Rock Deformation

The forces that cause deformation of rock are referred to as stresses (Force/unit area). So, to understand rock deformation we must first explore these forces or stresses.

Stress

Stress (force per unit area) is a measure of the tectonic force and confining pressure acting on bedrock. Stress can be compressive, tensional, or shearing.
Compressive stress is common in convergent plate boundaries, where two plates converge and the rock crumples.
Tensional stress pulls rock apart and is the opposite of tectonic compression (Fig. 6–1c).
Shear stress acts in parallel butopposite directions (Fig. 6–1d).

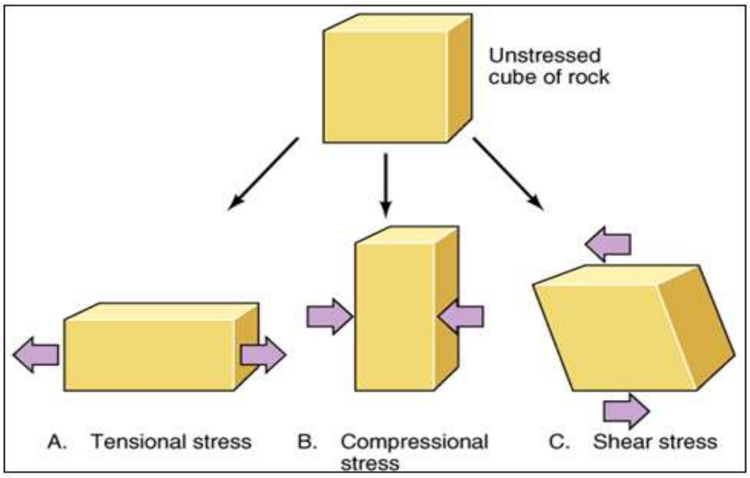


Figure 6–1 (a) Tensional stress (b) Compressive stress (c) Shear stress

Strain

Strain is the deformation produced by stress. A rock responds to tectonic stress by elastic deformation, plastic deformation, or brittle fracture.

Factors that affect deformation:

1. The nature of the material.
2. Temperature.
3. Pressure.
4. Time.

Geologic Structures

A geologic structure is any feature produced by rock deformation. Tectonic forces create three types of geologic structures: folds, faults, joints, and unconformities.

1. Folds

The term **fold** is used in geology when one or a stack of originally flat and planar surfaces, such as sedimentary strata, are bent or curved as a result of permanent deformation.

Fold Features

I. Limbs:- portion of fold separated by hinges.

II. Axial Plane:- divide a fold as symmetrically as possible into two halves

III. Fold Axis:- is a line parallel to the hinges. The term axis has also been used as synonymous with hinge.

IV. Hinge Line:- is the line of maximum curvature in a folded bed. It may be horizontal, vertical and inclined.

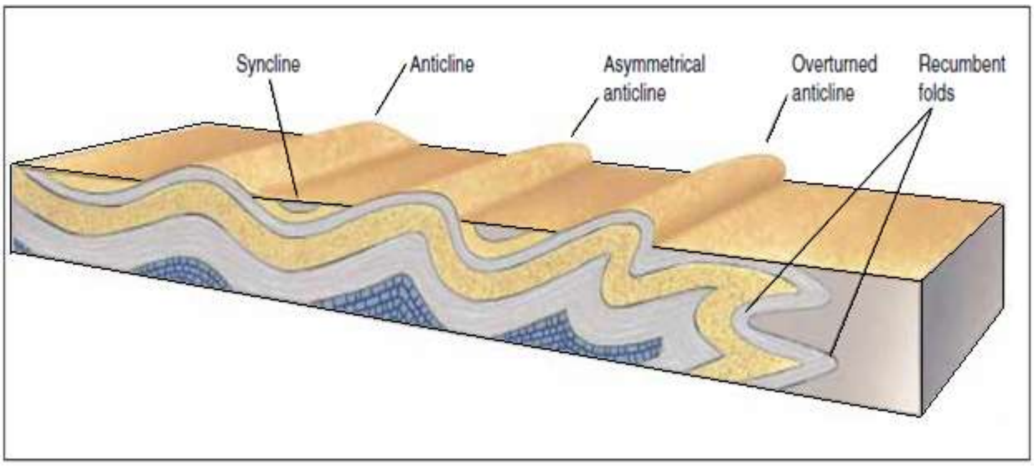
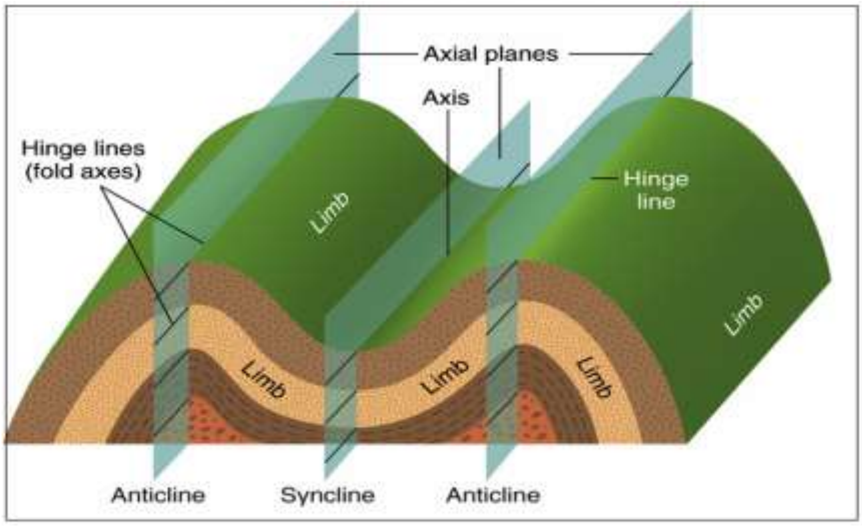


Figure (6–2) summarizes the characteristics of five common types of folds.



Figure(6.3) Diagrammatic sketch of two anticlines and a syncline illustrating the axial planes,hinge lines, and fold limbs.

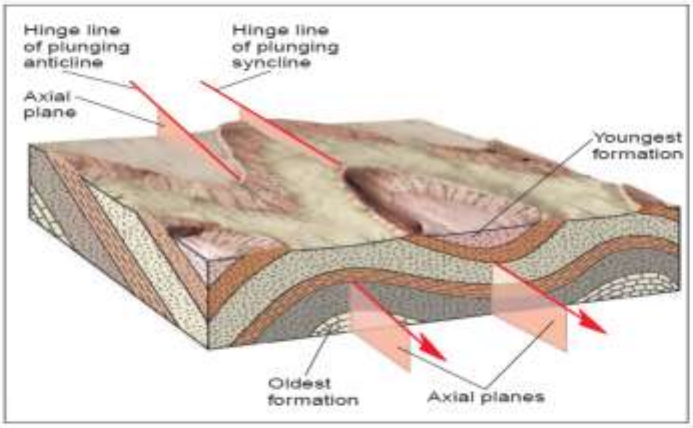


Figure (6.4) Plunging anticline on left and right and plunging syncline in center.

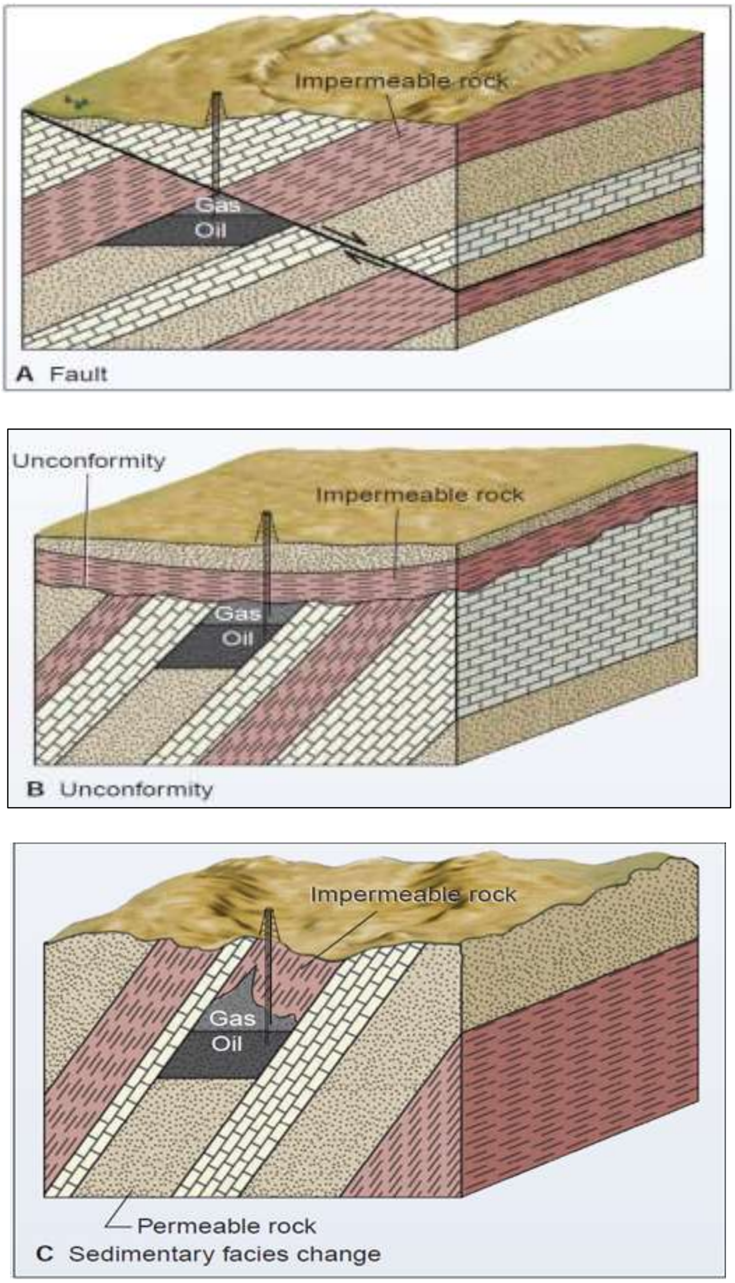


Figure (6.5) Structures other than anticlines that trap oil.

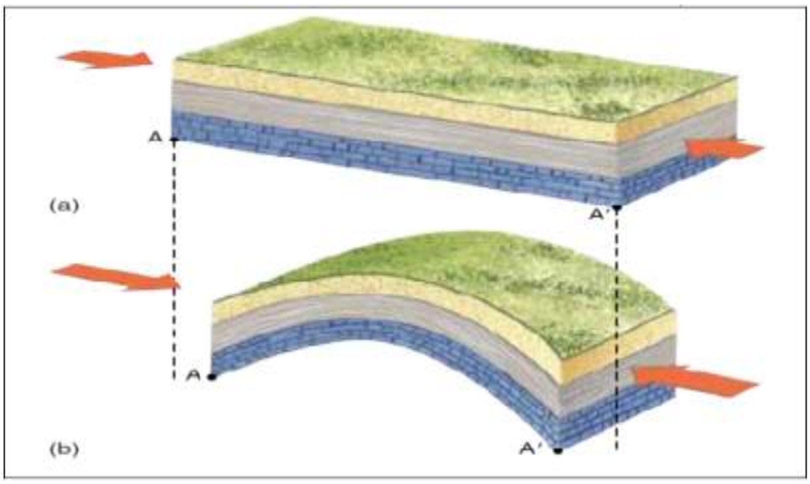


Figure (6–6) (a) Horizontally layered sedimentary rocks.(b) A fold in the same rocks.

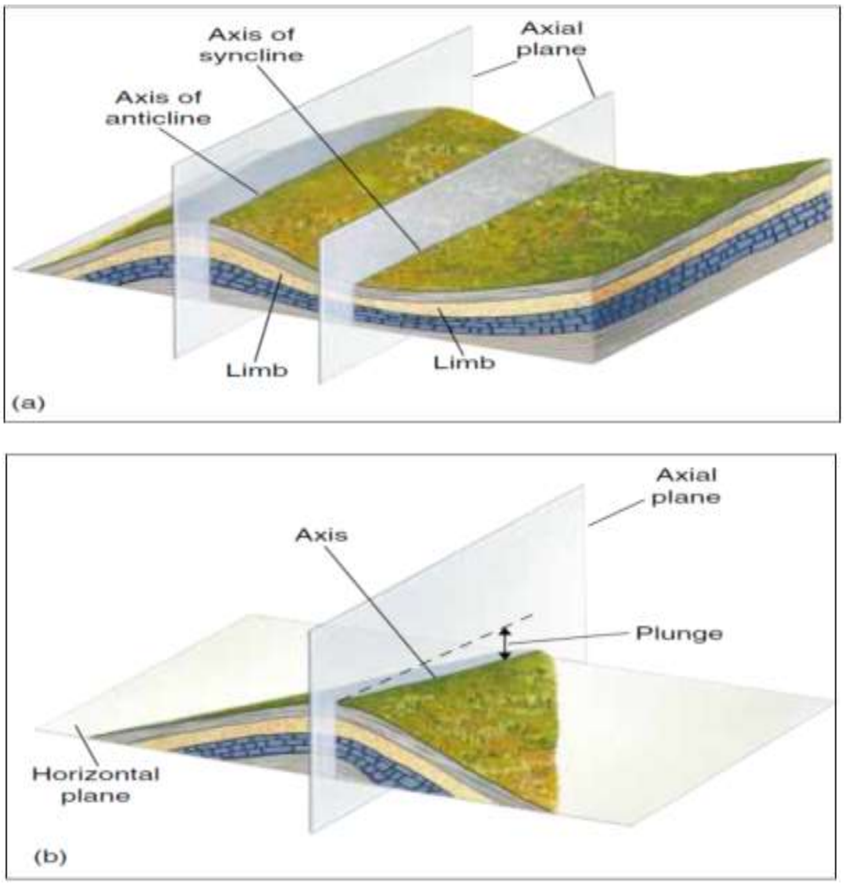
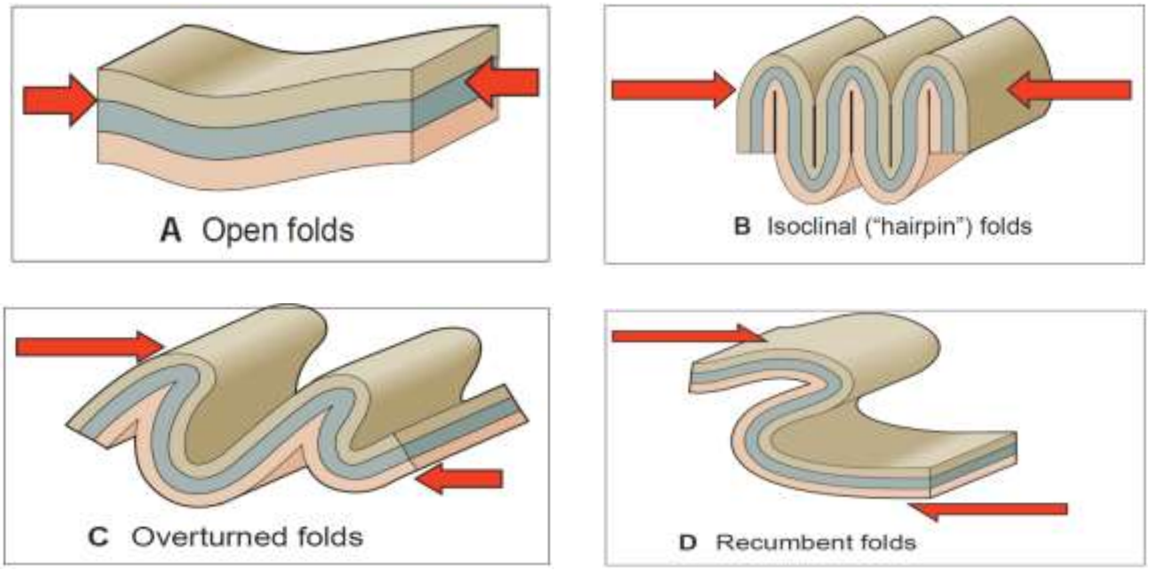


Figure (6–7) (a) An anticline, a syncline, and the parts of afold. (b) A plunging anticline.



Figure(6.8) (A) Open folds (B) Tight to isoclinal folds (C) Overturned anticline (D) Recumbent folds

2. Faults

A fault is a fracture along which rock on one side hasmoved relative to rock on the other side (Fig. 6–12).

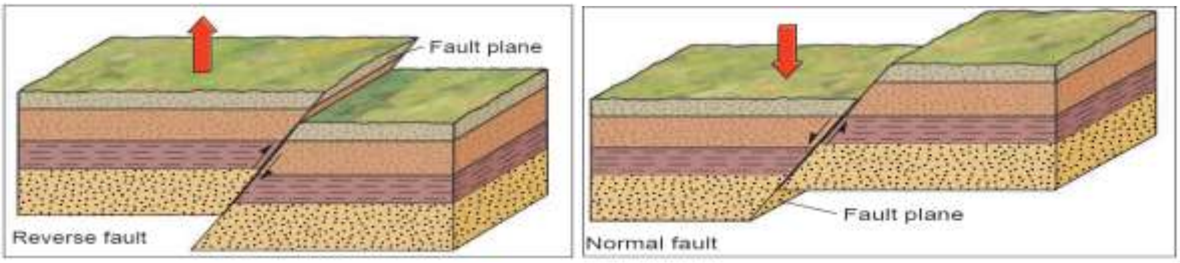
Slip is the distance that rocks on opposite sides of a faulthave moved. Movement along a fault may be gradual,orthe rock may move suddenly, generating an earthquake.

A fault in which the hanging wall has moved downrelative to the footwall is called a **normal fault**.

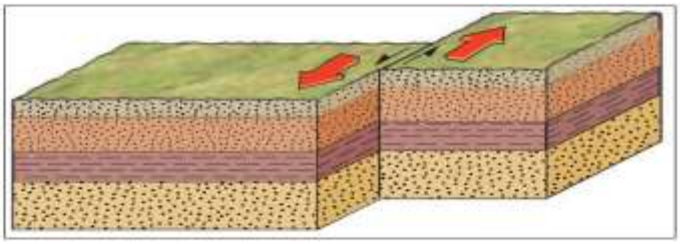
In a **reverse fault** (Fig. 6–9), the hanging wall has movedup relative to the footwall. The distance between points A and A′ is shortened by the faulting.

A **thrust fault** is a special type of reverse fault that is nearly horizontal. In some thrust faults, the rocks of the hanging wall have moved many kilometersover the footwall.
A **strike–slip fault** is one in which the fracture is vertical, or nearly so, and rocks on opposite sides of thefracture move horizontally past each other (Fig. 6-9).

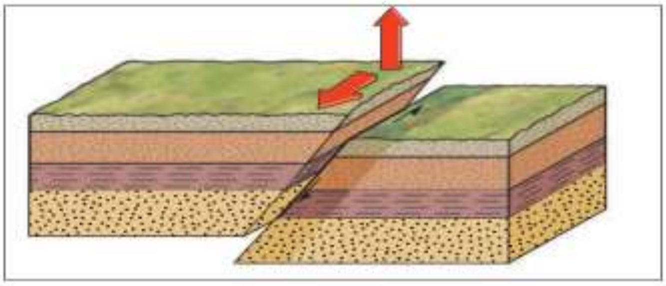
The graben, if tectonic forces stretch the crust over a large area, many normal faults may develop, allowing numerous grabens to settle downward between the faults. The blocks of rock between the down dropped grabens then appear to have moved upward relative to the grabens; they are called horsts. A fold accomplishes shortening.



A- Dip-slip faults



B- Strike-slip fault



C- Oblique-slip fault

Figure(6.9) (A) Dip-slip movement. (B) Strike-slip movement. (C) Oblique-slip movement

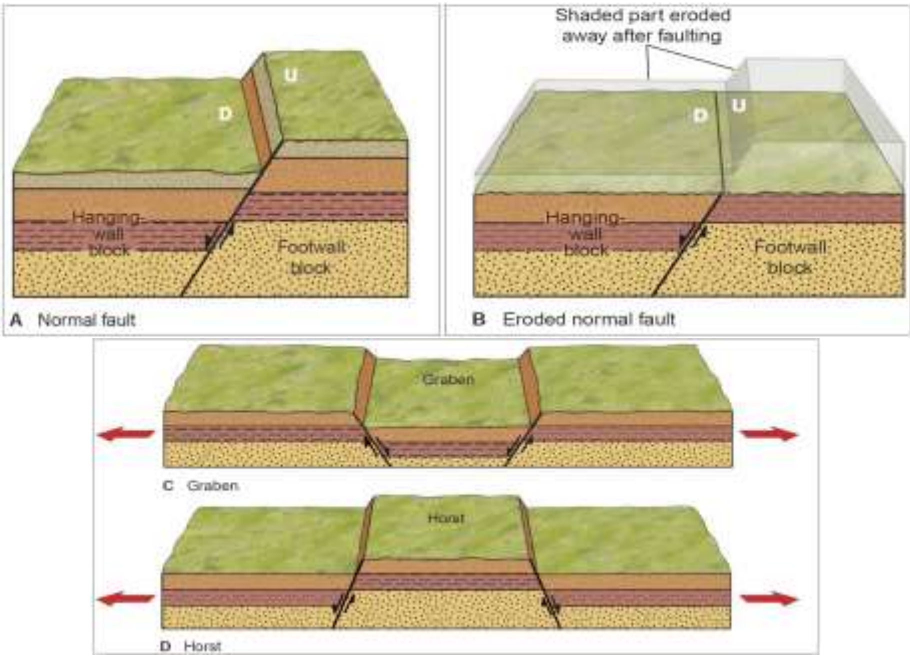


Figure (6.10) Normal faults. (A) the fault before erosion and the geometric relationships (B) The same area after erosion. (C) A graben. (D) A horst.

Structural Domes and Structural Basins

A structural dome is a structure in which the beds dip away from a central point. In cross section, a dome resembles an anticline and is sometimes called a doubly plunging anticline.

In a structural basin, the beds dip toward a central point (figure 6.15); in cross section, it is comparable to a syncline (doubly plunging syncline). A structural basin is like a set of nested bowls. If the set of bowls is turned upside down, it is analogous to a structural dome.

Domes and basins tend to be features on a grand scale (some are more than a hundred kilometers across), formed by uplift somewhat greater (for domes) or less (for basins) than that of the rest of a region.

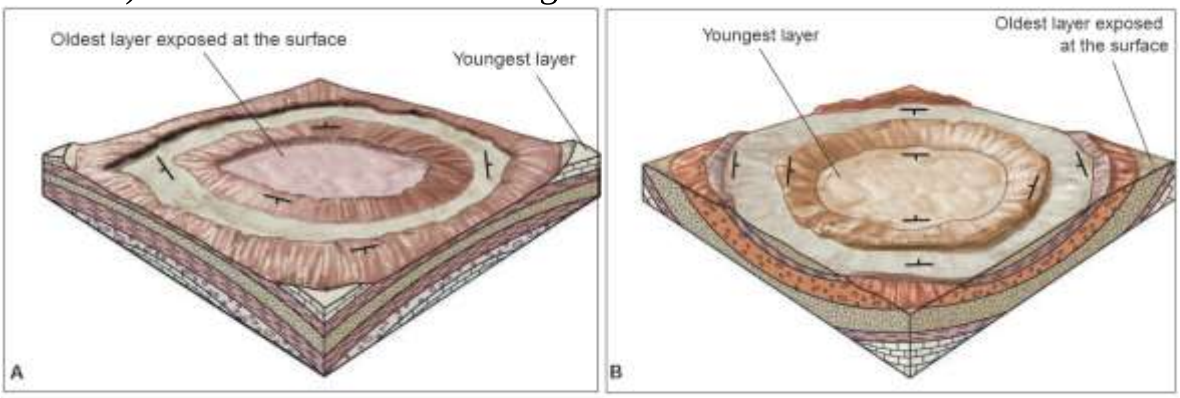


Figure (6.11) (A) Structural dome. (B) Structural basin.

3. Joints

A joint is a fracture in rock and is therefore similar to a fault, except that in a joint rocks on either side of thefracture have not moved. Tectonic forcesalso fracture rock to form joints. Most rocksnear the Earth's surface are jointed, but joints becomeless abundant with depth because rocks become moreplastic at deeper levels in the crust.

Joints and faults are important in engineering, mining, and quarrying because they are planes of weaknessin otherwise strong rock.

Strike and Dip

Strike is the compass direction of theline produced by the intersection of a tilted rock or structure with a horizontal plane. Dip is the angle of inclination of the tilted layer, also measured from the horizontal plane.

4. Unconformities

"The record is in the rocks" is a deceptively simple, yet extremely important, expression of how geologists are able to interpret geologic history by studying the rock record.

There are a number of different kinds of unconformities, depending on the attitude and nature of the rocks on either side of the hiatus.

I. A disconformityis a type of unconformity in which the rocks are parallel to one another on either side of the erosion surface.

II. Angular unconformities are easier to detect because the rocks on either side of the hiatus have angular relationships to one another, suggesting folding, tilting or faulting, and erosion of the underlying layers, before deposition of subsequent strata takes place.

III. An unconformity between sedimentary rocks and older plutonic igneous or massive metamorphic rocks that were exposed to erosion before the overlying sediments covered them, is called a nonconformity.