GEOLOGY 100

Study Guide and Course Content

(Revised Fall 2011)

Text: Physical Geology: Exploring the Earth, 6th Ed. Monroe, Wicander & Hazlett, 2007.

Lecture Notes: Palomar College Geology 100 Lecture Notes, J. Pesavento, 2009. (Located at Off Campus Books)

I. Reliability of Scientific Theory

CONCEPTS- We try to understand and explain the Earth's surface features, interior, etc., and any activity that the Earth displays. However, we can be deceived in our observations and come to the wrong conclusion.

A. Three steps of the Scientific Method
   1. Observation, Theory and Testing
   2. Facts can change due to lack of proper observations

B. Model, Theory and fact
   1. Using computers to model and/or predict an event or phenomena
   2. The relationship between theory and fact

C. Communication of the ideas

REVIEW QUESTIONS

1. What are the three steps of the Scientific Method?
2. What is the basic problem that we humans have when we "observe" something?
3. How does computer modeling help in understanding a phenomenon?
4. What is the difference between theory and fact?

II. Use of Geology (p4-10, p28-31)

CONCEPTS- The Earth provides us with everything we need for life. We are now realizing that there is not an infinite supply and we should not take the Earth's resources for granted.

REVIEW QUESTIONS

1. What are some of the major materials we gather from the Earth's surface that we use today for building, electronics, etc.?
2. What can the knowledge of Geology help us to understand concerning some of the dangers of living on this planet?

III. Formation of minerals from atoms (p73-77)

CONCEPTS- Solid material is made up of groups of atoms held together by some sort of "glue". The type of "glue" depends on the structure of that particular atom.

A. Nature of atoms
   1. Protons, Neutrons and Electrons
   2. Differences between atoms
      a. Elements (Periodic Table)
      b. Isotopes

B. Types of Bonding
   1. Covalent Bond - Sharing of Electrons

2. Covalent bond of water
    a. Water's unusual properties as a Dipolar Molecule
    b. The "act" of dissolving a solid
3. Ionic Bond
    a. Formation of Ions - Atoms with a Charge
    b. atoms of opposite charge attract each other
4. Metallic Bond - pure Copper, Silver & Gold

C. Ion size and charge balance - substitution of element in a mineral

D. Basic building block of rock forming minerals - Silicates

REVIEW QUESTIONS

1. What is the "make-up" of an atom? What makes one atom different from another in that we call it by a different name? Does the number of particles the atom has make this difference?
2. Why do atoms like Helium and Neon (Noble or Inert Gases) do not usually combined with other atoms to form molecules? What about the number and location of their electrons?
3. What are the names of the three major type of bonding or causes of atoms to hold together? How does each of them work? Why do they work that way?
4. What property does water have to enable it to dissolve most minerals? What is the name we give to this type of a molecule? What is meant by "dissolving" a substance? What are the water molecules doing? What happens to the substance when the water is removed?
5. Does the "charge" on an ion control what elements combine with each other? How about the size of the ion? How does this work or does not work?
6. What ion is considered the building block of rock forming minerals? What is this group of minerals called?

IV. Minerals (p72-73, p77-90)

CONCEPTS- Not all solid materials are minerals. Minerals have a very strict definition so that they form a unique group of substances. Minerals are used for various products. Therefore, it is important to be able to identify one mineral from another. This can be done by determining its physical properties.

A. Definition of a Mineral

B. Physical Properties - Color, Streak, Hardness, Cleavage and Fracture, Tenacity, Luster and Special Tests

REVIEW QUESTIONS

1. What are the five properties that make a mineral different from any other solid? Explain each of these properties.
2. What are some of the "physical properties" of a mineral to help us to identify it? Explain each of these properties.

V. General Properties of Rocks

CONCEPTS- The origin of rocks on the surface of the earth was, at first, misinterpreted and oversimplified. Rocks do have different origins that allow particular minerals to form. By noting the minerals and their size and shape we can conclude how the rock was formed. Once we compare one rock to another

we begin to understand how they relate to each other and how the Earth recycles materials. All these processes allow us to arrive at a basic premise of geology, i.e., that the process we observe now had occurred in the past. There is a uniformity of phenomena in time.

A. Lack of understanding of rocks - e.g. Neptunism vs. Plutonism
B. The Rock Cycle (p21)
C. Classification of rocks - Igneous, Sedimentary and Metamorphic
    1. What was the condition of the Earth's surface when the Earth formed?
    2. When did rocks form?
    3. Where do rocks form?
    4. What material do rocks use and what is the "state" of that material?
    5. Under what conditions do rocks form?
    6. What do rocks look like after formation? What is meant by "Texture"?
    7. Does the chemical composition vary within a rock type?
D. Uniformitarianism (p21-23, p264-265)

REVIEW QUESTIONS

1. What is the theory of Neptunism? How was this shown to be incorrect and that some rocks do form underground?
2. What were the properties of the surface of the Earth when it first formed?
3. What are the three general types of rocks? In general, how does each of them form? Under what conditions do they form? Where are the located with respect to the surface of the Earth when they form?
4. What is the Theory of Uniformitarianism? How does this help explain what we observe on the surface of the Earth and when "cuts" are made in the Earth?
5. When we classify rocks within each of the three classes, what properties does the rock have to make it unique from the other classes of rock? What are the three aspects of the grains that we describe as the "Texture" of the rock?
6. What is the "Rock Cycle" and how does it work? Do rocks change their classification? What happens to them to do this?

VI. Igneous Rocks (p102-167)

CONCEPTS- All of these rocks form directly from magma. Solid material can be in a condition where it melts. It then can solidify as the magma gets close to the surface or it can spill out onto the surface. The process of the magma forming mineral crystals depends on changes of temperature and pressure. A classification scheme can be set up using chemical composition and texture of the rock. The texture tells us if the magma solidified at the surface or underground. At the surface the lava builds up in a particular shape that depends on the viscosity of the lava. If the magma solidifies underground, it can move up and be exposed at the surface as a mountain range.

A. First crust of Earth
B. Origin of energy and magma (p103-109)
    1. Source of energy
    2. Temperature vs. pressure
    3. Role of Plate Tectonics (p153-156)

C. Crystallization of magma (p109-113)
    1. Bowen's Reaction Series
    2. Proof of Series

D. Classification of Igneous Rocks (p117-122)
    1. Chemical composition
        a. Felsic
        b. Intermediate
        c. Mafic
        d. Ultramafic
    2. Texture (p115-117)

E. Extrusive Igneous (p132-159)
    1. Viscosity of lava
        a. ropy (pahoehoe)
        b. blocky (aa)
    2. Pyroclastics - ash, blocks, bombs and tuff
    3. Calderas
    3. Type of volcanoes (p141-146)
        a. shield volcano
        b. cinder cone - pyroclastics
        c. composite volcano (stratovolcano)
    4. Lava tubes
    5. Pillow lava (p139)
    6. Columnar jointing (p138)
    7. Dangers of volcanic eruptions (p156-159)

F. Intrusive Igneous Rocks (p122-124)
    1. Concordant and discordant bodies
    2. Stoping (p107)
    3. Formation of batholith
    4. Pegmatites - quartz veins (p120-121)

REVIEW QUESTIONS

1. What was the condition of the crust of the Earth when it first formed from the smaller rock material that was part of the "Solar Nebula"? Was the curst still solid? What caused that "state of matter" of the Earth? If you sampled the material of the Earth from any location, i.e., from top to bottom; would there be any difference in the chemical composition?
2. What happened to the interior structure of the material of the Earth during the next few million years? The uppermost section of the Earth cooled and formed the initial crust. Did it have the same chemical composition that the crust has now?
3. What is magma? What is the state of the matter in a magma?
4. What are the sources of energy to form magma? What does the inter-play between pressure and temperature have to do with the melting of rock? How does the theory of Plate Tectonics affect the ability to melt rock?
5. Describe the experiment that the Geochemist, Bowen, preformed to demonstrate how minerals formed in a magma. There are two aspects of the reactions that he observed. What are these called due to the minerals that were formed? How does the discontinuous series work? How does the continuous series work? When these minerals are weathered,

which ones break down first? Those that first form or those that are the last to form? Why?

6. What proof do we have that Bowen's Reaction Series occurs in nature?
7. What are the four classes of Igneous Rocks according to their chemical composition? How does texture affect the classification? What is the Difference between Extrusive and Intrusive Igneous Rocks?
8. Describe the differences between Rhyolite, Andosite, Basalt and Granite, Diorite and Gabbro? What is meant by Utramafic Igneous rock?
9. What are the three factors that control the viscosity of a magma? What are the Hawaiian terms for the two types of lava flows? What is the difference between them and how do they appear on the surface?
10. What are pyroclastics?
11. What are the three types of volcanoes and how do they differ?
12. How do lava tubes form?
13. What are "pillow lavas"? How do they form?
14. What is "columnar jointing" and how does it form?
15. What are the names of the five plutonic bodies that form intrusive Igneous rock masses? Describe each of them and how do they differ from each other.
16. What is meant by the process of "Stoping"? What is meant by the process of "Displacement"? Describe the formation of the Sierra Nevada Mountains?
17. What is a pegmatite? How do they form? What is the size of the mineral grains that is characteristic of pegmatites?
18. What are Quartz veins and how do they form? How do "geodes" form? Why do quartz veins have gold in them? How is it possible to "pan for gold" in the streams that occur in the foothills of the Sierra Nevada Mountains?

VII. Weathering (p170-181)

CONCEPTS- Solid material that is exposed to the surface environment of the Earth breaks into pieces or changes its structure or chemical composition.

A. Mechanical (p170-175)
   1. Expansion and contraction
   2. Frost Action (Wedging)
   3. Exfoliation
   4. Spheroidal Weathering
   5. Organic material
   6. Impacts

B. Chemical (p175-181)
   1. Water
   2. Substances in water - Carbonic Acid
   3. Leaching
   4. Atmosphere - Oxidation and "pollutants"

REVIEW QUESTIONS

1. What is the relationship between weathering and erosion? Do they occur separately or do they occur in sequence, e.g., weathering then erosion? How do they differ?
2. What are the two major types of weathering and how do they differ?
3. Does temperature changes cause the breaking of rock masses? Does daily temperature changes have an effect on rocks? What is involve in rocks breaking down due to

temperature changes?

4. What is Frost Action or Frost Wedging? What happens to cause a rock to split?
5. How does Exfoliation cause huge masses of granitic rock to be separated from the main rock outcrop?
6. How does Spheroidal Weathering involve both chemical and mechanical processes to break down a boulder?
7. Can Organic material breakdown rock? Explain how this occurs.
8. What is involved in the Leaching process as water enters soils?
9. What role does Carbon Dioxide play when it combines with water? What substance is made and how does it contribute to the weathering of rock material?
10. What does the air do to chemically weather the surface of rocks?
11. In consideration of Bowen's Reaction Series, how do the minerals hold up to weathering? Which mineral or minerals lasts the longest at surface conditions before weathering?

VIII. Sedimentary Rocks (p200-229)

CONCEPTS- We find other rocks on or near the surface of the Earth that are quite different than igneous rocks. They occur in layers and are made by weathering and eroding of other rock.

A. Lithification processes (p203-204)

CONCEPTS- After the material is altered in some way without heat, it must be place under pressure and/or glued together to form a hard cohesive rock mass.

1. Pressure
2. Cement

B. Classification (p204-210)

CONCEPTS- Again, to keep order to the sedimentary process we set up a scheme so that we can easily make relationships between rock types.

1. clastic - e.g. Conglomerate and Breccia, Sandstone, siltstone and Shale
2. non-clastic - e.g. Limestone, Chalk, Chert and Coal

C. Evidence of environment of deposition (p210-218)

1. Fossils
2. Different stratified layers - distance of source region
3. Cross-bedding
4. Ripple marks
5. Graded bedding

REVIEW QUESTIONS

1. How does a Sedimentary Rock differ from an Igneous rock? What is the environment when it forms? What is the material that forms it? How is that material created? Does the rock masses form a particular structure?
2. What is meant by Lithification? What are the necessary conditions for Lithification? Can sandstone be formed solely by pressure? What else is needed to form sandstone? What are the three main types of this cement?
3. What two properties of Sedimentary rocks forms the basis of its classification scheme? Do these properties have anything to do with how the "parent" rock is weathered? What are the names of the two classes of Sedimentary Rocks?
4. In Clastic Sedimentary Rocks the subclasses are broken down into rock types by what parameter of the rock. What is the difference between a Conglomerate and a Breccia?

5. What mineral group makes up Shale? How are the "grains" held together? Is all of the water removed between the "Grains"?
6. In Non-Clastic Sedimentary Rocks the subclasses are based on what property of the rock? What is the most common type of Non-Clastic rock? Why?
7. How does the distance of the source region affect the type of Sedimentary Rock?
8. What is Cross-bedding and how does it form?
9. What are Ripple Marks and how do they form?
10. What is Graded Bedding and how does it form?

IX. Metamorphic Rocks (p232-259)

CONCEPTS- It is possible to change the texture and/or chemical composition of a rock without melting it. This can be done by heating the rock or applying large amounts of pressure to the rock. The direction of the applied pressure affects the texture, i.e., if the grains are oriented in the same direction or not. A rock subjected to different amounts of temperature and/or pressure changes according to those amounts. By observing a particular set of minerals or the sizes of grains, we can deduce the environment that the rock was subjected.

A. Texture
   1. Review orientation of the grains
   2. Changes in texture due to new environment

B. Chemical composition
   1. No change but different minerals
   2. Change due to injection of new material

C. Types (p237-242)
   1. Thermal or Contact Metamorphism
      a. Heat source - Magma
      b. Some pressure
      c. Chemically Active Solutions - Change Chemical Composition
   2. Regional metamorphism
      a. Heat source - interior
      b. Pressure
         (1) Confined
         (2) Directed
   3. Dynamic metamorphism
      a. Little heat
      b. Shear Pressure

D. Progressive and Retrogressive Metamorphism

E. Classification (p243-247)
   1. foliated - e.g. slate, phyllite, Schist and Gneiss
   2. non-foliated - e.g. Marble and Quartzite

F. Grades of metamorphism

REVIEW QUESTIONS

1. How does a Metamorphic Rock differ from Sedimentary and Igneous Rocks? What is one property of rocks that changes during the metamorphic process? How does Bowen's Reaction explain some of these changes?
2. How does the chemical composition of a Metamorphic rock change without it melting?

3. What are the three types of metamorphism based on pressure and/or heat? Explain how each type causes the metamorphic process and the size of the region that is metamorphosed?
4. What are the two sources of heat to cause the change of the rock without melting it?
5. What are the three types of pressure that cause the change? Where does the pressure originate? If it is from the rock being below the surface, how far down must it be to have the change take place?
6. What is the difference between Progressive and Retrogressive Metamorphism?
7. What property of Metamorphic rocks is the classification based? Give examples of each classification type?
8. As an example of grades of Metamorphism, what happens to shale as the pressure/heat is increased? What are the names of the Metamorphic Rocks that form? How do they differ from each other?

X. Dating Rock Formations (p262-297)

CONCEPTS- As a result of sedimentary processes there are certain principles that govern the layering and the intrusion of rocks. These can be used to determine the chronology of the formations. Radioactivity can be used to determine the absolute age of rocks.

A. Uniformitarianism - Review (p264-265)
B. Relative Dating (p265-280)
    1. Sedimentary Structure
    2. Original horizontality
    3. Superposition
    4. Cross-cutting relationships
    5. Lateral continuity
    6. Faunal succession - fossils
C. Conformities
D. Unconformities (p266-274)
    1. Disconformity
    2. Nonconformity
    3. Angular unconformity
E. Absolute Dating (p281-286)

REVIEW QUESTIONS

1. What is Uniformitarianism?
2. What is the Principle of Original Hoizontality?
3. What is the Principle of Superposition?
4. How did the Geologic Time Scheme evolve?
5. How do we determine the relative Geological "Periods" of two series of layers located at two different locations?
6. How do we determine the age of a dike that has been injected into a sedimentary structure? Cross-cutting relationships?
7. What is meant by "the layers are "Conformable" or there is a Conformity?
8. What are the three types of unconformities and how do you identify them?
9. What is the difference between relative dating and absolute dating?
10. In general, how does radioactive dating work? What is meant by a radioactive material? What is meant by a "parent" and a "daughter" product? What is meant by the "Half-Life"

of a radioactive element? What happens to a rock to have its "radioactive clock" reset? Is factors like temperature, pressure, etc. effective in changing the decay rate of a radioactive substance?

A 150 POINT MID-TERM EXAM WILL NOW BE GIVEN COVERING ALL THE MATERIAL THROUGH TOPIC "X".

XI. Deformation of Rocks - Structural Geology (p268-291)

CONCEPTS: Forces in the earth, caused by the cooling processes of the interior, affect the crust where we are located. These forces uplift, subside, fold and fault the crust. There are different kinds of folds and faults depending on the direct of the force on rock masses.

A. Energy
B. Stress and Strain (p391-393)
    1. Compression, tension and shear
    2. Plastic, elastic and fracture
C. Strike and Dip of beds (p393)
D. Folds (p394-397)
    1. Anticline and syncline
    2. Monocline
    3. Basins and domes
    4. Plunging folds
E. Faults (p398-403)
    1. Hanging wall and foot wall
    2. Normal, reverse and thrust faults
    3. Right-lateral and left-lateral faults
    4. Strike-slip, dip-slip and oblique-slip faults
    5. Graben and horst

REVIEW QUESTIONS

1. What process of the Earth causes the energy to deform rocks?
2. The energy is more often in the form of a "force". What, in general, is meant by a force?
3. Describe what is meant by stress and strain and their relationship to each other.
4. Different stresses on rock cause the material to be "under" compression, tension and shear. Describe and compare these three stresses.
5. The strain on rock material is influenced by the plastic, elastic or fracturing nature of the rock. How does the rock act in these three "states"?
6. Describe what is meant by the strike and dip of sedimentary layers.
7. Describe with drawings of cross-sections and aerial views what anticlines, synclines, monoclines, basins, domes and plunging folds look like. What does the pattern of old and young sedimentary layers look like in each of these structures.
8. In a vertical fault, identify the hanging wall block and the foot wall block.
9. Draw and describe in words a normal, reverse and thrust fault.
10. What is the difference between a vertical or dip-slip fault ,a lateral or strike-slip fault and a oblique-slip fault?

11. Draw and describe in words a graben and horst and the type of faulting that produces them.

XII. Earthquakes (p300-333)

CONCEPTS: Earthquakes are a release of energy as a result of rock masses moving with respect to each other. The energy that travels through the crust and the interior of the earth is expressed by different vibrations or waves. Analysis of the waves enable us to determine the location of the source of energy and the interior structure of the earth. Understanding of the surface waves helps us predict earthquakes and prevent damage and loss of life.

- A. Causes
- B. Elastic rebound
- C. Slow creep
- D. Reading seismogram
- E. Focus - epicenter
- F. Types of waves
  1. Primary waves
  2. Secondary waves
  3. Surface waves - L and R waves
- G. Relationship between P and S waves
  1. Velocity
  2. Location of epicenter (p308-310)
- H. Surface waves
  1. Cause most damage
  2. Resonant frequency
  3. Fires
  4. Type of material under buildings
  5. Liquefaction (p315)
  6. Tsunamis (p315-319)
  7. Richter Magnitude Scale vs. Mercalli Intensity Scale (p311-314)
- I. Earthquake prediction and/or control (323-327)

REVIEW QUESTIONS

1. In general, what causes EQ's and how does this relate to "elastic rebound"?
2. What is "slow creep" and why is this a safer way to release the energy?
3. What is the difference between a seismometer, seismograph and a seismogram?
4. Describe the exact meaning of the "focus" of an EQ and where the "epicenter" is located with respect to it.
5. Draw and describe with words how the energy is expressed in P-waves, S-waves and surface waves (L and R waves), and what these look like on the seismogram.
6. How do we find the distance to the focus of an EQ from our seismic station?
7. How do we find the exact location of the focus of an EQ?
8. Why do surface waves cause so much damage?
9. How do "resonant frequencies" affect the destruction of a structure?
10. How does the rock material that a building is place on affect the EQ's destructiveness?
11. Describe liquefaction.
12. Why is the destructiveness of tsunamis so pronounced along shorelines?
13. The Richter Magnitude Scale is based on what factor of the seismic record? What is the

approximate difference in energy between two sequential numbers on the Scale? Why does it take a field study of the affected area to determine the proper number on the Scale?

14. What does the Mercalli Intensity Scale measure in terms of EQ's?

XIII. Earth's interior structure (p336-357)

CONCEPTS: From seismic data we can obtain some idea about the interior structure of the Earth. The Earth has distinct layers. Most of these layers are solid, but there are two that are plastic or liquid. It is the liquid section of the core that produces the magnetic field. It is the Asthenosphere that allows the "plates" which make up the lithosphere to move.

- A. Evidence from seismograms (p340-341)
- B. Inner and outer core (p344-346)
  1. Motion of matter and energy in core and mantle
  2. Generation of magnetic field and polar reversals
- C. Upper and lower mantle (p343-344)
  1. Asthenosphere
  2. Mohorovicic discontinuity
- D. Lithosphere

REVIEW QUESTIONS

1. Why are there "shadow zones" from direct S-waves?
2. What were the two "anomalies" that Inge Laymann discovered in studying seismograms that enable her to conclude that there is an Inner Core of the Earth?
3. What are the states of matter (solid or liquid) of the Inner and Outer Core?
4. What elements do we think the Inner and the Outer Core is composed? What piece of information allows us to come up with reasonable candidates?
5. What is the state of matter and chemical composition of the Lower Mantle?
6. Draw, name and describe the parts of the Upper Mantle along with the change of speeds of the seismic waves?
7. How thick is the Upper Mantle compared to the Lower Mantle?
8. What are the layers of the Lithosphere?
9. Is there a difference in the thickness of the crust? Where?
10. What is the Mohorovicic Discontinuity?
11. What are the two conditions that an object must have to produce a magnetic field?

XIV. Formation and evolution of the Earth (p10-13)

CONCEPTS: We have determined that there is a particular amount of each element that makes up the Earth. The Earth did not make these materials. They were formed billions of years ago by a fusion process. After these materials were made and were thrown out into space, gravity pulled this "stuff" together to form our Solar System and Earth.

- A. Abundances of elements
- B. Formation of elements
- C. Formation and evolution of the Solar System
- D. Evolution of the Earth

XV. Plate Tectonics (p34-69)

CONCEPTS: This theory explains almost all of the global geological phenomena including earthquakes, volcanoes, mountain ranges, islands, etc. The plate boundaries can be identified as diverging or converging to give the displayed topography or activity. The field of peleomagnetism helped verify the theory.

A. Early ideas (p34-39)
   1. Alfred Wagener (1880-1930)
   2. Pangea
   3. Paleoclimates, fossils, geological features, etc. as evidence
   4. Laurasia and Gondwanaland
   5. Lack of mechanism for movement

B. Revival of theory (p40-45)
   1. Paleomagnetism
   2. Proof of movement - N. American Terrains
   3. Problem of sea floor
   4. Resolution of problem by Hess in 1962

C. Features of plates and plate boundaries (p46-59)
   1. Diverging boundaries
      a. Sea floor spreading
         1. Oceanic ridges
         2. Rift valley
      b. Driving force
         1. Mantle convection
         2. Plumes and hot spots
      c. Age of sea floor
         1. Magnetic anomalies
      d. Fracture Zones and Transform Faults
   2. Converging boundaries
      a. Ocean-ocean convergence
         1. Subduction zone
         2. Island arcs
         3. Trenches
         4. Gravity anomalies
      b. Ocean-continent convergence
         1. Subduction zone
         2. Magmatic arc
         3. Faulting
      c. Continent-continent convergence

REVIEW QUESTIONS

1. Who was Alfred Wagener and how did he come up with “Continental Drift”?
2. What types of evidence did Wagener use for his theory?
3. What is the name of the super-continent and what it broke into?
4. What was the main reason that his theory was not accepted?
5. What is paleomagnetism?
6. What proof of the movement of rock material do we have that eliminates the possibility of polar wondering?

7. If the continents are moving then there should be evidence on the ocean floor. What did Harry Hess discover? What was his solution to the problem?
8. What evidence do we have that the "Ridge System" on the ocean floor is a divergent boundary?
9. How did the "rift valley" form?
10. Do we see evidence of divergence on continental regions? Where?
11. What could be the driving mechanism for divergence?
12. The Hawaiian Islands are a good example of a "hot spot". What are plumes or hot spots and why do we think the Hawaiian Islands are a good example?
13. Given the distribution of the age of the sea floor, how does this help prove that ridge zones are divergent plate boundaries?
14. After sampling the rock on either side of the ridge zones, what conclusion was made about the magnetic field of the Earth over time?
15. Explain the differences and relationships between fracture zones and transform faults.
16. If there are divergent plate boundaries, why must there be convergent boundaries?
17. What are the shapes of the convergent boundaries with respect to the ridge zones, ocean basins, continents, etc.?
18. Describe subduction zones and the structural activities (faulting, magma, volcanoes, etc.) associated with it.
19. Explain the formation of the Himalayan Mountians.

XVI. Surface Relief and Mountain Building (p404-417)

CONCEPT: There is an obvious difference between the landmasses and the oceans. Why is there a difference? Look at the chemical compositions of each crustal material and consider the material that is below them. Apply this same idea to any mountain range on the planet.

- A. Formation of continental and oceanic crust
- B. Isostasy
  1. Crustal material
  2. Ice-age glaciers
- C. Mountain building

REVIEW QUESTIONS

1. After the first crust of the Earth formed, what is the present theory of the original ocean and continental crust before Plate Tectonics modified the surface?
2. Explain the concept of "Isostasy" in terms of mountains, glaciers, etc.
3. Explain the formation of the Sierra Nevada Mountains.

XVII. Erosional Processes

CONCEPT: Erosion involves the transport of crustal material. Since movement of matter is required, an energy source is needed. Also, it helps to have something else carry the material.

- A. Energy
- B. Agents

REVIEW QUESTIONS

1. What is the difference between weathering and erosion? Do both processes occur together? Why?
2. Describe the sources or types of energy to cause erosion.

3. What are agents of erosion, name them and how do they relate to the energy?

XVIII. Mass Wasting (Downslope Movement) (p426-455)

CONCEPTS: When material on the Earth's surface is "placed" in a relatively unstable condition, gravity will force that material down to a more stable configuration. Various triggering mechanisms may cause the downslope movement.

- A. Triggering Mechanisms
  1. Any type of vibration
  2. Adding water to unconsolidated material
  3. Overloading
  4. Undercutting
- B. Rock fall and debris fall - talus formation
- C. Rock avalanche
- D. Rock slide and debris slide
- E. Slumping
- F. Earthflow
- G. Mudflow
- H. Creep

REVIEW QUESTIONS

1. What would cause material to be in a position of instability and how does this relate to the triggering mechanism that cause the material to fall?
2. Describe the following: rock/debris falls, rock avalanche, rock/debris slide, slumping, earthflow, mudflow and creep. How do these relate to each other.

XIX. Rivers - Flowing water (p458-495)

CONCEPTS: The energy of moving water to lower regions on the planet is responsible for most of the erosion of the Earth's surface. There are many controlling factors of how that energy is expressed. Once these are understood and measured, we can monitor the effects of erosion and the amount of the most precious resource - WATER. The eroded material is deposited depending on the condition of the stream or where the water is placed. These conditions are controlled by the energy balance of the stream. When rainfalls are high and/or when snows melt, stream or rivers can spill over their banks. This causes large area to be flooded and much material to be eroded and deposited.

- A. Hydrologic cycle (p459-460)
  1. Evaporation and transpiration
  2. Infiltration
  3. Runoff
- B. Raindrop impact
- C. Flows - overland sheet erosion and stream (p460-462)
- D. Use of energy (p462-463)
  1. River speed and use of energy
     a. Cross Sectional Speed with no meanders
     b. Cross Sectional Speed with meanders - asymmetry of stream bed
     c. Controlled by gradient, friction, volume and loads
        (1) Steeper (Increase) gradient - increase speed with no friction
        (2) Increase friction - decrease speed

(3) Increase volume - increase speed
(4) Increase load - decrease speed

d. Shape of river channel - water contact with stream bed
c. In general, stream speed increases down stream when gradient is less

2. Discharge = width x depth x speed

E. River erosion and deposition (p464-473)
1. Loads-dissolved, suspended and bed
2. Abrasion of bed and potholes
3. Rate of river erosion
4. Meanders - Oxbow Lake
5. Graded and non-graded stream
6. Alluvial fans
7. Deltas and building beaches - longshore current
8. Damming of rivers

F. Flooding (p474-479)
1. Floodplain
2. Natural levees
3. Mud flows

G. Formation of river valleys
1. Grand Canyon

REVIEW QUESTIONS

1. What is the process of the Hydrologic Cycle?
2. Given the amount of water involved in precipitation, What is the average percentage that evaporates and transpires, infiltrates and erodes (runoff)?
3. How does a river system form? Consider sheet erosion, local weaknesses in rock material, elevation of water table, distance to base level, etc.
4. How does the speed of a stream vary in cross section (from bank to bank and from surface to bottom) without any meanders? How does the speed change in cross section in a meander?
5. Does the erosional energy of a river vary in terms of the meanders the river as it works its way down the slope? Is the energy less or greater on the inside or outside of the meander?
6. What factors control the speed of a stream? How do they work?
7. How does the shape of a stream control the speed?
8. Why, in general, does a stream increase speed as the water moves downstream?
9. The carrying capacity of the river depends on what properties of the river?
10. What is meant by the discharge of a river? How do you measure this quantity and why is it important to measure this?
11. What are the three types of “loads” in a river?
12. How are potholes formed?
13. What is a Oxbow lake and How does it form?
14. What is the difference between a “graded stream” and a “nongraded stream”?
15. Explain the formation of alluvial fans?
16. What is a Delta and how does it form? Why do some major rivers in the world have Deltas and others do not?
17. What are the effects of damming a river on the deposition of material and the erosion process?

18. Why do we have flooding? Is it preventable?
19. How are natural levees formed?

XX. Glaciers (p532-565)

CONCEPTS: When snow falls and piles up it can change into ice. These large masses of ice can move slowly downhill. This downward movement removes large amounts of material. The surface features are unique as a result of glacial activities. When slight changes of surface conditions occur, snow that normally melts during the summer remains. This process continues for many years causing large amounts of ice to form. There are many theories to explain this change.

A. Formation of Glaciers
    1. Change from snow flakes to ice - a Metamorphic process
    2. Conditions for the snow fall to remain
        a. Persistent higher average annual precipitation
        b. Persistent slightly cooler annual temperature
    3. Movement of Glaciers
        a. Downhill flows
        b. Condition of the bottom of the ice mass
        c. Factors that control the speed of flow - like liquid water
        d. Formation of Crevasses
        e. Advances and Retreats
    4. Theories of Glaciation
        a. Astronomical
        b. Terrestrial
B. Kinds of Glaciers
    1. Mountain (Valley or Alpine) Glaciers
    2. Continental - e.g. Greenland and Antarctica
C. Glacial Erosion
    1. "Bulldozing Effect"
        a. More ice - more material moved
        b. Steeper gradient - more material moved
        c. U-Shaped Valleys (Troughs) and Fjords
    2. Plucking
    3. Glacial Abrasions, Striations and Polishing
    4. Erosional Features - Horns, Arete, Cirques, Tarns, Hanging Valleys and Truncated Spurs
D. Glacial Deposition
    1. Drift - due to ice and flowing water (stratified drift)
    2. Till - due to ice only (unsorted material)
    3. Moraines - End, Recessional, Ground, Lateral and Medial
    4. Deposition Features
        a. Drumlins - elongated hills made of till
        b. Kames - hills made of drift in a depression in ice
        c. Eskers - sinuous ridges made of drift
        d. Erratic Boulders - till
        e. Kettles - circular lakes from large pieces of ice

REVIEW QUESTIONS

1. How does a Glacier form? What happens to the snow? What average annual temperatures are required? How does the precipitation rate affect the glacial process?
2. What enables the Glaciers to move down hill since they are a solid block of ice? What enables an ice skater to move on the ice?
3. What factors control the speed of glacier movement?
4. How are "crevasses" formed on the glacier? Is the rate of movement affected by the slope?
5. What are some of the theories of "Ice Ages"? How do they Work?
6. What is the difference between the Mountain and Continental Glaciers?
7. What happens to the material that is in front of the glacier as it moves downward? What is the topography after the glacier passed? How do Fjord form?
8. What effect does the glacier have on the bed rock that it is moving across? What is Plucking? Can you see on the surface of the rock that a Glacier had moved through the area? Describe the surface of the bedrock that the ice has moved over.
9. Describe the glacial erosional features and how they form.
10. What is the difference between glacial "drift" and glacial "till"?
11. How does an End Moraine form? What is the difference between an End Moraine and a Terminal Moraine?
12. What are Ground, Medial and Lateral moraines and how do they form?
13. What are the Glacial Deposition Features and how do they form?

XXI. Arid Regions (p568-595)

CONCEPTS: In arid regions water still dominates as the main agent of erosion. Without vegetation to hold the soils in place, agents of erosion have an easy time removing material. Wind becomes a more obvious agent of erosion making various features and landforms that are unique to dry climates.

A. Comparison of moist region to that of dry region
    1. Types of weathering
    2. Types of downslope movement
    3. Amount of Vegetation
    4. General topography
B. Effects of water erosion in arid regions
    1. Flash floods
    2. Alluvial fans and Bajadas
    3. Pediments
C. Playa - types of deposition
D. Wind Erosion
    1. Bed load - saltation
    2. Suspended load - dead zone
    3. Deflation and Deflation Armor
    4. Abrasion - ventifacts
E. Wind deposition
    1. Dunes
    2. Loess

REVIEW QUESTIONS

1. Is mechanical or chemical weather the primary type of weathering in arid regions?

2. How does the type of downslope movement differ in the two regions?
3. What is the general topography of arid regions compared to moist regions?
4. How do flash floods form? Why are they so dangerous in arid regions?
5. How do Alluvial Fans form and what is a Bajada?
6. What are Pediments with respect to mountain erosion and alluvial material?
7. What are Playas and what types of deposition are involved and how do they form?
8. In dealing with wind erosion, what are bed loads and suspended loads?
9. What is the necessary wind velocity to pick up sand grains and how high do they get above the ground?
10. Does dust grain material require a specific wind velocity? What is a “dead zone”?
11. What is meant by deflation? What is deflation armor and how does it form?
12. What are ventifacts?
13. How are sand dunes form? Do they move? Do they have different shapes?
14. What are Loess deposits and how do they appear on the surface?