**Chapter 1 *Introduction to Earth Systems***

1 What distinguishes science from other ways of understanding the world?

- **Method of Understanding the World**

**- A Body of Knowledge Gained from This Method**

**- What We Can Do with This Knowledge and Technology**

3 Be sure you can explain how geologists can formulate theories about Earth processes that operate too slowly for humans to observe directly.

4 Explain why you have a civic duty to do well in this course.

**Everywhere we go, geology was there first. Its our duty to observe and understand these events**

7 How do the crust, mantle, and core differ?

**They are the three layers of the earth: crust is the lightest, mantle is the middle, core is at the center and made of nickel and iron**

8 How was Earth’s ocean formed?

**From the eruption of volcanic activity**

10 Be sure you can name Earth’s four subsystems (that is, the *\_\_\_-spheres*).

* **Atmosphere**
* **Hydrosphere**
* **Biosphere**
* **Geosphere**

Important terms:

scientific theory –

lithosphere –

asthenosphere –

igneous –

metamorphic –

sedimentary –

atmosphere –

hydrosphere –

biosphere –

geosphere –

**Chapter 2 *Plate Tectonics***

3 What are the *lithospheric plates*? What layers of the Earth do they include? What layer separates them from the bulk of the mantle?

**The lithospheric plates are the plates that**

5 How is the interior of the Earth divided by the *state* of the materials?

**The division of state of the earth interior is divided by:**

**Lithosphere (ridge), Asthenosphere (partly melted), Lower Mantle (ridge)**

8 Explain how gravity can help move lithospheric plates.

9 Explain an older idea that attributed plate movement entirely to heat (convection) within Earth’s interior.

\* Not a question but a statement: *The current view is that plate motion is driven by heat and gravity.*

11 What five (5) lines of evidence supported the hypothesis of *Continental Drift*? You should be able to name these and also explain how they supported the idea.

**The Five Lines of evidence for the Continental Drift Theory:**

**Fit of continents**

**Patterns of past glaciation**

**Patterns of past climate belts**

**Distribution of fossils**

**Matching rocks and mountain belts**

14 What are the *three types of plate boundaries*?

**Divergent, Convergent, Transform**

15 Why is it important to consider the *type of crust* at plate boundaries?

**It is important to consider the type of crust because depending on if the boundary id effecting the oceanic or continental crust will lead to different boundary effects and formations that can be created.**

Important terms: asthenosphere, lithosphere, convection, rift, volcanic island arc, volcanic arc, subduction zone,

**Chapter 3 *Minerals and Matter***

1 Be sure to know the differences among these terms: rock, mineral, compound, element (atom).

2 Be sure to know the characteristics that define minerals:

(1) naturally occurring

**Formed by Geologic Processes**

(2) formed by geologic processes (possibly aided by organisms)

(3) solid

(4) crystalline structure

(5) definite chemical composition

(6) inorganic (this should be taken to mean “not derived from carbohydrates” so that, for example, coal would be excluded; we recognize that carbonate minerals can be produced by organisms)

4 Why are silicate minerals the most common minerals in rocks?

**Because they make up so many of the different metals and minerals that are found in most rocks and most minerals. Silicate and Oxygen are the two most common.**

8 What value is there in being able to identify the minerals in any given rock?

**The value of being able to identify the minerals in any given rock is that we have the ability to learn what type of rock was found, and deduce the location it originated from and how it was formed based on these findings.**

Important terms: rock, mineral, compound, element (atom), silicate mineral

**Chapter 4 *Igneous Rocks and Rock Cycle (Interlude C)***

3 What does a rock with fine grained texture tell us about its history?

**A rock with fine grained texture tells us that the rock had gone through a rapid cooling process.**

4 What does a rock with coarse grained texture tell us about its history?

**A rock with a coarse grained texture tells us the rock had gone through a slow cooling process.**

5 Why does a magma that cools slowly produce a rock with coarse grained texture?

6 Why does a magma that cools quickly produce a rock with fine grained texture?

7 What does a rock with mixed grained texture tell us about its history?

**A rock with a mixed grained texture tells us it went through slow then rapid cooling process.**

12 Are igneous rocks classified (named) based on composition, on texture, or on both?

**Igneous rocks are classified based on composition and texture.**

17 At what kinds of plate boundaries are igneous rocks likely to form? Describe the process at each.

18 How can igneous rocks form in the middle of tectonic plates?

**Interlude C *Rock Cycle***

3 How has the evolution of Earth affected the evolution of life? How has the evolution of life affected the evolution of Earth?

4 What are the three main types of rocks? How does each form?

6 Which of the earth’s dynamic subsystems (that is, the *–spheres*) interact in the formation of sedimentary rocks?

7 What is meant by *The Rock Cycle*?

8 What are the connections among Earth’s interior heat, plate tectonics, and the Rock Cycle?

Important terms: silicate mineral, texture, composition

**Chapter 6 *Sedimentary Rocks***

2 How does mechanical weathering differ from chemical weathering?

**Mechanical weathering deals with the environment and its effects on creating, transporting, depositing and solidifying sedimentary rocks. Chemical weathering deals with the atoms and minerals in the sediments that are effected.**

4 What are the three main categories of depositional environments?

**Continental, transitional, marine**

6 How do clastic (detrital) sedimentary rocks differ from chemical sedimentary rocks?

**Clastic deals with solid minerals result of mechanical weathering, chemical is with the ions and atoms of the sediment. How they are saturated in water.**

8 What are sedimentary structures and how are they useful?

**Sedimentary structures are layering of different sediment rock and they are useful because the different layering can tell the time periods of when certain sediments were more common and when one sediment existed before and after another. It is a type of timeline for sedimentary rocks.**

13 What is a sedimentary basin?

**It is deposition on a very large scale**

14 What plate tectonic setting creates: passive margin basins? foreland basins? intracontinental basins? rift basins?

**Supplemental lecture on shale gas/fracking and global carbon cycles**

1 Explain why some shales are considered unconventional reservoirs for oil and gas.

3 Describe the two technological developments that allow natural gas to be extracted from unconventional shale reservoirs.

Important terms: weathering, physical weathering, chemical weathering, erosion, lithification, cementation, quartz, calcium carbonate, evaporite rocks, cross bedding, conventional gas/oil reservoir; unconventional gas/oil reservoir, fracking, directional drilling,

**Chapter 7 *Metamorphism and Metamorphic Rocks***

3 What are four *agents of change* in metamorphism?

**Heat, Hydrothermal Fluids, Uniform Pressure, Directed Pressure (stress)**

8 Explain the *three characteristics* that are used to *classify* metamorphic rocks.

9 How does *foliated texture* differ from *nonfoliated texture*?

12 In what *two ways* is the intensity of change determined for a metamorphic rock? (ans: rock type as a broad category and index minerals as subdivisions in a category)

14 What are *“index minerals”* and why are they important?

15 Explain how mapping the distribution of metamorphic grade can be useful.

16 Describe how metamorphism is related to plate tectonics.

Important terms: heat, pressure, chemical fluids, foliation, non-foliated rocks index mineral

**Chapter 8 *Earthquakes and Earth’s Interior***

1 What are *earthquakes*? How can they be related to breaking a stick? What is the time scale for the build-up of stress at a fault? What is the time frame for release of that stress?

**Earthquakes are a sudden release of energy as the rock breaks along a fault**

7 Using the Richter Magnitude scale, how much larger is an earthquake of magnitude 6.5 than an earthquake of magnitude 4.5

**The magnitude 6.5 earthquake is 1000 times larger and 100 times stronger than a magnitude 4.5 earthquake**

*Be sure you understand that Richter magnitude is a logarithmic scale so you can explain the difference between earthquakes of, for example, magnitude 4.5 and 6.5. The difference between these Richter Magnitudes is 2 (6.5-4.5= 2). This means the amount of energy in the larger (6.5) is 10 raised to the power 2, or 100 times more than in the smaller one (4.5). An earthquake with Richter Magnitude 7.5 is 10 times more powerful than one with magnitude 6.5 (7.5-6.5=1; energy difference is equal to 101 ) and 1000 times more powerful than one with magnitude 4.5 (7.5-4.5=3; energy difference is equal to 103 ).*

8 Describe the relationship between magnitude and frequency of earthquakes. Can you give this as a mathematical equation?

9 How are earthquakes used to understand the *interior of the earth*?

**When they happen, as we collect the data of the waves that are generated, they produce different results when traveling through mineral deposits in the earth, different sections of the planet and so on**

20 Describe how wastewater injection can cause earthquakes. Where in the U.S. has this been a concern?

**When fracking occurs if a well is drilled down to deep the reaction of waist water being injected can cause earthquakes.**

Important terms: pressure (P) wave, shear (S) wave, surface wave, body wave, magnitude, frequency, risk

**Chapter 5 Volcanoes and Volcanic Hazards**

1 Describe how magma can be generated by these plate tectonic processes: convergent margins with oceanic crust on both plates; convergent margins with oceanic crust and continental crust; divergent margins within oceanic crust; divergent margins within continental crust.

2 The origins you described for the previous question are all located on the margin of lithospheric plates. Describe an additional way that magma can be generated within a lithospheric plate, far from its edges.

7 How do estimates of the amount of CO2 expelled by volcanoes during a year compare with the amount generated by burning fossil fuels?

12 What are three types of volcanoes? How do they differ? What determines the type of volcano that will form?

16 Describe five hazards from volcanoes.

21 Describe the process thought to create both flood basalts and chains of volcanoes.

How does the age of volcanoes in the Hawaiian Islands indicate the direction and rate of tectonic plate motion?

Important terms: shield volcano, composite volcano, cinder cone, hot spot or mantle plume, pyroclastic flow, mudflow (lahar), ash fall, volcanic bomb, lava flow

**Chapter 15 Oceans and Coasts**

2 Describe how the shape of the ocean floor has been mapped, starting with the earliest surveys and including the latest approaches using satellite measurements.

4 Describe the three major provinces of the ocean floor. What is an additional feature of the sea floor related to plate tectonic processes?

8 What is the connection between mid-ocean ridge spreading rate and sea level?

10 What factors cause portions of ocean waters to have different densities?

11 Describe the three scales of ocean currents -- small, intermediate, global—including their approximate size/extent and what drives them.

12 Explain how the global ocean current is connected to climate.

13 Problems at coasts result when natural processes interfere with humans and our structures. Discuss the nature and severity of these problems: rising sea level, hurricanes/typhoons.

These terms are used in the text but are **not important** for our purposes: backwash, barrier island, beach erosion, beach nourishment, beach profile, fjord, longshore current, longshore drift, rogue wave, sand spit, sea stack, swash, tidal reach, tide, wave base, wave-cut bench, wave refraction

**Chapter 9 Geologic Structures and Mountain Building**

3 What are the three types of *deformation* that alter rock layers?

**Bend, Break, Flow**

8 What are *geologic structures*? How do geologic structures give information about the ways that rock layers have been deformed?

9 What are the two types of *folds*?

10 What are the three types of *faults*? What type of stress causes each one? (For example, *reverse faults* are created by *compression*.)

11 What is an *orogeny*? What is formed during an orogeny?

**An orogeny is the formation of mountains and mountain belts**

12 Define these terms: continental shield, platform, craton.

13 Briefly explain how mountain belts are created at *convergent* plate boundaries with *oceanic* crust against *oceanic* crust.

14 Briefly explain how mountain belts are created at *convergent* plate boundaries with *oceanic* crust against *continental* crust.

15 Briefly explain how mountain belts are created at *convergent* plate boundaries with *continental* crust against *continental* crust.

16 Briefly explain how *fault-block mountains* are created within areas of *continental* crust subjected to *tension*.

These terms are used in the text but are **not important** for our purposes: bearing, crustal root, epeiorogeny, exhumation, isostasy, joint, monocline, oblique-slip fault, orogenic collapse, slickensides, vein

terms to know: elastic, ductile, brittle, dome, anticline, syncline, basin, normal fault, reverse fault, thrust fault, strike-slip fault, orogeny

Extended answer questions:

• A region is characterized by numerous anticlines and synclines. There are also several faults present that appear to have formed at the same time as the folding. Without looking at any details, what type of faults would you assume them to be? Why?

• Describe the characteristics of regions dominated by fault-block mountains such as the Basin and Range (describe what creates the basins and what creates the ranges). What is their relationship to plate tectonics and why don't they create large-scale mountain belts like subduction at continental margins or continental collisions?

**Chapter 14 Streams and Floods**

3 Explain the connection among these terms: *runoff, infiltration, recharge, sheetwash/overland flow, channel flow.*

4 What is a *drainage system*? What is a *drainage basin*?

8 What is the significance of large potholes in the valley wall in Glen Helen in Yellow Springs? (lecture only)

9 In what ways do rivers normally erode and deposit at different but nearby places?

11 Which comes first: rivers or valleys? That is, do rivers occur because valleys exist and therefore collect the water that makes rivers flow or do rivers create and shape their valleys?

12 How quickly do most valleys change?

13 What is river stage? What is flood stage?

14 Explain what is meant by a “100 year flood.”

**These is referring to that the same flood will likely occur in the next 100 years**

15 What is the general relationship between magnitude (river stage or discharge) and frequency (probability of occurrence or recurrence interval)?

16 What is a *floodplain*? Can all flooding of the floodplain be prevented with *levees*? Would you build a home on a floodplain?

These terms are used in the text but are **not important** for our purposes: alluvial fan, base level, competence, drainage reversal, ephemeral stream, flasah flood, floodway, headward erosion, oxbow lake, stream rejuvenation, stream piracy, stream terrace, waterfall.

Terms to know:

gradient, velocity, infiltration capacity, discharge, cut bank, point bar, artificial levees, floodplains, natural levees, abrasion, pothole, cut bank

Extended answer questions:

• Outline the ways in which streams erode, transport, and deposit sediment.

• Describe the common approaches to flood control.

Extended answer questions:

• Describe the hierarchical nature of drainage basins.

• Distinguish between two end-member types on the spectrum of river channels grading from meandering to braided.

• Describe the common measures of flood control.

**Chapter 16 Groundwater**

1 How important is *groundwater* in the *hydrologic cycle*?

**Groundwater is a main source of fresh water and it helps form landscapes**

2 Know these important terms:

***Porosity* – percentage of total volume that is open space**

***Permeability* – ease of transmitting fluid**

***Aquifer* – material with sufficient porosity and permeability to supply water**

***aquitard* – material with permeability low enough to significantly slow groundwater flow**

***water table* – the upper boundary of an aquifer in which material is fully saturated with water**

5 What are *buried valley aquifers* and why are they important in the mid-continent of North America? (lecture only)

6 What is the typical *rate* at which groundwater flows

8 What is a *cone of depression*? How can the cone of depression for one well affect adjacent wells?

**A cone of depression occurs when a well is created and as water fills up into the well a code of depression is formed where the water funnels into the well.**

10 What are the threats to the quality of groundwater from human activity?

These terms are used in the text but are **not important** for our purposes: artesian, capillary fringe, disappearing stream, geothermal, geyser, hot spring, karst, oasis, perched water table, spleothem, stalactite, stalagmite

Terms to know: water table, porosity, permeability, aquifer, aquitard,

**Darcy’s Law – the volume rate of water flow through an aquifer**

Extended answer questions:

• Discuss water wells and their relationship to the water table.

• List and discuss important environmental problems associated with groundwater.

**Chapter 18 Glaciers and Glaciation**

1 What evidence of continental glaciation can be seen in satellite photos of southwestern Ohio? (lecture only)

2 How is the distribution of highly productive water wells in Ohio explained by processes of continental glaciation (lecture only)

4 How important are glaciers in the *hydrologic cycle*? What proportion of all water do they represent? What proportion of freshwater?

5 How are glaciers an important indicator of past climate? Of present climate?

7 Describe how the position of the *margin* (end) of a glacier depends on the balance of *accumulation* (snowfall exceeding summer melt) and *wastage* (melt exceeding snowfall).

**If the melting point exceeds the accumulation, then the margin is pushed back and the glacier retreats. If the accumulation is greater then the glacier moves forward**

10 What are *buried valley aquifers* and why are they important to the Dayton area? (lecture only)

12 What is the Pleistocene Ice Age? When was it? When were other ice ages?

14 Know definitions for these important terms: proxy, flux, reservoir.

16 What is meant by the terms *Hot house* and *Ice house* for states of Earth’s climate?

17 How have CO2 concentrations (estimated using proxies) changed over the past 500 thousand years? How high (compared to present levels) has the concentration risen?

19 What are the three components of orbital variations of Earth identified in the Milankovitch Theory? How do these compare with estimates of climate change over the past 800 thousand years?

20 What is the connection between orbital variations, CO2 changes, and glacial cycles?

These terms are used in the text but are **not important** for our purposes: arête, cirque, drumlin, erratic, fjord, firn, glacial striation, glacial subsidence, hanging valley, horn, kettle hole, patterned ground, pluvial, roche moutonnee, U-shaped valleys, tidewater glacier, varve.

Extended answer questions:

• Explain the role of glaciers in the hydrologic cycle.

• Distinguish between the two basic types of glacial drift. List and describe the major depositional features associated with glacial landscapes.

• Briefly summarize current ideas on the causes of ice ages.

**Chapter 19 Global Climate Change**

1 What is the importance of distinguishing questions that are *empirical* from those that relate to *policy*?

**The importance of distinguishing the difference of empirical and policy:**

**Empirical: verifiable by observation and experience rather than a theory**

**Policy: a course of action adapted by the gov. meant to have the best outcome**

2 What evidence supports the conclusion that global climate has warmed over the past century?

3 Be sure you can explain the mechanism by which greenhouse gases trap heat (the *greenhouse effect*).

4 What evidences supports the conclusion that global climate change is due mostly to the greenhouse effect?

5 What evidence supports the conclusion that increases in atmospheric CO2 are due mostly to burning fossil fuel?

6 Describe how isotopes of oxygen can be used to estimate past temperatures. For what kinds of samples can we measure oxygen isotopes?

7 How can ice cores be used to estimate past temperatures? How far back does this record extend?

8 How can ice cores be used to measure past CO2 levels in the atmosphere?

9 How can sediment cores be used to estimate changes in global temperature?

10 Describe how climate models operate (four steps defined in lecture).

11 Describe how the quality of a climate model is tested using historical measurements.

12 Explain why predictions of future climate change depend so heavily on estimates of how CO2 concentration in the atmosphere might change.

Important terms: proxy, flux, reservoir, greenhouse effect, climate model, glacial-interglacial oscillation

Extended answer questions

• Explain why unraveling past climate changes is important and discuss several ways in which such changes are detected.