure and a characteristic chemical composition. Since a mineral has restraints placed on its atomic structure and composition it also tends to have certain physical properties that are unique or that can be used in combination with other of its physical properties to make it possible to identify it. In this unit we will be examining four physical properties that have proven useful in the identification of minerals: **LUSTER**, **STREAK**, **HARDNESS**, and **CLEAVAGE**.

1. **LUSTER** is the appearance of reflected light from the surface of a mineral. There are two basic types of luster, **METALLIC** and **NONMETALLIC**. Minerals with metallic luster look like metals in reflected light, whereas minerals with nonmetallic luster do not.

a. Examine specimen 1-1, which is a piece of **GALENA**. What type of luster does galena have?

_____

b. Examine specimen 1-2, which is a piece of **ORTHOCLASE**. What type of luster does orthoclase have?

_____

2. Another property that all minerals have is a **STREAK**, or their color in powdered form. To determine the streak of a mineral, simply scratch the surface of an unglazed ceramic tile (streak plate) with it. Streak is not always a useful property, for a great number of minerals have the same color streak. For instance, nearly all minerals that have a nonmetallic luster also have white streaks. Minerals with metallic luster have colored streaks, some unique to a specific mineral.

a. Examine specimen 1-3, a piece of **PYRITE** or "fools gold." What is the color of its streak (besides dark)?

_____

b. Determine the streak of specimen 1-1, galena: _____

Although luster and streak can be useful properties for mineral identification, there are two other properties that are much more useful. **HARDNESS**, the resistance of a mineral to scratching, and **CLEAVAGE**, the tendency of a mineral to break along parallel plane surfaces, when used in combination with one another usually permit any common mineral to be identified.

HARDNESS is classified using a relative scale termed the **MOHS SCALE**. Mohs Scale and the minerals that serve as the indices of hardness are listed below. In most cases the ten minerals that make up the Mohs Scale won't be readily available to you at all times, so it is important to know some common testing materials that will be. These common testing materials are also listed below.

MOHS SCALE

Hardness	Mineral	Common Testing Materials
1	Talc	
2	Gypsum	fingernail (>2.0-<2.5)
3	Calcite	copper penny (pre-1981)
4	Fluorite	
5	Apatite	steel knife (5.0)
6	Orthoclase	glass plate (5.5-6.0)
7	Quartz	
8	Topaz	
9	Corundum	
10	Diamond	

3. Determine the hardnesses of the following minerals using the common testing materials provided in the test kit in your lab drawer.

a. Specimen 1-2, orthoclase: _____

b. Specimen 1-4, **QUARTZ**: _____

c. Specimen 1-5, **CALCITE**: _____

d. Specimen 1-14, **FLUORITE**: _____

4. The atomic structure of a mineral determines what type of **CLEAVAGE** it will have, if any. If it has any weak directions of bonding, those will most likely result in directions of cleavage. Determine the number of cleavage directions and the angles between those cleavages for the following minerals, using the method described in lecture. Examine specimen 1-1 as an example. Galena has 3 pairs of parallel plane surfaces or 3 cleavage directions. Using just your eyesight you can fairly easily see that although you could have 3 different pairs of angles between the cleavages, they all have 90-degree angles.

a. Specimen 1-6, **BIOTITE**: _____

b. Specimen 1-2, orthoclase: _____

4. c. Specimen 1-5, calcite: _____

d. Specimen 1-15, **OPAL**: _____

5. Fill in all of the blanks in the following table of minerals (you have already determined many of the answers in the previous questions):

Minerals	Hardness	Cleavage Number and Angles	Luster	Streak
1-1. galena		3 at 90		
1-2. orthoclase				white
1-3. pyrite	6.5	none		
1-4. quartz			nonmetallic	white
1-5. calcite			nonmetallic	white
1-6. biotite	2.0		nonmetallic	white
1-7. **PLAGIOCLASE**		2 at 90		
1-8. **AUGITE**		2 at 90		
1-9. **GYPSUM**				
1-10. **HALITE**			nonmetallic	white

6. Based on any properties you can use, try to match the use/economic importance (may use more than once) in the right-hand column below with the minerals in the left-hand column.

MINERAL

1-1. galena _____

1-2. orthoclase _____

1-4. quartz _____

1-5. calcite _____

1-9. gypsum _____

1-10. halite _____

1-11. **SULFUR** _____

USE/ECONOMIC IMPORTANCE

a. abrasives
b. cement
c. aglime
d. lead ore
e. flat paint
f. porcelain/china
g. soft-scrub cleanser
h. chemicals
i. water conditioner/softener
j. silver ore
k. calcium source
l. plaster of paris
m. glass
n. gemstone
o. drywall/sheetrock
p. electronics

You have now had the opportunity to examine and become familiar with several different minerals. Minerals generally do not occur separately in the Earth's crust but as components or parts of rocks. In fact, a **ROCK** is defined as an aggregate of minerals in which each of the minerals retains its distinguishing characteristics.

7. Specimen 1-12 is a rock termed **GRANITE**. Which three minerals from a choice of 1-2, 1-4, 1-6, 1-7, and 1-8, that you have already studied in this lab unit, make up granite and which of those probably accounts for the greatest portion of the rock? (Since most of the mineral properties you have just become familiar with are difficult to use on rocks composed of fairly small minerals, this may be one time where **COLOR** and perhaps **LUSTER** are the best means for mineral recognition)

_____

_____

8. Specimen 1-13 is a rock termed **GABBRO**. Which two minerals from a choice of 1-2, 1-4, 1-6, 1-7, and 1-8, ***that you didn't use for granite in question #7 above***, make up gabbro? (as with the granite in the question above, **COLOR** and perhaps **LUSTER** may be the best means for mineral recognition in the gabbro)

_____

Name:

UNIT 2

IGNEOUS

AND

SEDIMENTARY

ROCKS

Part 1: Igneous Rocks

1. Watch the short video projected on the screen, showing the cooling of the same magma at two different rates to form igneous rocks. Which of the two choices below best describes the appearance of the rock on the left, which formed as a result of cooling quickly (white and black colors are minerals, not holes)? Place a checkmark next to the one that you feel is the best description.

_____a. boundaries of all minerals fit tightly together

_____b. there are empty spaces between some of the minerals

_____c. obvious lines or sheets of the same color mineral

Which of the two choices below best describes the appearance of the rock on the right, which formed as a result of slow cooling (white and black colors are minerals, not holes)? Place a checkmark next to the one that you feel is the best description.

_____a. boundaries of all minerals fit tightly together

_____b. there are empty spaces between some of the minerals

_____c. obvious lines or sheets of the same color mineral

2. The way that mineral grains fit together or are arranged in a rock is termed the **FABRIC** of the rock. Since all igneous rocks form when magma cools, **ALL igneous rocks composed of minerals have the SAME fabric**. Compare the different fabrics shown on the sheet in your lab drawer with the descriptions you selected for the fabric of each of the igneous rocks in question 1. Place a checkmark next to the fabric listed below that best describes the fabric of an igneous rock.

a. **GRANULAR** fabric, rounded minerals with holes or pores in most specimens _____

b. **INTERLOCKING** fabric, minerals fit tightly together, no spaces in between and little or no parallel alignment of minerals _____

c. **PARALLEL** fabric, long dimensions of minerals appear parallel to one another _____

3. Examine the specimens of **GRANITE**, Rock 1-1, and **GABBRO**, Rock 1-2. **TEXTURE** describes the size of the minerals that make up a rock. Place a checkmark next to the texture listed below that best describes the textures of both granite and gabbro.

a. **GLASSY** texture, resembles glass--no minerals present _____

b. **APHANITIC** texture, minerals present but too small to see with unaided eyes _____

c. **PHANERITIC** texture, minerals seen with unaided eyes _____

Granite and gabbro both form when magmas of the appropriate compositions cool **SLOWLY**, within the Earth's crust or upper mantle, to become rocks. All igneous rocks formed from a magma that cooled slowly (in thousands to millions of years) have the same texture.

4. Examine Rock 2-2, **BASALT**. Place a checkmark next to the texture listed below that best describes the texture of basalt.

a. **GLASSY** texture, resembles glass--no minerals present _____

b. **APHANITIC** texture, minerals present but too small to see with unaided eyes _____

c. **PHANERITIC** texture, minerals seen with unaided eyes _____

Basalt forms when a magma of the appropriate composition extrudes onto the earth's surface (magma that extrudes onto the earth's surface is called lava by geologists) and cools quickly (in days or weeks). All igneous rocks formed from lava that cooled quickly have the same texture.

5. Examine Rock 2-1, **OBSIDIAN**. Place a checkmark next to the texture listed below that best describes the texture of obsidian.

a. **GLASSY** texture, looks like and is glass, no minerals are present _____

b. **APHANITIC** texture, minerals present but too small to see with unaided eyes _____

c. **PHANERITIC** texture, minerals seen with unaided eyes _____

Obsidian forms when a magma of any composition extrudes onto the earth's surface and cools instantly (in seconds or minutes).

Two other igneous rocks, **SCORIA**, the dark red rock marked with just a white spot and no number in your lab drawer, and **PUMICE (no specimen)**, also form when magma extrudes onto the earth's surface and cools instantly.

Does **SCORIA** have the same texture as obsidian? If you answer no, please describe how the texture of scoria differs from that of obsidian.

_____

_____

Place a check next to the texture listed below that best describes the texture of scoria, the porous dark red rock marked with a white spot.

glassy_____ aphanitic_____ phaneritic_____

cellular (tremendous # of tiny holes covering surface) _____

Both scoria and pumice are made of glass, just like obsidian, even though they don't look like glass. The holes in scoria and pumice form when large amounts of gas escape from lava as it is cooling instantly, and the holes mark where gas bubbles escaped.

6. From observations made thus far on the formation of granite, gabbro, obsidian, and basalt, briefly summarize the relationship of cooling rate to texture of an igneous rock.

The slower the cooling rate the _____ the size of the minerals in the rock. The faster the cooling rate the _____ the size of the minerals in the rock. Instant cooling can result in two different textures in an igneous rock, _____ and _____, even though the rock is always made of this substance: _____.

7. Basalt has the same mineral composition as gabbro. Considering the conclusion you reached in #6 above, did basalt solidify faster or slower than gabbro? _____

8. Did gabbro solidify faster or slower than obsidian? _____

9. Did obsidian solidify faster or slower than basalt? _____

10. Examine Rock 2-3, a rock termed **RHYOLITE**. Rhyolite has the same mineral composition as granite since it forms from the same magma type. Does rhyolite solidify faster or slower than granite?

_____

11. Identify the three igneous rocks in the small tray in your lab drawer by filling in the blanks in the table below.

Rock	Color Light, Interme-diate, Dark	Texture	Intrusive or Extrusive	Name
2-4				
2-5				
2-6				

Name:

Lab Unit 2

Part 2: Sedimentary Rocks

SEDIMENTARY rocks are formed by the accumulation of material derived from preexisting rocks of any type, including igneous rocks like the ones you have just worked with. A large flowchart in your lab drawer provides a summary of the processes involved in the formation of sedimentary rocks. Please note that the flowchart indicates that two distinct types of material result from weathering, solid weathered products and materials in solution. Solid weathering products are the materials that make up the **DETRITAL** sedimentary rocks and materials in solution make up the **CHEMICAL** sedimentary rocks. We will first examine detrital sedimentary rocks and their formation.

Please arrange the specimens labeled 2-7, 2-8, and 2-9, and the tray labeled 2-10 in front of you. These materials will be required in the following questions. Most sediments become detrital sedimentary rocks by the processes of **COMPACTION** and **CEMENTATION**. The mineral matter most commonly serving as cement to hold the sediments together: **IRON OXIDES**, **SILICA**, and **CALCITE**.

12. There are two iron-oxide minerals, **HEMATITE** and **LIMONITE**, which are common cementing agents in sedimentary rocks.

    a. Examine specimen 2-7. This is a piece of the mineral **HEMATITE**. Its most obvious and distinctive property is the color of its streak. Rub the hematite gently across the streak plate. The color of its streak is

    _____

    b. Examine specimen 2-8. This is a piece of **LIMONITE**. Its most obvious and distinctive property is also the color of its streak. Determine the color of limonite's streak.

    _____

It is easy to determine if hematite or limonite is the cement holding together a detrital sedimentary rock, for the colors of the streaks of those two minerals are the colors a sedimentary rock will be if it is held together by one of those minerals. You only have to observe the color of a sedimentary rock, **NOT DO** a streak test with it, in order to recognize whether or not hematite or limonite is the cement holding it together.

13. You have already become familiar in a previous lab exercise with the two other common cementing agents, silica and calcite. **SILICA**, familiar to you as the mineral **QUARTZ**, is a tough cement that bonds sediments together tightly. Sediments will not protrude, or stick out of, a sedimentary rock held together by silica. Thereby, a rock held together with silica will generally have a fairly smooth surface, although it may have sharp edges.

a. **CALCITE** should also be familiar to you from a previous exercise. Specimen 2-9 is a piece of calcite. You earlier learned two diagnostic properties of calcite, that it has a hardness of 3 and 3 directions of cleavage not at 90°.

b. Since it is often difficult or impossible to recognize those properties in a cement, another method must be used to recognize if calcite is the cementing agent in a rock. Place a small drop of dilute hydrochloric acid (HCl) on a clean surface of calcite and observe the reaction. Describe what you observed below and wipe off the specimen.

_____

c. Based on the observation you just made, what would be the best way to determine if calcite is the cementing agent of a rock?

_____

14. Tray 2-10 contains four rocks labeled A, B, C, and D. Complete the table below which concerns these four rocks and the sizes of their sediments, their names, and their cementing agents. Any sedimentary rock can be held together by any of the four cement types, thus for this question you are trying to determine the cement type for the rocks in Tray 2-10 only, **NOT** a general cement type that frequently serves as a cement for that type of sedimentary rock.

Rock	Sediment size	Rock Name	Cementing agent of *THIS* specimen
A	**GRAVEL**	**CONGLOMERATE**	limonite
B		**SANDSTONE**	
C	**SILT**	**SILTSTONE**	
D		**SHALE**	calcite

Now that you have had the opportunity to become familiar with the detrital sedimentary rocks and their properties, let us begin to look at the **CHEMICAL** sedimentary rocks. Chemical sedimentary rocks are made up of the materials that are carried away from the site of weathering in solution. These materials are then precipitated (crystallized out of the water) directly in the form of various minerals by organic or inorganic processes. These minerals are then lithified by cementation and/or compaction to become several different types of sedimentary rock.

15. Tray 2-11 contains three varieties of a chemical sedimentary rock called **LIMESTONE**. Place a drop of dilute HCL on any of the three specimens. Please wipe the acid off after you have made your observations. Based on your observations, what mineral is limestone composed of?

All limestones consist mainly of this mineral because limestones are characteristically composed of whole or broken fossils, the shells or skeletons of organisms, which are commonly composed of this mineral. When marine or freshwater organisms die, their shells and skeletons typically settle to the bottom of the body of water and are eventually compacted and cemented together to form limestone.

16. Specimen 2-12 is a piece of **CHERT**. Chert, like limestone, is a chemical sedimentary rock composed of fossils. Unlike limestone, the fossils that compose chert are made of silica and are commonly microscopic in size, so they cannot be seen with your normal eyesight. Chert is very easy to differentiate from other chemical sedimentary rocks because of the hardness of silica (quartz), which is 7. Due to the hardness of silica or quartz, chert is the only chemical sedimentary rock that will scratch glass. Try to scratch the glass plate with your specimen 2-12. Please complete the sentence below by checking the correct response as to your observation of trying to scratch the glass plate with 2-12.

Chert scratches the glass plate ___ barely ___ easily

Not all chemical sedimentary rocks form in the same manner as limestone and chert. Some form as a result of minerals precipitating directly from water as a result of pressure or temperature changes or processes like evaporation.

17. Specimen 2-13 is a piece of **ROCK SALT**, which is composed of the mineral **HALITE**, a mineral which you should be familiar with from a previous lab, which is a compound of sodium (Na) and chlorine (Cl), also known as sodium chloride or salt. Halite typically forms as the result of evaporation of sea

water. If large amounts of halite are lithified, rock salt is formed. Rock salt is usually relatively easy to recognize because of the properties of halite: color, hardness, and salty taste.

You needn't test the specimen to verify if it is salty or not, but do list the color and hardness of halite below:

_____

18. Specimen 2-14 is a piece of **ROCK GYPSUM**. Rock gypsum is a rock formed when large amounts of the mineral gypsum (a compound of calcium (Ca), sulfur (S), oxygen (O), and water) are lithified. It usually forms in the same manner as rock salt. You should already be familiar with the physical properties of the mineral gypsum because you determined them in a previous lab. As a review, one of its more useful properties is its hardness. Test the gypsum for hardness and write your answer in the blank that follows: _____. The hardness and granular appearance of rock gypsum are the two properties most useful for its identification.

19. Based on the properties of the four chemical sedimentary rocks just discussed, match the four rocks labeled A, B, C, and D in Tray 2-15 with their appropriate name in the table below.

Rock name	Rock in Tray 2-15
Limestone	
Chert	
Rock Salt	
Rock Gypsum	

Name:

LAB UNIT 3

METAMORPHIC

ROCKS

As you learned in lecture, **METAMORPHIC** rocks are rocks that are formed by the alteration of pre-existing rocks. The rocks that are altered are the **PARENT** rocks of the metamorphic rocks that are formed. You will be examining three different sedimentary rocks (parent rocks) and metamorphic rocks formed from them as a result of alteration by **HEAT**, **PRESSURE**, and **CHEMICALLY ACTIVE FLUIDS**, in questions 1 through 7.

1. Examine Rock 3-1. If you look closely, you will see that it is composed of small fragments of **FOSSILS**.

   a. What ***MINERAL*** is it composed of? (put HCl on it) _____

   b. Rocks composed of >50% of this mineral are called **LIMESTONE**, so that is what rock 3-1 is.

   c. Since it is a sedimentary rock composed of fossil pieces and fragments which don't fit tightly together, what type of fabric (how the minerals or sediments are arranged in a rock) does it most likely have (See p. 8, question 2, of lab unit 2 for description of these fabric types, if necessary)?

   ___interlocking ___granular ___parallel

2. Examine Rock 3-2. Although this rock looks much different than the previous rock, it really is another variety of the **SAME** rock as Rock 3-1. One major difference between the two is that the **FOSSILS** are fragmented to a much greater degree in Rock 3-2, and are not as easily recognizable as in Rock 3-1.

   a. The ***MINERAL*** in rock 3-2 is? (test with HCl) _____

   Based on the HCl test and fossils, Rock 3-2 is _____

   b. Although this is a sedimentary rock and does have the same fabric as Rock 3-1, the fabric of Rock 3-2 based on using just ordinary eyesight appears to also closely resemble the fabric of most igneous rocks, where minerals fit tightly together. The type of fabric of igneous rocks is called

   ___ interlocking ___ granular ___ parallel

3. Examine Rock 3-3. This is the ***METAMORPHIC*** rock called **MARBLE**.

   a. What mineral is it made of? _____

   b. Does it contain any obvious fossils? _____

c. Does its fabric look more like that of a sedimentary rock or an igneous rock? _____

4. Examine Rock 3-4. This is another sedimentary rock you should be familiar with.

   a. What is its name? _____ b. What is its fabric? _____

   c. What mineral is it made of? _____

   d. What type of cement holds it together? _____

5. Examine Rock 3-5. This is a ***METAMORPHIC*** rock called **QUARTZITE** that forms when sedimentary rocks of the type like Rock 3-4 are altered by heat and pressure.

   a. What mineral is it made of? _____

   b. What type of fabric does it appear to have? _____

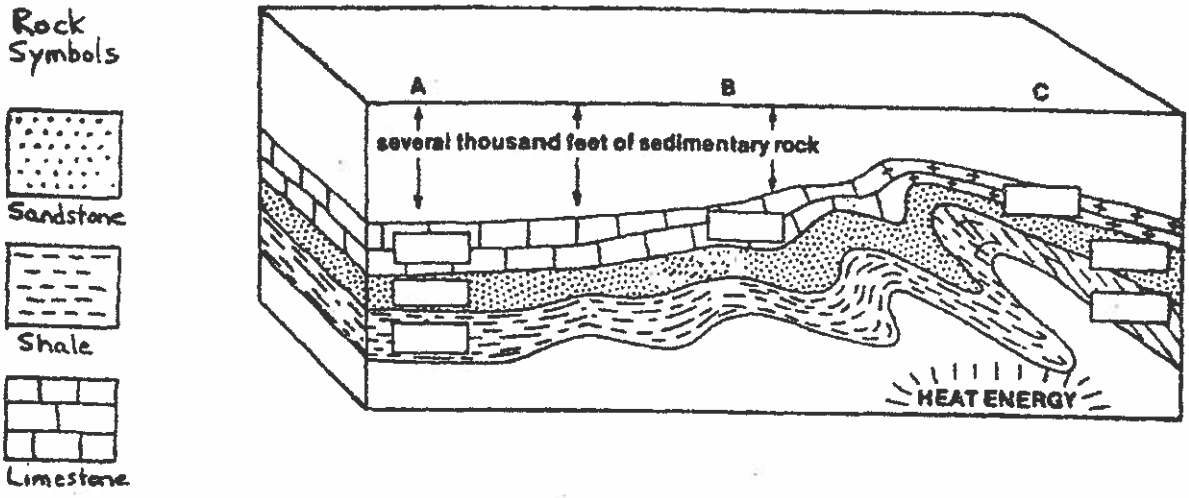
6. Examine Rock 3-6. This is another rock that you should be familiar with from a previous lab unit. It is the sedimentary rock called _____, consisting of clay-sized sediments. It tends to break into chips or flakes parallel to the bedding of the rock.

7. Examine Rock 3-7. This is a ***METAMORPHIC*** rock called **SLATE** that forms when sedimentary rocks of the type like Rock 3-6 are subjected to low-grade metamorphism, or temperatures and pressures that are fairly low, but still different enough from those under which the parent rock formed to cause metamorphism. What is the texture of Rock 3-7?

   ____ aphanitic ____ phaneritic ____ glassy

   SLATE also breaks into flakes or even sheets, but NOT parallel to the bedding of the rock. Instead, slate splits along layers that are parallel to its ***FOLIATION***, which is the type called ***ROCK CLEAVAGE***. ***FOLIATION*** is the alignment of all of the minerals in the rock into parallel sheets or rows at right angles to the pressure that was responsible for the metamorphism.

8. The block diagram below shows a region that is underlain by all of the rock types you have examined in the previous questions. Please complete the diagram by placing the numbers of the rocks you have looked at so far, rocks 3-1 through 3-7, into the proper boxes on the diagram. Make sure that the rock is the same type of rock as indicated by the rock symbols for the layer you are placing it in, or is a metamorphic rock that would form from that parent rock indicated by that rock symbol. Horizontally-layered rocks have generally not been metamorphosed, whereas folded or bended rock layers have generally been metamorphosed.



9. Of the seven specimens studied so far in this exercise, how many are:

   sedimentary? ____ metamorphic? ____

   transitional between sedimentary and metamorphic? ____

10. All of the metamorphic rocks we have examined so far have been formed from parent rocks that consisted mainly or exclusively of one type of mineral. Examine Rock 3-8, which is a ***METAMORPHIC*** rock formed from a parent sedimentary rock consisting of ***TWO*** types of minerals.

    a. What is the major mineral in Rock 3-8? (use test kit) _____

    b. If this were the only mineral in this rock, what would be the name of this rock and what would be its parent rock?

    _____

c. Another mineral that is present in Rock 3-8 is **MICA**, either the type you have seen in an earlier exercise called biotite, or a different lighter-colored variety called **MUSCOVITE**. What mineral below must have been present in the parent rock of Rock 3-8 to metamorphose and form the mica now visible in Rock 3-8?

____ quartz ____ clay ____ feldspar ____ dolomite

11. Rocks 3-9, 3-10, 3-11, and 3-12 are all ***METAMORPHIC*** rocks that could have formed as a result of ***REGIONAL*** metamorphism of ***SHALE***. They differ in appearance mainly because they formed at different **GRADES** (pressure and temperature) of regional metamorphism.

a. Examine Rock 3-9. This is the metamorphic rock called **PHYLLITE**, which forms at ***LOW***-grade regional metamorphism and consists of mica. What is the texture of the mica?

____ aphanitic ____ phaneritic

Compare/contrast and distinguish between Rocks 3-9 and 3-7 (slate; also forms under ***LOW***-grade regional metamorphic conditions):

_____

_____

b. Rocks 3-10 and 3-11 are **SCHISTS**, which formed at ***INTERMEDIATE*** grades of regional metamorphism. The most abundant mineral in both is _____

Both Rocks 3-10 and 3-11 may also contain feldspar and quartz. Rock 3-11 consists of a mineral not found in Rock 3-10, called ***GARNET***. Garnet is the fairly large dark red or purple mineral present.

c. The biggest difference between Rocks 3-7 and 3-9 and Rocks 3-10 and 3-11 is ***TEXTURE***. The ***TEXTURE*** of Rocks 3-10 and 3-11 is

____ glassy ____ aphanitic ____ phaneritic

d. The ***FOLIATION*** of Rocks 3-10 and 3-11 is best described as:

____ rock cleavage ____ schistosity (sheets of minerals)

____ banding (minerals in light and dark layers

e. Rock 3-12 is a **GNEISS**, which forms at ***HIGH*** grades of regional metamorphism. List three minerals that make up this rock (hint: they're common minerals you've seen before)

_____

Shale is not the only parent rock of gneiss. In fact, shale is probably ***NOT*** the most important parent rock of gneiss. Based on the minerals you recognized in Rock 3-12, what is the ***MOST COMMON*** parent rock of gneiss (it is made of the same three minerals and you viewed it in a previous lab)?

_____

f. Now that you have examined Rocks 3-9, 3-10, 3-11, and 3-12, which of the following best describes the textural changes that occur going from ***LOW***-grade to ***HIGH***-grade metamorphism (***HINT: Compare just*** 3-9, 3-10, and 3-12 to best see trend)?

____ minerals stay the same size

____ minerals get larger in size

____ minerals get smaller in size

Therefore, the ***HIGHER*** the grade of metamorphism, the _____ the minerals become.

12. Examine plastic sheet A and all rocks labeled A- (numbers refer to same numbers on plastic sheet A). Keeping in mind what causes ***METAMORPHISM*** (heat and pressure: ***PRESSURE FOLDS OR TILTS ROCKS***), that ***IGNEOUS ROCKS*** form from magmas that ***CUT THROUGH ROCKS*** on their way toward the surface, and that ***SEDIMENTARY ROCKS*** form from sediments that are deposited in ***HORIZONTAL LAYERS***, which rocks on plastic sheet A are

igneous: _____

sedimentary: _____

metamorphic: _____

Name:

UNIT 4A

CONTINENTAL DRIFT
REQUIRED COMPUTER LAB

&

UNIT 4B

PLATE TECTONICS
OPTIONAL COMPUTER LAB

The following lab, Unit 4A is a required computer lab on **CONTINENTAL DRIFT**, a hypothesis/theory developed by Alfred Wegener that was quite similar to the current theory of **PLATE TECTONICS**. The answers to all of the questions that follow are found in *The Theory of Plate Tectonics*, a CD-ROM written by Edward J. Tarbuck and Fred Lutgens. The Department of Geological Sciences of The Ohio State University at Lima has a site license for this CD-ROM, so all you need to do to complete this optional lab is to go to the geology computer lab (room 110 in Science Building) and access the **ADVANCED VERSION** of *The Theory of Plate Tectonics*. Just click on the Plate Tectonics icon on the Desktop window and choose the **ADVANCED VERSION**. Click on the Introduction section and please read/listen to the 15 screens that comprise it. Then read/listen to Continental Drift: An Idea Before Its Time section (screens 16-62). Please answer the questions in the Review section (Screens 63-83) at the end of Continental Drift: An Idea Before Its Time.

INTRODUCTION
(No questions to answer; just read/listen to screens)

CONTINENTAL DRIFT: AN IDEA BEFORE ITS TIME
(Read/Listen to screens 16-62; Answer questions in screens 63-83)
You may simply write down the letter of the correct answer(s) if the responses are lettered.

Screen 63. What was Pangaea? _____

64. When did Pangaea exist? _____

65. Who proposed the continental drift hypothesis? _____

66. Which of the following are evidence that support Wegener's continental drift hypothesis? _____

67. Wegener's hypothesis was accepted shortly after his work was translated into other languages _____

68. The best fit of South America and Africa is found by using _____

69. One of the reasons Wegener's hypothesis was rejected was _____

70. Why do scientists rule out a major cooling period on Earth as the explanation for ancient glaciation in Australia? _____

71. Why don't scientists think *Mesosaurus* swam freely from South America to Africa? _____

72 & 73. Follow directions on screens; no written answers needed.

74. During the breakup of Pangaea, the North Atlantic opened up before the South Atlantic. True or false? _____

75. The separation of North America from Africa marked the opening of the North Atlantic Ocean.
When did this occur? _____

76. When did South America completely separate from Africa to form the South Atlantic? _____

77. What general path does India take during the last 100 million years of Earth's history? _____

78. In what general direction has Africa traveled over the past 100 million years? _____

79. During the last 20 million years or so, what sea formed as a result of the separation of Africa and the
Arabian Peninsula? _____

80. What is the name of the chain of islands and seamounts shown in the Pacific Ocean? _____

81. When did the first islands in this chain form? _____

82. Where was Australia located 135 million years ago? _____

83. When did the continents of North and South
America rejoin? _____

This is the end of Lab Unit 4A. The lab unit that follows, Lab Unit 4B is optional, it is ***NOT*** required.

The following lab, Unit 4B, is an optional computer lab on plate tectonics for anyone that might want/need additional information and exercises to better understand this very important theory. You are ***NOT REQUIRED*** to do this lab. However, anyone that does complete this lab will not only gain a better understanding of the theory of plate tectonics, but will also receive extra credit toward the lab portion of their grade in Geological Sciences 100. The answers to all of the questions that follow are found in *The Theory of Plate Tectonics*, a CD-ROM written by Edward J. Tarbuck and Fred Lutgens. The Department of Geological Sciences of The Ohio State University at Lima has a site license for this CD-ROM, so all you need to do to complete this optional lab is to go to the geology computer lab (room 110 in Science Building) and access the advanced version of *The Theory of Plate Tectonics*. Just click on the Plate Tectonics icon on the Desktop window and choose the **ADVANCED VERSION**.

4 Plate Tectonics: The New Paradigm
(Read/Listen to screens 148-171)
(Answer questions in screens 172-187)
You may simply write down the letter of the correct answer(s) if the responses are lettered.

Screens 172 & 173. Follow directions on screens. No written answers are required.

174. Most of the largest plates _____

175. Which of these plates are composed mostly of oceanic crust? _____

176. According to the plate tectonics model _____

177. All major interactions between plates occur _____

178. The earth's rigid outer layer is called _____

179. The earth's rigid outer layer overlies a zone of weaker and hotter material known as _____

180. Which layer of the earth allows the plates to move? _____

181. The lithosphere is thickest under the oceans and thinnest beneath the continents _____

182. Which of these plates is the largest? _____

183. Plates remain exactly the same size and shape thru time _____

184. Divergent plate boundaries are located where _____

185. Transform fault plate boundaries are located where _____

186. Convergent plate boundaries are located where _____

187. Which of these plates is decreasing in size as it evolves? _____

5 Divergent Plate Boundaries
(Read/Listen to screens 189-218)
(Answer questions in screens 219-225)
You may simply write down the letter of the correct answer(s) if the responses are lettered.

219. Plates are moving apart at _____

220. New oceanic crust is created at divergent boundaries at a rate of about _____

221. Most divergent boundaries are located _____

222. Follow directions on screen. No written answer is required.

223. Which of these bodies of water provides scientists with a view of how Atlantic Ocean may have looked in its infancy? _____

224. The primary reason for the elevated position of the oceanic ridge system is that _____

225. Which of these is NOT an active spreading center? _____

6 Convergent Plate Boundaries
(Read/Listen to screens 227-242)
(Answer questions in screens 243-247)
You may simply write down the letter of the correct answer(s) if the responses are lettered.

243. Convergent plate margins occur where two plates are moving toward one another and the movement is accommodated by _____

244. Subduction occurs because: _____

245. Older oceanic lithosphere is cooler, thicker, and denser than young oceanic lithosphere _____

246. Why doesn't lithosphere capped with continental crust descend to any great depth in Earth? _____

247. Which of these diagrams best illustrates subduction of a buoyant slab of oceanic lithosphere? _____

7 Transform Fault Boundaries
(Read/Listen to screens 345-366)
(Answer questions in screens 367-372)
You may simply write down the letter of the correct answer(s) if the responses are lettered.

367. Which of these are true about transform faults? _____

368. Which of the two arrows indicates the direction of the transform fault motion? _____

369. Transform faults are part of linear breaks in the oceanic crust called _____

370. Great earthquakes can be generated at transform fault boundaries _____

371. Which of the following are characteristics of the San Andreas Fault? _____

372. Along the San Andreas Fault, the Pacific plate is moving toward the northwest, relative to the North American plate _____

9 What Drives Plate Motions
(Read/Listen to screens 484-507)
(Answer questions in screens 508-512)
You may simply write down the letter of the correct answer(s) if the responses are lettered.

508. The main force driving Earth's plates appear to be _____

509. Which one of these forces counteracts plate motion? _____

510. Match the following:

A form of gravity sliding caused by the elevated position of ocean ridge material _____

Driven by oceanic lithosphere that is cool and dense enough to sink into the asthenosphere _____

Consists of large cells in which warm, less dense material rises and cooler, dense material sinks _____

Consists of narrow zones of upward flow of hot material _____

511. Where are most mantle plumes thought to originate? _____

512. Why is the mechanism that drives Earth's plates sometimes called plate-mantle convection? _____

Name:

UNIT 5A

INTRODUCTION

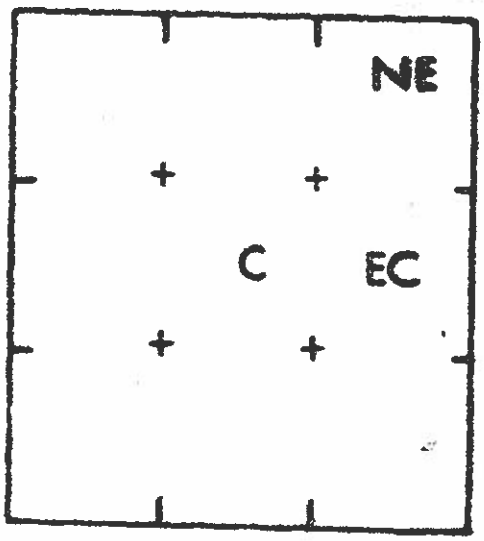
TO

TOPOGRAPHIC MAPS

UNIT 5B

TOPOGRAPHIC MAPS
OPTIONAL COMPUTER LAB

Topographic maps are a type of map that is quite useful in the earth sciences because they provide information on the three-dimensional appearance of the surface of the earth, as well as additional useful information. There will be a lecture about topographic maps during lab period prior to answering any of the questions listed below or on the following page. Any topographic map (also called a quadrangle) can be conveniently divided into a nine-fold grid, each part which is termed a rectangle, by using latitude and longitude lines. You need not understand latitude and longitude at all, however, to be able to use this method of location on a map. Common corners of the nine rectangles are shown on the map below by + marks. The rectangles are convenient to use in locating points or features on topographic maps, and are used in lab units 6, 7, and 8. On the map below, NE = northeast , C = central, and EC = east-central. Complete the map by adding abbreviations for the remaining six rectangles.



All of the following questions refer to the Bellbrook Quadrangle

1. What is the contour interval of the map?

2. In what grid/rectangle is Kettering located?

3. Where is Beaver Creek located (what grid/rectangle)? What direction is Beaver Creek flowing? What body of water is Beaver Creek flowing into?

4. In what grid/rectangle is the town of Bellbrook located? Was Bellbrook's Township School built before 1965?

5. Most of the forested areas on the map are associated with what type of feature?

6. Where is Bellbrook High School? Was it built before 1965? Most of the buildings of that high school are at what elevation above sea level?

7. In which grid/rectangle are the highest elevations found? What is the highest elevation you can find anywhere on the map?

8. In what grid/rectangle are 'The Narrows' State Scenic River Reserve located? What river are they associated with? Are the slopes in the immediate vicinity of 'The Narrows' steeper or gentler than those in the immediate vicinity of Beaver Creek?

9. What major highway was still under construction in this region in 1987?

This is the end of Lab Unit 5A: Introduction to Topographic Maps. If you would like more information, as well as a review of the information already presented on topographic maps, you may also do the following lab, unit 5B: Topographic Maps. It is not a lab that you are required to do, however.

The following lab, unit 5B is an optional computer lab based on a CD-ROM program, Introduction to Topographic Maps version 2, that may be accessed in the geology computer lab (room 110, Science Building). It is ***NOT REQUIRED***. It is recommended that if you do choose to do this lab, you complete it prior to doing lab units 6, 7, and 8, which require the ability to understand and use topographic maps. This optional lab is intended to provide an even more detailed coverage of topographic maps than is possible during regular lab time, and may help students who would like or need more information on topographic maps or a review of the information covered during regular class time. Much like the previous optional computer lab, also based on a CD-ROM which the School of Earth Sciences at The Ohio State University at Lima has the site license for, Introduction to Topographic Maps is divided into a number of parts. You need only read the material and answer the questions in the following parts to receive the extra credit for doing this lab: Introduction, General Topographic Map Information, Map Scale, Principle of Contour Lines, Using Contour Lines, and Review.

Introduction

There are no questions in this part, but please read through all of the introduction anyway.

General Topographic Map Information

Skip to #36 and please read and look over map symbols for Roads and Related Features, Control Data and Monuments, and Rivers, Lakes, and Canals.

37. Please drag the answers to their appropriate boxes.

40. Please drag the answers to their appropriate boxes.

47. What is the name of the river illustrated in the southeast corner of this topographic map? _____

Map Scale

Please read #s 50-62 and then answer the following:

63. How many miles on the Earth does the width of this topographic map cover? _____

64. How many kilometers on the Earth does the width of this topographic map cover? _____

67. Which of the maps covers the largest area? _____

68. Which of the maps has the most detail? _____

Principle of Contour Lines

Please read #s 143 to 165 and then answer the following:

166. What is the highest contour line elevation of the land shown on the area represented by this topographic map? _____

167. What is the lowest contour line elevation of the land shown on the area represented by this topographic map? _____

170 & 171. Locate Salt Creek. Direction it is flowing: _____

Using Contour Lines

Please read #s 174-176 and then answer the following:

177. Contour interval used? _____

178. Indicate the correct elevation for the following points:

point A _____ point B _____ point C _____ point D _____

183. What is the local relief (difference) between the top of Mt. San Carlos and the bench mark (BM) in the northwest corner of this map? _____

187. What is the slope along slope B? _____

Review

Please answer the following:

226. What type of roadway is illustrated? _____

235. Toward what direction is stream A flowing? _____

236. Toward what direction is stream B flowing? _____

237. Slope of stream B from its head to its mouth? _____

Name:

UNIT 6

THE GEOLOGIC WORK

OF

RUNNING WATER:

LANDSCAPES

Refer to the **FRANKSTOWN QUADRANGLE** for the following questions.

1. Compare the slope on the NW side of Lock Mountain with the slope on the SE side, then answer the following:

a. The more smooth and even slope is on the _____ side.

b. The rougher and more stream-dissected slope is on the

_____ side.

c. Which side is more uniformly forested (green)? _____

2. The blue lines used on the map to show streams on the SE side of Lock Mountain are dashed, indicating intermittent streams.

a. all of which flow into the body of water called

_____, which flows

b. ____ N/NE ____ S/SW ____ E/SE ____ W/NW

3. The drainage pattern of the region **SOUTHEAST** of Lock Mt. formed by those streams and that body of water is called

a. ____ dendritic ____ trellised ____ radial ____ rectangular

4. What does this type of drainage pattern suggest about the type and structure of bedrock in the region?

_____

_____

_____

The following questions (5-14) all refer to the geographic region called the Colorado Plateau. The first part of the region we will examine is shown on the **SODA CANYON QUADRANGLE**.

5. What type of regional drainage pattern do you observe?

____ dendritic ____ trellised ____ radial ____ rectangular

What does this type of regional drainage pattern usually indicate about the type and structure of the bedrock underlying the region?

_____

6. Which of the following best describes the appearance of the valleys of the **TRIBUTARIES north** of the Mancos River in the NW rectangle?

_____ wide floodplains with meandering rivers and oxbow lakes

_____ extremely wide floodplains, swamps, parallel tributaries

_____ narrow or no floodplains

7. Based on your answer to #6 above, what is the stage of valley development of the tributaries?

_____ youth _____ maturity _____ old age

Please refer to the **MEXICAN HAT QUADRANGLE** for the following questions.

8. Note that the San Juan River has a meandering path or channel pattern throughout much of its path across the region, especially in the northwest quarter of the quadrangle. If the **ONLY** information available to you about the valley of the San Juan River was a view from an airplane at 30,000 feet of the **PATH** or **COURSE** of the river in that valley, what would be the determination you would have to make about the stage of valley development for the San Juan River valley in this area?

_____

9. How would you characterize the appearance of the San Juan River valley if you were in a boat on the river looking upriver or downriver, given the choices below?

_____ wide floodplains with meandering rivers and oxbow lakes

_____ extremely wide floodplains, swamps, parallel tributaries

_____ narrow or no floodplains

10. Based **SOLELY** on your answer to #9 above and not the information in #8, what stage of valley development is the San Juan River valley in?

_____ youth _____ maturity _____ old age

11. Are your answers to questions 8 and 10 above the same? _____

12. What stage of valley development is the San Juan River valley actually in, and what may have occurred in this area to cause this?

_____

_____

Please refer to the **BRIGHT ANGEL QUADRANGLE** for the following questions.

13. The Colorado River has cut the deep valley of the Grand Canyon during the past **10 MILLION YEARS**. Based on the shape of the valley, what stage of valley development must the Grand Canyon actually be in?

____ initial ____ youth ____ full maturity

____ old age ____ rejuvenation

14. What is the likely reason for the Grand Canyon to be in that stage of valley development? (Hint: the Grand Canyon is in the same stage as the valley of the San Juan River)

_____

_____

What is the drainage pattern for this region? (Hint: although it may be difficult to determine drainage pattern by looking at the map, the rocks exposed in the walls of the Grand canyon are in horizontal layers)

_____ dendritic _____ trellised _____ radial _____ rectangular

Please refer to the **DUBLIN QUADRANGLE** for the following.

15. The path of the Scioto River and the shape of its valley indicate that the Scioto River Valley is the stage of valley development known as

____ youth ____ maturity ____ old age ____ rejuvenation

16. The path of the Olentangy River and the shape of its valley indicate that the Olentangy River Valley is largely in the stage of valley development known as

____ youth ____ maturity ____ old age ____ rejuvenation

17. Which of the two river valleys appears to have been developing for the greatest length of time? What is the basis for your answer?

_____

_____

Please refer to the **NASHUA QUADRANGLE** for the following.

18. WEST and SOUTHWEST of Nashua in the C rectangle are two curved depressions, one of which still has water in it. The same type of depression, still filled with water, is located just WEST of the word RIVER in the WC rectangle. What are these features called?

_____

19. Just SOUTH of the word RIVER in the SE rectangle is a sediment deposit (many small brown dots) on the inside of one of the bends the Missouri River makes. What type of feature is this sediment deposit?

_____

20. The small island in the Missouri River in the SE rectangle, just NORTH of Nichols Ranch is probably what type of feature? How did it most likely form?

_____

_____

21. The Milk River and Missouri River are located in valleys that are in the stage of development known as _____.

Name:

UNIT 7

THE GEOLOGIC WORK

OF

GLACIERS:

LANDSCAPES

Refer to the **CHIEF MOUNTAIN QUADRANGLE** for the following:

1. The top of Mt. Logan (SE rectangle) is an example of what type of alpine or valley glaciation **EROSIONAL** landform?

_____

2. Kaina Lake (NC rectangle) is located in what type of alpine or valley glaciation **EROSIONAL** landform? _____ Since Kaina Lake is located in that type of landform, Kaina Lake is a good example of this type of alpine or valley glacier feature with this name: _____.

3. Ptarmigan Wall (southern part of NC rectangle) is located between Belly River Valley and Ptarmigan Creek Valley. What type of valley glaciation **EROSIONAL** landform is it an example

of? _____

4. Appekunny Falls on the creek by that name in the upper east-central (upper middle right-hand side) part of the map and an unnamed falls on Allen Creek just south of Appekunny Creek are located in what type of valley glacial **EROSIONAL** landform?

_____

5. Glenns Lake (NC rectangle) and Lake Sherburne (EC rectangle) are found in what type of valley glacial **EROSIONAL** landform? How can you differentiate this type of landform from a stream-eroded landform?

_____

_____

6. Do you think that Grinnell and Swiftcurrent Glaciers in the central part of the map were ever larger than they are today? What evidence do you have to back up your answer?

_____

_____

_____

_____

Refer to the **CATO, NEW YORK QUADRANGLE** for the following:

7. Parker Pond, Mud Pond, and Otter Lake are probably examples of what type of continental glaciation landform or feature? How were they formed?

_____

_____

8. Southwest of Bethel Corners in the NW rectangle are several elongate hills. What kind of continental glaciation **DEPOSITIONAL** landform are they? Would the sediment in them be sorted or unsorted? If you look at all of the quadrangle map you will see these features almost everywhere. What do they tell you about where the ice sheets or continental glaciers came from that deposited them?

_____

_____

_____

9. Just north of the intersection of Emerick and Southard Road in the EC rectangle is a hill that may have a different origin than most of the elongate hills on the map. What continental glaciation **DEPOSITIONAL** landform might it be? Would the sediments that make it up be sorted or unsorted?

_____

10. The rock labeled 7-1 comes from the top layer of bedrock in a quarry located in the area shown on CATO, NEW YORK QUADRANGLE. What type of glacial feature does the rock display, if any?

_____

11. If rock 7-1 was still part of the top layer of bedrock in that quarry, would it provide any information about glacial movement in that area, and if yes, what information?

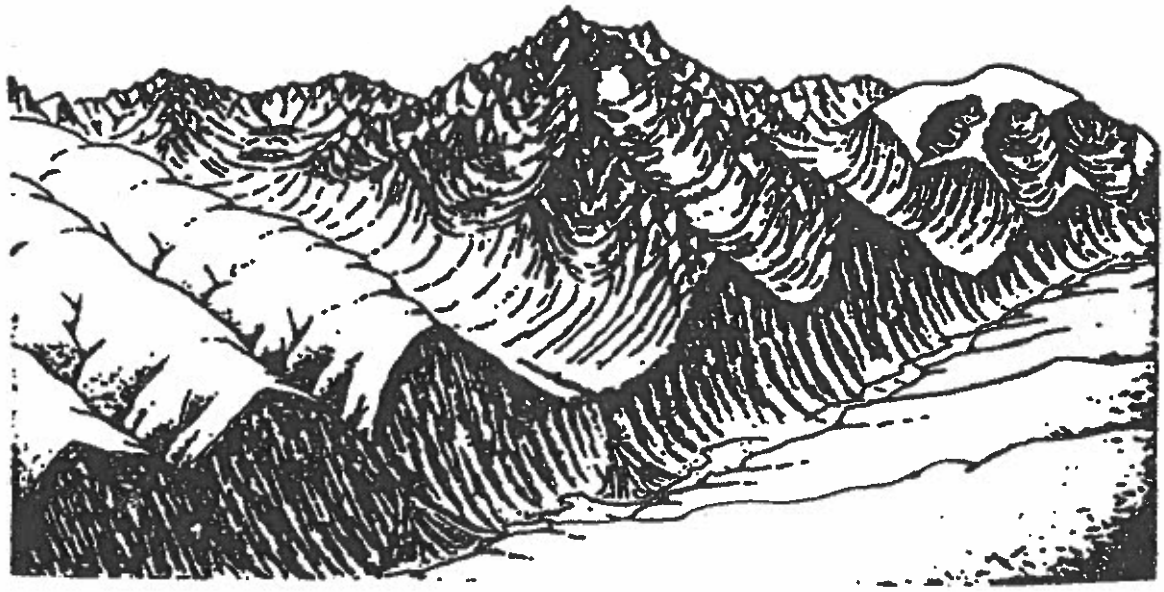
_____

12. Are the sediments in jar 7-2 more likely to have been found in the hills mentioned in question 8 or the hills mentioned in question 9 above? What is the reason for your answer?

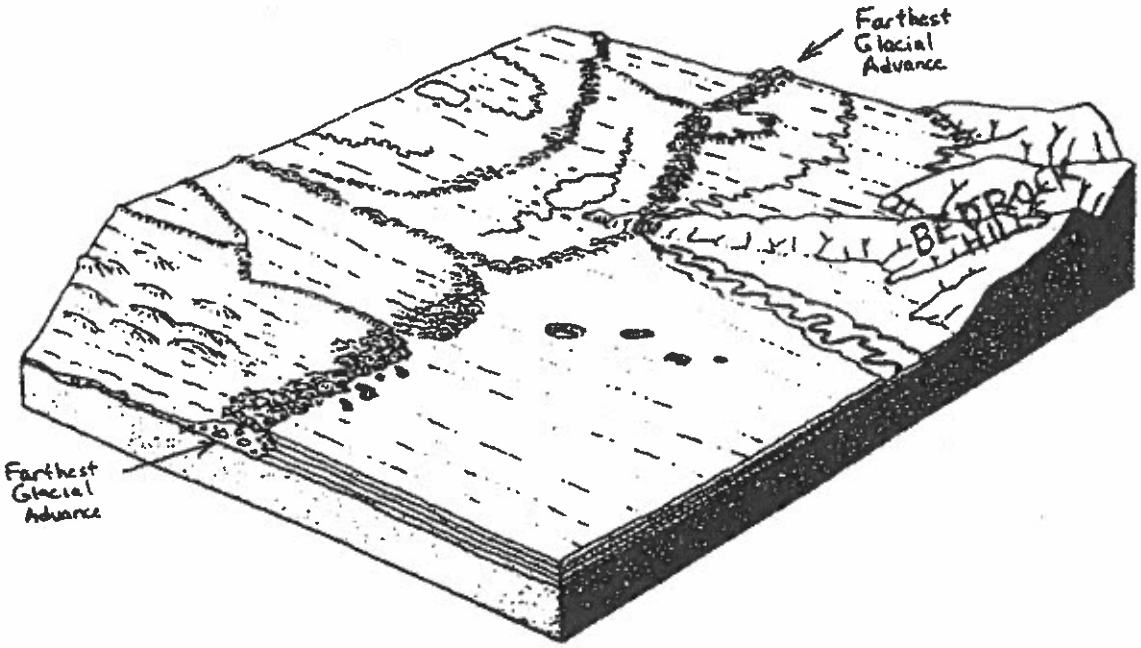
_____

_____

13. Label the following **EROSIONAL** landforms on the diagram below:
U-shaped Valley, Hanging Valley, Cirque, Horn, Arete



14. Label the following **DEPOSITIONAL** features on the diagram below. Please **UNDERLINE** all OUTWASH deposits: Terminal Moraine, Drumlin, Kettle, End Moraine, Till Plain, Esker, and Outwash Plain.



Name:

UNIT 8

RELATIVE AGE

DETERMINATIONS

AND THE

GRAND CANYON

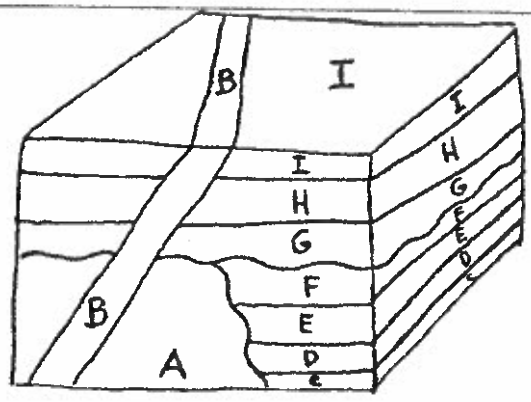
All of the previous lab units in this manual were concerned with aspects of **PHYSICAL** geology. In this unit and all remaining units we will be concerned with the other major division of geology, **HISTORICAL** geology. **HISTORICAL** geology is concerned with the history of the Earth and how it has changed through time; it is also concerned with the history of life on Earth. What we know about Earth history has been reconstructed by examining the rock record. In order to determine a history from the rock record, the events those rocks represent must be ordered, so we know what took place first, what took place second, etc. **RELATIVE AGE DETERMINATION** is a process that accomplishes just that. All that is needed to be able to do relative age determinations of rocks within limited regions are a few simplistic principles. These principles should have been covered in lecture by now. A brief summary of the three principles follows:

PRINCIPLE OF ORIGINAL HORIZONTALITY: All sedimentary rock beds are initially formed in horizontal or nearly horizontal layers. If the beds are now tilted or folded, the tilting or folding represents something that happened **AFTER** the original formation of those beds.

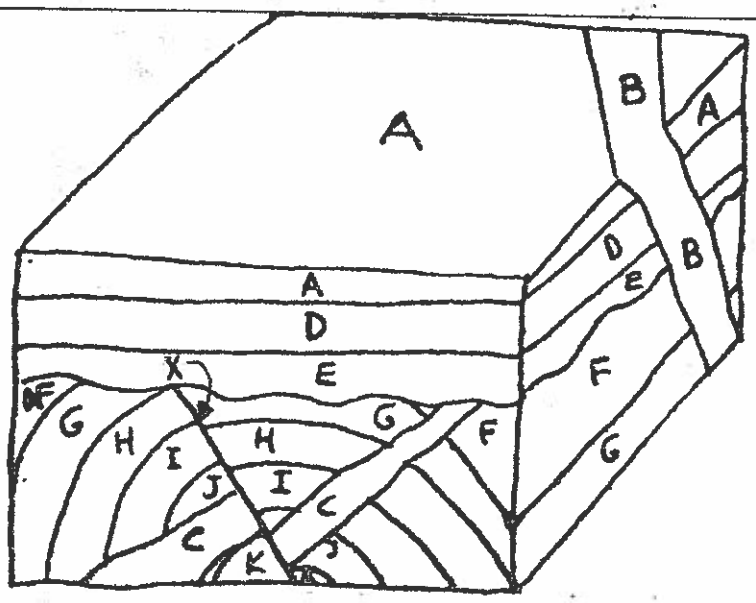
PRINCIPLE OF SUPERPOSITION: **OLDEST** rocks are always on the **BOTTOM** of a sequence and **YOUNGEST** rocks on the **TOP** of that sequence.

PRINCIPLE OF CROSS-CUTTING RELATIONSHIPS: Any rocks which cut across other rocks must be **YOUNGER**, or have come after, the rocks they cut across.

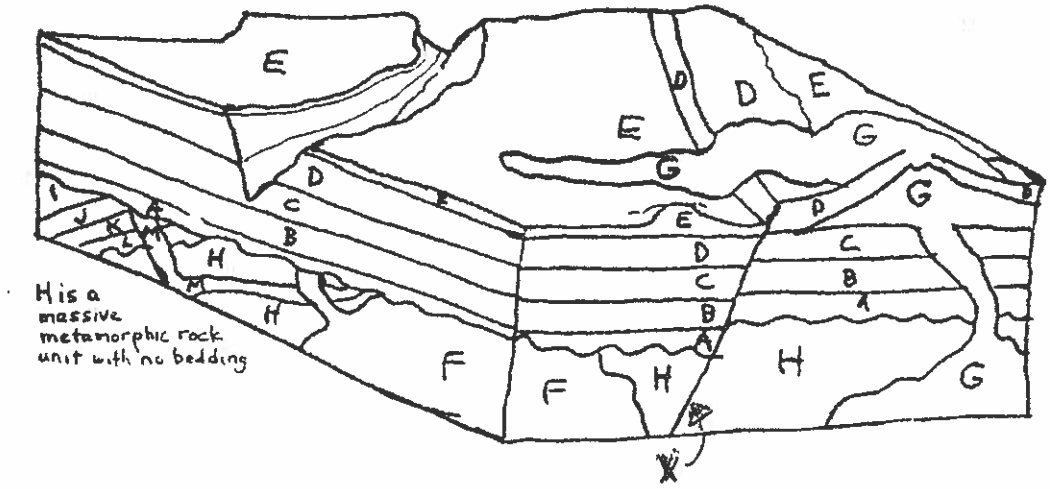
1. Determine the relative ages of the rock units in the diagram below by ordering the events (letters) on the line below, oldest to youngest, left to right. Draw an arrow to any **UNCONFORMITIES** and label with the name for the specific type it represents (**ONLY** if types of unconformities were covered in lecture prior to this lab).



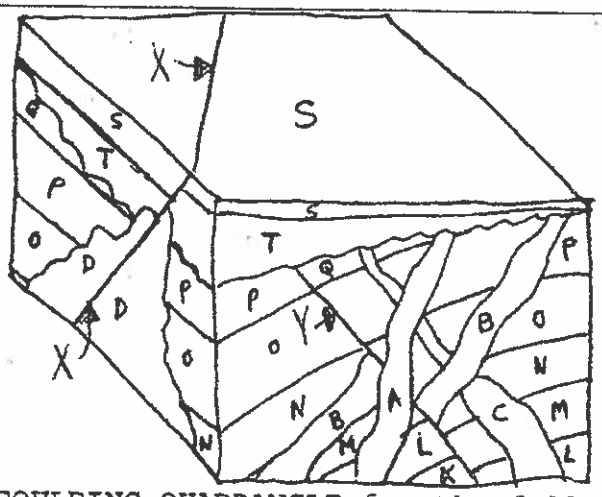
2. Determine the relative ages of the rock units in the diagram below by ordering the events (letters) on the line below, oldest to youngest, left to right. Draw an arrow to any **UNCONFORMITIES** and label with the name for the specific type it represents (**ONLY** if types of unconformities were covered in lecture prior to this lab).



3. Determine the relative ages of the rock units in the diagram below by ordering the events (letters) on the line below, oldest to youngest, left to right. Draw an arrow to any **UNCONFORMITIES** and label with the name for the specific type it represents (**ONLY** if types of unconformities were covered in lecture prior to this lab).



4. Determine the relative ages of the rock units in the diagram below by ordering the events (letters) on the line below, oldest to youngest, left to right. Draw an arrow to any **UNCONFORMITY** and label with the name for the specific type it represents (**ONLY IF TYPES OF UNCONFORMITIES WERE COVERED IN LECTURE PRIOR TO THIS LAB**).



5. Refer to the **GOULDING QUADRANGLE** for the following.

a. Examine the elevations of several points on the NE edge of Douglas Mesa in the NE rectangle. It is fairly clear that the rocks immediately underlying the mesa are at _____ the rocks immediately underlying the plateau at the top edge of the inner canyon of the San Juan River valley.

____ the same elevation as ____ a lower elevation than

____ a higher elevation than

b. Therefore, according to the Principle of Superposition, if all of those rocks are horizontal sedimentary rocks, the rocks immediately underlying Douglas Mesa are what in relation to the rocks immediately underlying the plateau at the top edge of the inner canyon of the San Juan R. valley?

____ younger than ____ the same age as ____ older than

c. Examine some of the elevations of Eagle Mesa and Sentinel Mesa in the southern part of the map area. The rocks immediately underlying Eagle and Sentinel Mesas are _____ the rocks immediately underlying Douglas Mesa.

____ the same elevation as ____ below ____ above

d. The youngest rocks in the region are thereby the rocks immediately underlying

____San Juan River valley ____ Douglas Mesa ____ Eagle Mesa

Refer to the **BRIGHT ANGEL QUADRANGLE** for the following.

6. The largest and most famous of all the canyons on the Colorado Plateau, the Grand Canyon, can be seen on this quadrangle. Locate the following topographic features and determine their elevations.

   a. Yaki Point (NW corner of SE rectangle/spot elevation) _____

   b. Bright Angel Point (NE rectangle/spot elevation) _____

   c. Colorado River (C rectangle/contour crosses river) _____

7. Based on your answers to #6 above, the oldest rocks exposed in the Grand Canyon region should be located at/near

   _____

8. Based on your answers to #6 above again, the youngest rocks exposed in this portion of the Grand Canyon region should be located at

   _____

Name:

UNIT 9

PALEONTOLOGY

AND

FOSSIL

CLASSIFICATION

PALEONTOLOGY is the study of ancient life. Most of what we know about ancient life we have learned from **FOSSILS**, which are any direct indication of past life. Fossils are often subdivided into two major categories, **BODY FOSSILS** and **TRACE FOSSILS**. **BODY FOSSILS** are the remains or altered remains of organisms, whereas **TRACE FOSSILS** are the remains of life activities of organisms, like burrows, tracks, or trails.

Fossils are classified into major groups in many of the same ways that botanists and zoologists classify organisms. One way to classify organisms, including fossils, is by their **SYMMETRY**. **SYMMETRY** is the way that an organism can or cannot be split into two or more identical segments or parts. There are three basic types of symmetry:

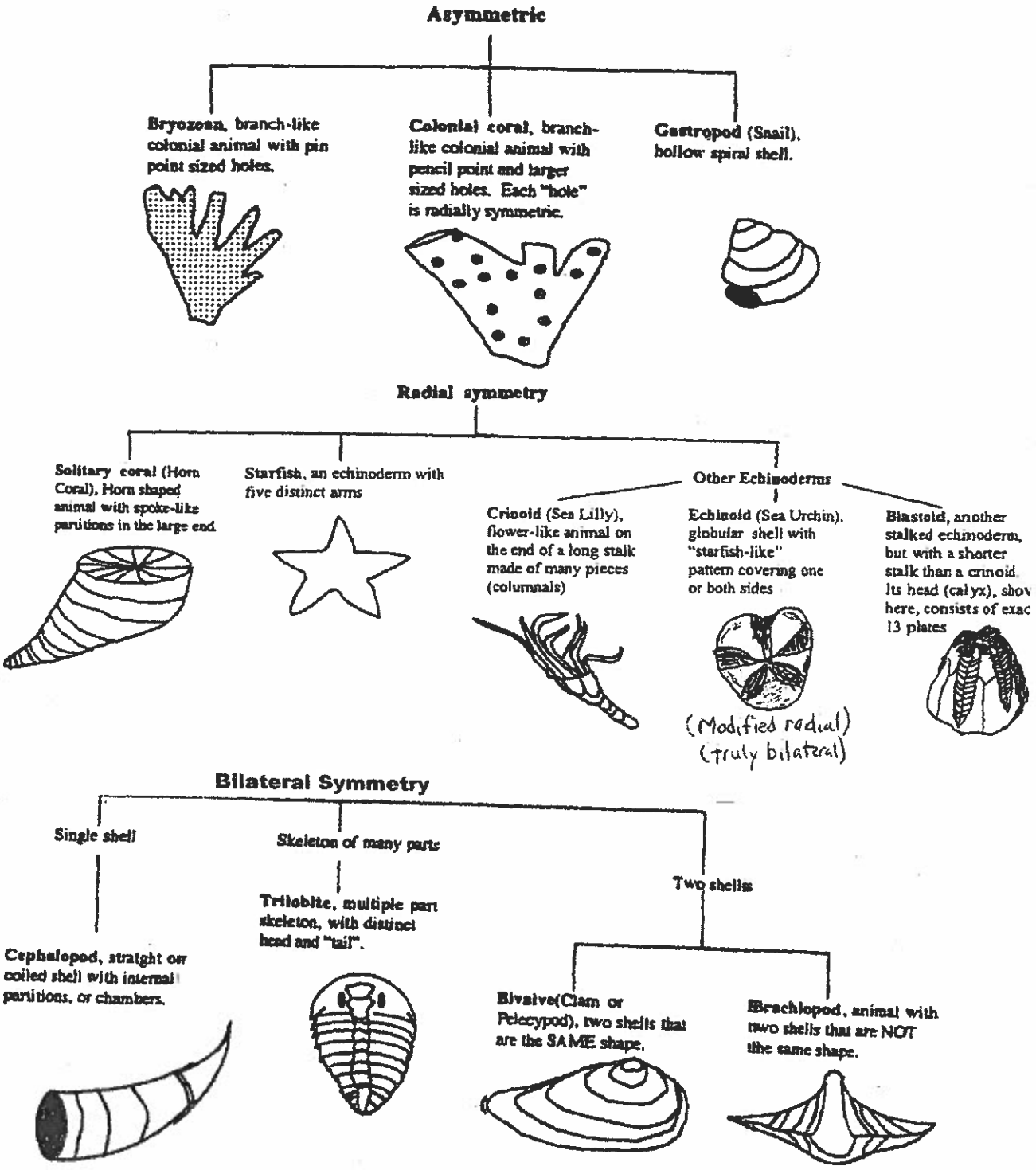
ASYMMETRY is a lack of symmetry. If a fossil has asymmetry, or is asymmetrical, it cannot be split into identical segments in any manner. See the bryozoan, colonial coral, and gastropod on the next page for examples of fossils that have asymmetry.

BILATERAL SYMMETRY is a type of symmetry in which an organism or fossil can be split along a plane to form two identical parts, or "mirror images." See the cephalopod, trilobite, bivalve, and brachiopod on the next page for examples of fossils that have bilateral symmetry.

RADIAL SYMMETRY is a type of symmetry in which an organism or fossil can be split or divided into many identical segments or parts. See the solitary coral, starfish, and crinoid on the next page for examples of fossils that have radial symmetry.

Although symmetry is extremely important in classification, it is usually only the first step to use when classifying fossils, for there are many fossils that have the same kind of symmetry. You no doubt noticed on the next page that there were a minimum of three fossil groups each that have asymmetry, bilateral symmetry, and radial symmetry. Additional criteria that are useful for classifying a fossil include the shape of the exoskeleton, endoskeleton, or shell that originally supported or protected the organism, the number of parts that make up the skeleton, and differences in skeletal ornamentation. For example, the three fossils with asymmetry on the next page differ in that two, the bryozoan and colonial coral, may have branching skeletons, whereas the other, the gastropod, has a coiled one-piece shell. For another example, examine the cephalopod, trilobite, bivalve, and brachiopod on the next page. All of them have bilateral symmetry, but the cephalopod shell consists of just one piece, whereas the bivalve and brachiopod shells consist of two pieces and the trilobite skeleton of many pieces. Even though the bivalve and brachiopod both have two pieces to their

shells, their shells differ in the shape and ornamentation.



1. What type of symmetry is shown by specimen 9-1? _____

2. What type of symmetry is shown by the coiled shell, specimen 9-2, which at one time contained a snail? _____

3. The now fossilized exoskeleton of this animal, specimen 9-3, consists of many pieces. What type of symmetry does it exhibit? _____

4. Fill out the table below, using the figure on the previous page as your guide.

Fossil	Symmetry	Characteristic Features	Name
9-4			
9-5			
9-6			
9-7			
9-8			
9-9			
9-10			
9-11			

5. Specimen 9-12, a cephalopod, and specimen 9-13, a gastropod, both belong to the same major animal group, the Phylum Mollusca. Although they both belong to the same phylum, they are obviously quite different from each other. In what major way do the two specimens differ?

_____

_____

Name:

Date Visited:

OPTIONAL EXTRA-CREDIT

SELF-GUIDED FIELD TRIP

TO ALLEN COUNTY HISTORICAL MUSEUM

The Allen County Historical Museum has an excellent collection of minerals, rocks, and fossils. In fact, the minerals on display rival those on display in the Smithsonian. What follows are questions that you will need to answer by visiting the Allen County Museum and observing rather closely the minerals, rocks, and fossils on display there. The Allen County Museum is located on the corner of Market and Metcalf Streets, just west of downtown Lima, and adjacent to the Lima Public Library. The museum is open Tuesday through Sunday. The museum is closed on Mondays and holidays. The hours vary. Check their website for times and additional information about the museum: https://www.allencountymuseum.org/. There is no required admission fee (there is a $5 suggested donation if you would like to support the museum, but it is ***NOT*** required). ***YOU MUST SIGN THE GUEST REGISTER BEFORE GOING ON*** the self-guided field trip (OR YOU WILL RECEIVE NO CREDIT), which begins on the lower level of the museum, starting with the four small display cases labeled METALLIC MINERALS, which are located on the right side of the entryway from the mineral and rock room into the main part of the lower level of the museum. The self-guided tour will gradually work clockwise (to the right) around the mineral display cases on the outside of the mineral and rock room, then to the minerals displayed on the inside display cases, and finally to the rocks in the display cases on the inside and along the outside walls of the room.

Antimony Strontium Case

1. The only mineral on display that contains strontium is a strontium sulfate called _____. It was named because of its _____ color.

Gold Silver Tungsten Tin Beryllium Titanium Mercury Arsenic Case

2. The mineral which contains beryllium and is also a gemstone is called _____. This mineral is often green, so the gemstone variety is likely the expensive gem called _____ (You will not find the answer on display, so you will need to make an educated guess).

3. The only mineral in the case that contains a significant amount of tin is _____.

4. Cinnabar is one of the most important sources of _____.

5. Titanium is found in this mineral: _____.

Aluminum Manganese Case

6. Bauxite is an ore of _____.

7. Two minerals containing aluminum that are used in pottery are:
_____ and _____.

8. A mineral (and gem) containing aluminum is _____.

9. _____ is a rose-colored manganese carbonate.

Lead Uranium Zinc Case

10. Sphalerite is the principal ore of _____.

11. The most common lead ore is _____.

Copper Case

12. List five minerals which contain copper:

_____

Iron Case

13. The iron-bearing mineral called "fool's gold" is _____.
List four additional iron-bearing minerals:

_____

NONMETALLIC MINERALS

Evaporites Carbonates Case

14. Most of the minerals in the display case are this carbonate mineral: _____. The variety of that mineral which produces double images of anything placed underneath it is called _____.

15. Gypsum is an evaporite used in _____ and _____.

Silicates Case

16. List three of the pyroxenes, amphiboles, and/or feldspars on display: _____. The only green-colored mineral belonging to any of those three groups which is a gemstone and used for statues and carvings is _____.

17. List four of the varieties of quartz that are on display:

_____

18. The variety of quartz on display from Ohio is _____.

Larger Pieces Case

19. The most common carbonate mineral is _____.

20. This variety of quartz (not labeled) is also a semi-precious gemstone and used in the manufacture of glass and oscillators and filters in radio and telephone services: _____.

NONMETALLIC MINERALS (in smaller display cases)

Silicates Case

21. Some of the garnets on display are in this rock: _____.

22. Black-colored mica on display is labeled _____ in the display case. Clear or silvery mica on display is generally labeled _____ (See Lab Unit 3 for the answer).

23. Four potential uses of the silicates in the next display case, which contains talc, chrysotile asbestos, and other silicates are:

_____

Sulfates Sulfur Phosphates Case

24. Barite is often found in the shape of a _____.

25. The mineral used for phosphate fertilizer is _____.

Another very distinctive yellow-colored mineral is _____.

Chlorides Fluorides Case

26. This purple, yellow, or blue-colored mineral is a fluoride and often found with celestite, quartz, and/or dolomite:

_____.

27. Halite is used for this: _____.

Rare and Spectacular Minerals Case (in interior of room)

28. The mineral that is often pink-colored and used for jewelry

is _____.

Free-Standing Case with Opal

29. The opal on display is in a sandstone which from this

location: _____.

Free-Standing Case with Herkimer Diamonds

30. Herkimer Diamonds are not real diamonds, but based on their clear transparent appearance, and doubly terminating crystals (come to a point on both ends), they are likely a type of the

very common hard mineral called _____, which does have some of its doubly terminating crystals on display.

VOLCANOES CASE

31. Two of the types of rocks on display are _____ and

_____.

32. The specimen labeled Lava Rock is likely _____ (Refer to Lab Unit 2, Part 1 to help determine answer).

ROCKS CASES (Left-hand side of entryway into main part of lower level)

33. Two igneous rocks on display with a granitic composition are _____ and _____.

34. The sedimentary rock composed of quartz is called _____.

35. The sedimentary rock composed of calcite is _____.

36. The sedimentary rock composed of decomposed plants is called _____.

37. The metamorphic rock commonly used as a building stone which has four varieties on display in the case is _____.

Please Touch Case

38. One metamorphic rocks that you can touch that is labeled with its name is _____.

39. The only igneous rock you can touch is _____.

40. The large unlabeled, rose-colored mineral is likely _____.

Please exit the mineral and rock room and walk to the nearby **Fossils Display Area**

FOSSILS

41. Two of the three specimens on display in the fossil area which are likely associated with dinosaurs, including at least one dinosaur that was a plant eater, are _____ and _____.

42. Teeth of two extinct members of the elephant family or that resembled members of that family that lived during the Ice Age are on display.
The two members are a _____ and a _____. The tooth of the _____ was found near Lima.

Western Ohio Fossils Case

43. Fossils found in Lima are generally from this System or Period of rocks: _____. Fossils in the Cincinnati region are from this System or Period of rocks: _____. Fossils in the Toledo region are from this System or Period of rocks: _____.

44. The different animals represented as fossils in western Ohio and on display include (list all the groups on display):

_____

_____

45. This group of arthropods was the most successful one during the Paleozoic: _____. This group was attached to the seafloor and elevated above it by means of a long stalk or column: _____.