Earth Science

Chapter 11- Deformation of the Crust

Section 1 - How Rock Deforms

E.Q.: ***What is the principal of isostosy and the main types of rock stress, folds, and faults?***

STANDARDS:

SES2. Students will understand how plate tectonics creates certain geologic features, materials, and hazards.

a. Distinguish among types of plate tectonic settings produced by plates diverging, converging, and sliding past each other.

b. Relate modern and ancient geologic features to each kind of plate tectonic setting.

SES6. Students will explain how life on Earth responds to and shapes Earth systems.

d. Describe how fossils provide a record of shared ancestry, evolution, and extinction that is best explained by the mechanism of natural selection.

Objectives:

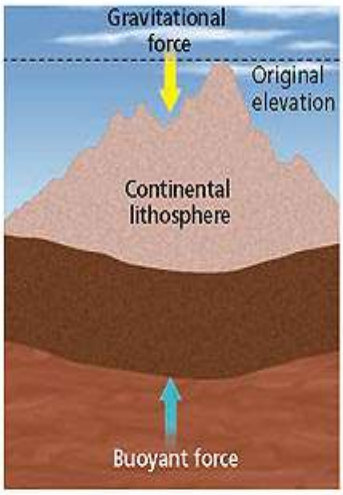
- **Summarize the principle of isostasy.**
- **Identify the three main types of stress.**
- **Compare folds and faults.**

Isostasy

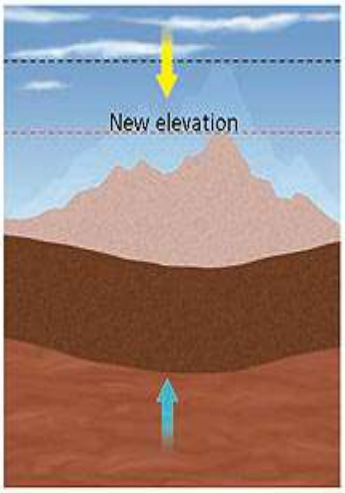
- ***deformatio*n - the bending , tilting, and breaking of Earth's crust; The change in shape of volume of rock in response to stress**
- **Deformation can occur when the weight of some part of Earth's crust changes. Earth's crust is part of the lithosphere.**
- **When the forces acting on the lithosphere are balanced, the lithosphere and asthenosphere are balanced, and in a state of *isostasy.***

- ***isostasy*** **- a condition of gravitational and buoyant equilibrium between Earth's lithosphere and asthenosphere**
- **When the weight of the lithosphere changes, the lithosphere sinks or rises until a balance is reached once again.**
- **The movements of the lithosphere to reach isostasy are called isostatic adjustments.**

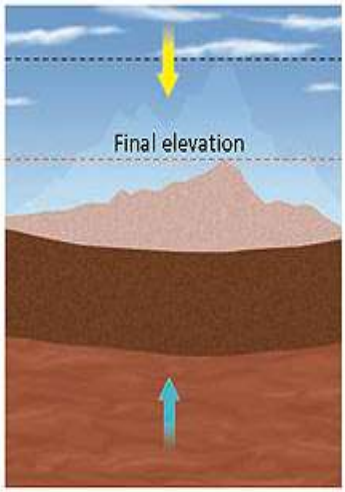
The diagram below shows isostatic adjustments as a result of erosion.



When the gravitational force equals the buoyant force, the lithosphere and asthenosphere are in isostasy.



As erosion wears away the crust, the lithosphere becomes lighter and is pushed up by the asthenosphere.



As erosion continues, the isostatic adjustment also continues.

Mountains and Isostasy

- **Isostatic adjustments regularly occur in mountainous regions.**
- **The surface of mountains is worn away by erosion over millions of years, resulting in a reduction of height and weight of the mountain range.**
- **The surrounding crust becomes lighter, and the area rises by isostatic adjustment in process called *uplift*.**

Deposition and Isostasy

- **Isostatic adjustments occur in areas where rivers carrying a large load flow into large bodies of water, such as an ocean.**
- **Most of the material that the river carries is deposited on the ocean floor.**
- **The added weight to the area causes the ocean floor to sink by isostatic adjustment in a process called *subsidence*.**

Glaciers and Isostasy

- **Isostatic adjustments also occur as a result of the growth and retreat of glaciers and ice sheets.**
- **The weight of the ice causes the lithosphere to sink, while the ocean floor rises because the weight of the overlying water is less.**
- **When glaciers or ice sheets melt, the land rises and the ocean floor sinks.**

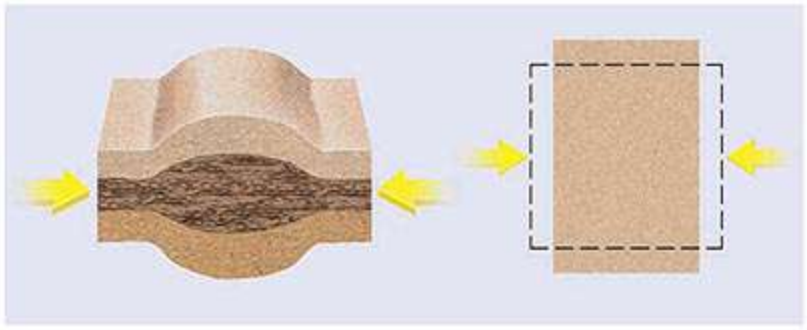
Stress

- ***stress* - the amount of force per unit area that acts on a rock**
- **As Earth's lithosphere moves, or when tectonic plates collide, these actions exert force on the rock called stress.**
- **There are three types of stress: compression, tension, and shear stress.**

Compression

- ***Compression* is the type of stress that squeezes and shortens a body of rock.**
- **Compression commonly reduces the amount of space that rock occupies, and pushes rocks higher up or deeper down into the crust.**
- **Compression occurs at or near convergent boundaries.**

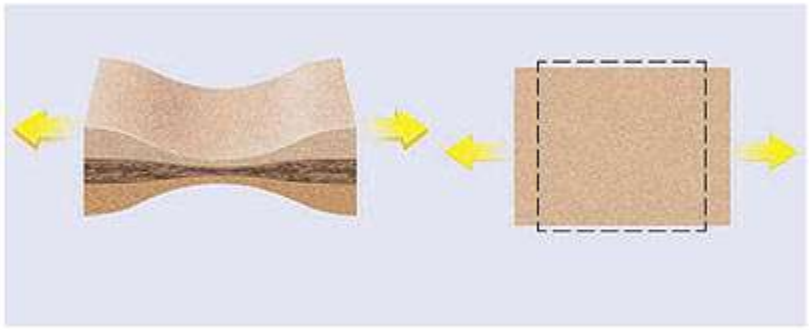
Compression



Tension

- ***Tension*** **is stress that stretches and pulls a body of rock apart.**
- **When rocks are pulled apart by tension, the rocks tend to become thinner.**
- **Tension occurs at or near divergent boundaries.**

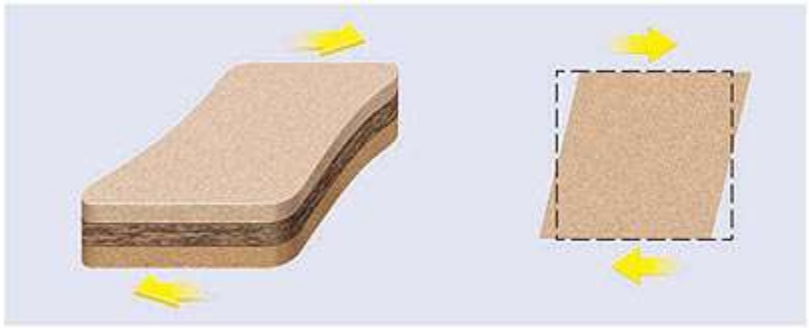
Tension



Shear Stress

- ***Shear stress*** **- distorts a body of rock by pushing parts of the rock in opposite directions.**
- **Sheared rocks bend, twist, or break apart as they slide past each other.**
- **Shear stress occurs at transform boundaries.**

Shear stress



Reading Check

Which two kinds of stress pull rock apart?

Tension and shear stress can both pull rock apart.

Strain

- ***strain*** **- any change in a rock's shape or volume caused by stress**
- **When stress is applied slowly, the deformed rock may regain its original shape when the stress is removed.**
- **The amount of stress that rock can withstand without permanently changing shape is limited.**
- **If a stress exceeds the rock's limit, the rock's shape permanently changes.**

Types of Permanent Strain

- **Brittle strain and ductile strain are types of permanent strain.**
- **Materials that respond to stress by breaking or fracturing are *brittle*. Brittle strain appears as cracks fractures.**
- ***Ductile*** **materials respond to stress by bending or deforming without breaking. Ductile strain is a change in the volume or shape of rock in which the rock does not crack or fracture.**

Factors that Affect Strain

- **The composition of rock determines where rock is ductile or brittle, but temperature and pressure also affect how rock deforms.**
- **At lower temperature and pressure, rock is likely deform in a brittle way. At higher temperature and pressure, rock will deform in a ductile way.**
- **The amount and type of stress and the rate at which stress is applied affects strain.**
- **The greater the stress on the rock is, the more likely rock is to undergo brittle strain.**

- **The more quickly stress is applied to rock, the more likely rock is to respond in a brittle way.**

Folds

- ***fold* - a form of ductile strain in which rock layers bend, usually as a result of compression.**
- **When rock deforms in a ductile way, folds form.**
- **A fold is most easily observed where flat layers of rock were compressed or squeezed inward.**
- **Although a fold commonly results from compression, it can also from as a result of shear stress.**

Anatomy of a Fold

- **Folds have several features by which they are described.**
- **The sloping sides of a fold are called *limbs*.**
- **The limbs meet at the bend in the rock layers, which is called the *hinge*.**
- **If both halves of a fold are symmetrical, then the fold has an axial plane.**
- **The axial plane is a place that could slice the fold into two symmetrical halves.**
- **If a fold is overturned, it appears to be lying on its side.**

Reading Check

Name two features of a fold.

Limbs and hinges

Types of Folds

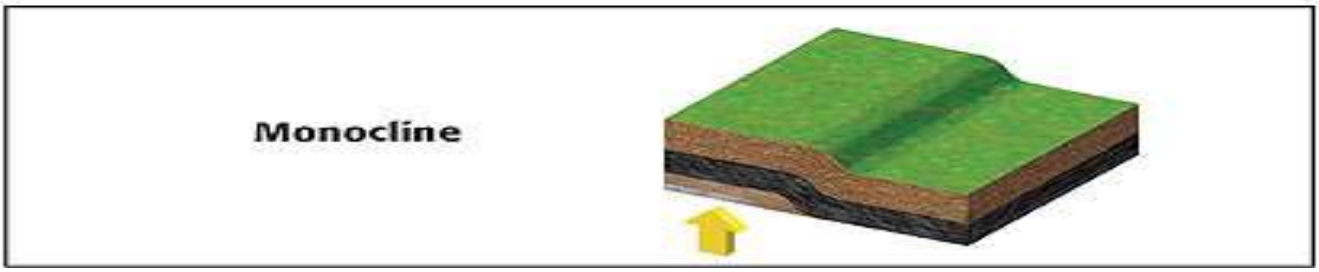
- **To categorize a fold, scientists study the relative ages of the rocks in the fold.**
- **An *anticline* is a fold in which the oldest layer is in the center of the fold. Anticlines are commonly arch shaped.**
- **A *syncline* is a fold in which the youngest layer is in the center of the fold. Synclines are commonly bowl shaped.**

- **A *monocline* is a fold in which both limbs are horizontal or almost horizontal. Monoclines form when one part of Earth's crust moves up or down relative to another part.**

Sizes of Folds

- **Folds vary greatly in size. Some folds are small enough to be contained in a hand-held rock specimen.**
- **Other folds cover thousands of square kilometers can be seen only from the air.**
- **A large anticline may form a ridge, which is a large, narrow strip of elevated land that can occur near mountains.**
- **A large syncline may form a valley.**

The diagram below shows the major types of folds.



Faults

- ***fault*** **- a break in a body of rock along which one block slides relative to another; a form of brittle strain**
- **Stress on rock can cause rock to break.**
- **Breaks in rock along which there is no movement of the surrounding rock is called a *fracture*.**
- **A break along which the surrounding rock moves is called a fault.**
- **The surface or plane along which the motion occurs is called the *fault plane*.**
- **In a nonvertical fault, the *hanging wall* is the rock above the fault plane.**
- **The *footwall* is the rock below the fault plane.**

Normal Faults

- **A normal fault is a fault in which the hanging wall moves downward relative to the footwall.**
- **Normal faults commonly form at divergent boundaries, where the crust is being pulled apart by tension.**
- **Normal faults may occur as a series of parallel fault lines, forming steep, steplike landforms.**

Reverse Faults

- **When compression causes the hanging wall to move upward relative to the footwall, a *reverse fault* forms.**

- **A *thrust fault* is a special type of reverse fault in which the fault plane is at a low angle or is nearly horizontal.**
- **Reverse faults and thrust faults are common in steep mountain ranges, such as the Rockies and the Alps.**

Reading Check

How does a thrust fault differ from a reverse fault?

A thrust fault is a type of reverse fault in which the fault plane is at a low angle relative to the surface.

Strike-Slip Faults

- **In a strike-slip fault, the rock on either side of the fault plane slides horizontally in response to shear stress.**
- **Strike-slip faults got their name because they slide, or *slip*, parallel to the direction of the length, or *strike*, of the fault.**
- **Strike-slip faults commonly occur at transform boundaries.**
- **Strike-slip faults also occur at fracture zones between offset segments of mid-ocean ridges.**
- **Commonly, strike-slip faults occur as groups of smaller faults in areas where large-scale deformation is happening.**

Sizes of Faults

- **Like folds, faults vary greatly in size. Some faults are so small that they affect only a few layers of rock in a small region.**
- **Other faults are thousands of kilometers long and may extend several kilometers below Earth's surface.**
- **Large faults that cover thousands of kilometers are composed of systems of many smaller, related faults.**

The diagram below shows the major types of faults.