Structural Geology Part II

Fractures (Faults and Joints)

Shear Zones

A **shear zone** is a zone of ductile or brittle—ductile deformation between two blocks that have moved relative to each other .

Shear zones are tabular to sheet like, planar or curviplanar zones in which rocks are more highly strained than rocks adjacent to the zone.

Shear zones have certain characteristics that permit us to recognize them in the field, in thin sections, and on geologic maps and cross-sections. The distinguishing characteristics vary, depending on whether the shear zone formed under brittle, ductile, or intermediate conditions.

A fault zone is a shear zone formed under brittle conditions.

When shear zones form under ductile conditions, deformation is accompanied by metamorphism and produces rocks with foliation, lineation, folds, and related features.

Most shear zones contain features that permit us to determine the sense of displacement along the zone.

TYPES OF SHEAR ZONES

We divide shear zones into three general types, based on the characteristic type of deformation.

1- brittle shear zone contains fractures and other features formed by brittle deformation mechanisms.

2- ductile shear zone displays structures, such as foliation and lineation.

3- Brittle-ductile shear zones, which show evidence for both brittle and ductile deformation, form where conditions during shearing were intermediate between brittle and ductile, or where conditions changed from ductile to brittle or from brittle to ductile.

Brittle Shear Zones

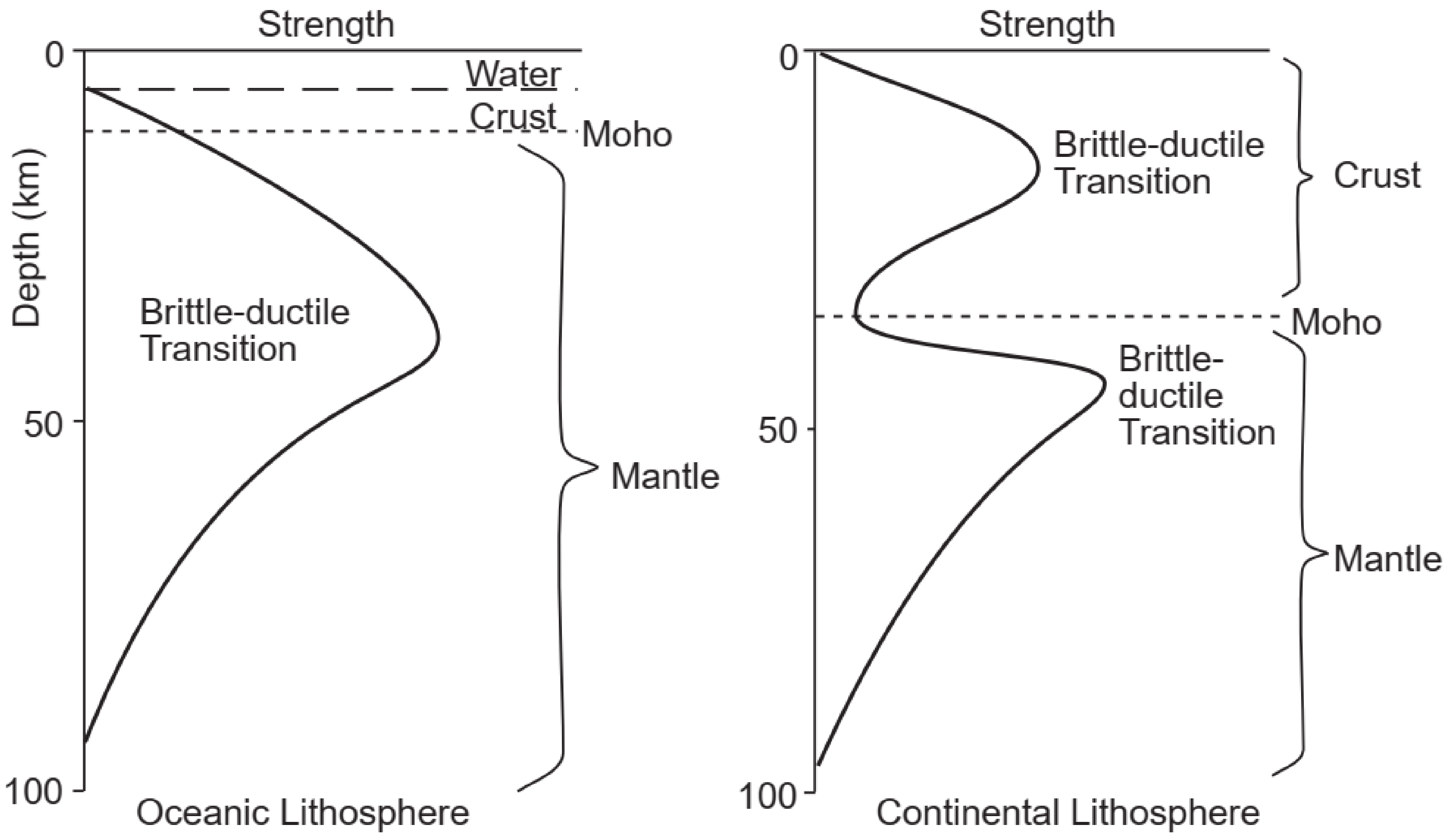
Brittle shear zones form in the shallow parts of the crust, generally within 5-10m km of the Earth's surface, where deformation is dominated by brittle mechanisms, such as fracturing and faulting. Brittle shear zones are in effect fault zones, and they are marked by fault gouge and other rocks of the breccia series.

Zones of intensely fractured and crushed rocks associated with faults vary in thickness from less than a millimeter to a kilometer or more. In general, the thickness of a brittle shear zone increases with the amount of displacement accommodated by the zone.

Ductile Shear Zones

Ductile shear zones are formed by shearing under ductile conditions, generally in the middle to lower crust and in the asthenosphere. For the most common crustal rocks (e.g., granite), brittle deformation at shallow crustal levels gives way downward into ductile deformation at the brittle-ductile transition .

A similar brittle-to-ductile transition is present within the mantle, probably near the lithosphere-asthenosphere boundary.

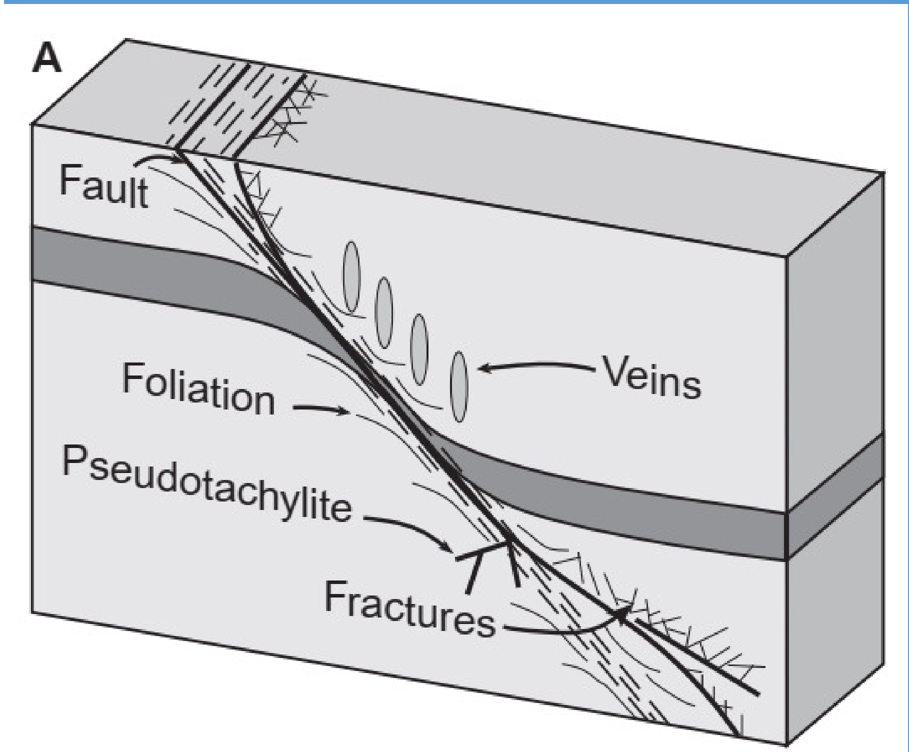

Strength
0
Water
Crust
Moho
Depth (km)
Brittle-ductile
Transition
50
Mantle
100
Oceanic Lithosphere
Strength
0
Brittle-ductile
Transition
Crust
Moho
Brittle-
ductile
Transition
50
Mantle
100
Continental Lithosphere

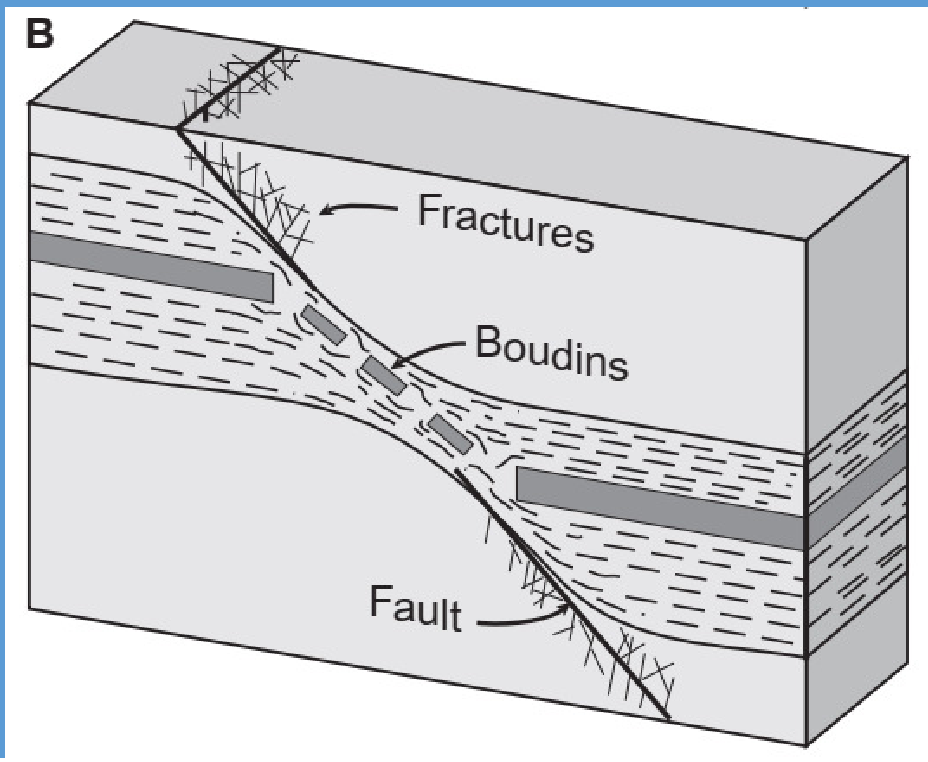
Brittle-Ductile Shear Zones

Brittle-ductile shear zones contain evidence of deformation by both brittle and ductile mechanisms.

Many brittle-ductile shear zones contain boudins, rock fragments, and porphyroclasts of the more brittle minerals and rock.

A brittle-ductile character to a shear zone may indicate that physical conditions fluctuated during deformation.





Fabric/ Tectonites

The term fabric includes the complete spatial and geometrical configuration of all the components that make up a rock.

Fabric is a total sum of grain shape, grain size and grain orientation.

Isotropy and homogeneity

A rock with randomly oriented fabric elements will have the same physical and geometrical properties in all directions, and is therefore *isotropic*. Such rocks are rare in nature.

If any two identically oriented, equal-volume samples taken from a rock mass are identical in every respect, the mass from which they came is said to be *homogeneous*.
A region of a rock body which is homogeneous with respect to the orientation or pattern of orientation for a given fabric element is a termed a fabric *domain*.

Almost all rocks, including sedimentary, igneous and metamorphic, show some degree of preferred orientation and therefore are *anisotropic*. Such rocks are often recorded the processes of formation and deformation by these anisotropic fabrics are termed *tectonites*.

These fabrics may be *planar* or *linear*, and they are marked by a preferred orientation of shape or lattice.

Petrofabric Analysis

Petrofabric is the study of deformational features in the rocks, usually of grain scale. The most commonly studied features are (distribution , morphology and orientation) twinning , pressure solution and recrystallization fabrics.

Petrofabric provides information on the following:

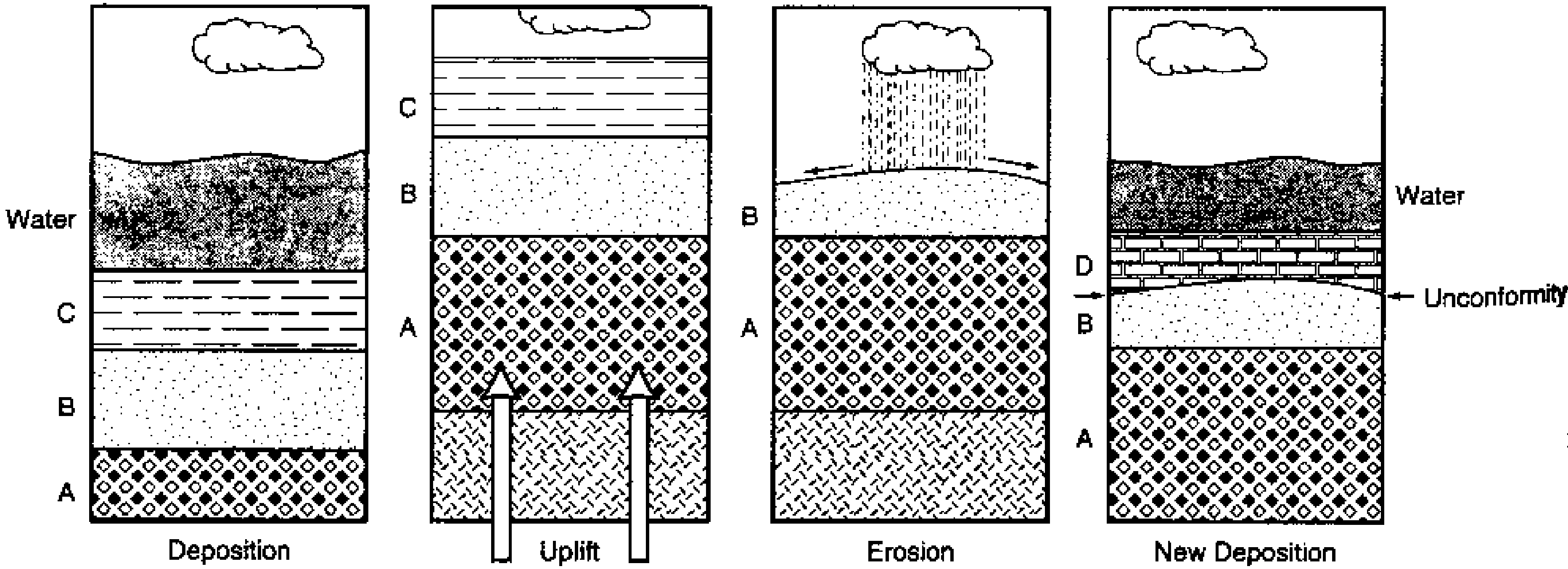
1. Mechanism of deformation.
2. Orientation and magnitude of principle stresses.
3. Deformation effects on porosity and permeability.

Unconformity

The fundamental "laws" of stratigraphy, formulated in the 17th Century by Nicolas Steno, is the law of Original Horizontality, which is known as *Conformity.*

That is, any deposition when takes place is totally in horizontal fashion.

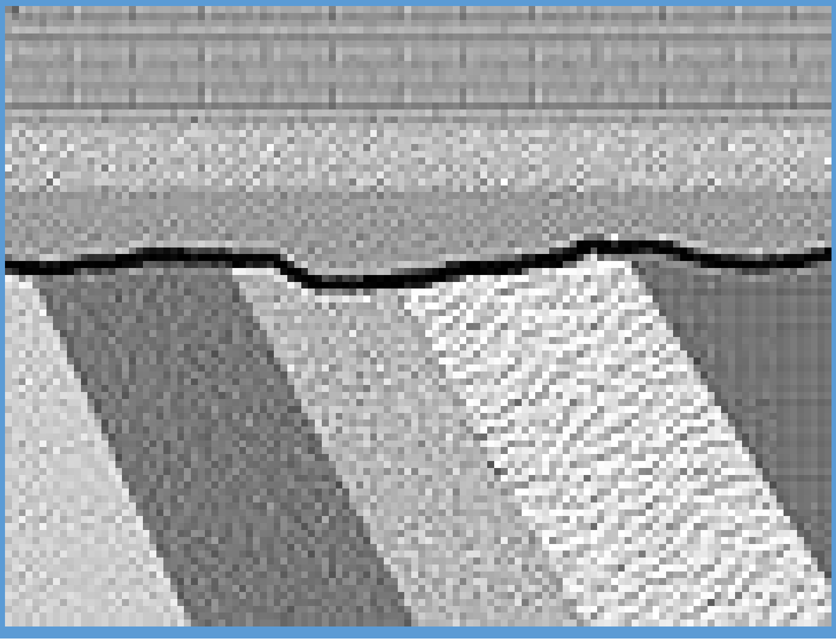
Unconformity is a surface of non – deposition and erosion.
It is represented by a time gap. It is referred to a period of non-deposition.
Unconformity can be local, can be regional extent.
It can represents small or large time gap.
Unconformity surfaces almost undulatory surface.
Unconformity are associated with conglomerate or arkosic rock types in many cases.
Unconformities are resulted due to tectonic activity in form of uplift or subsidence of land.
It is different then all other geological structures viz. the fold, joints and faults

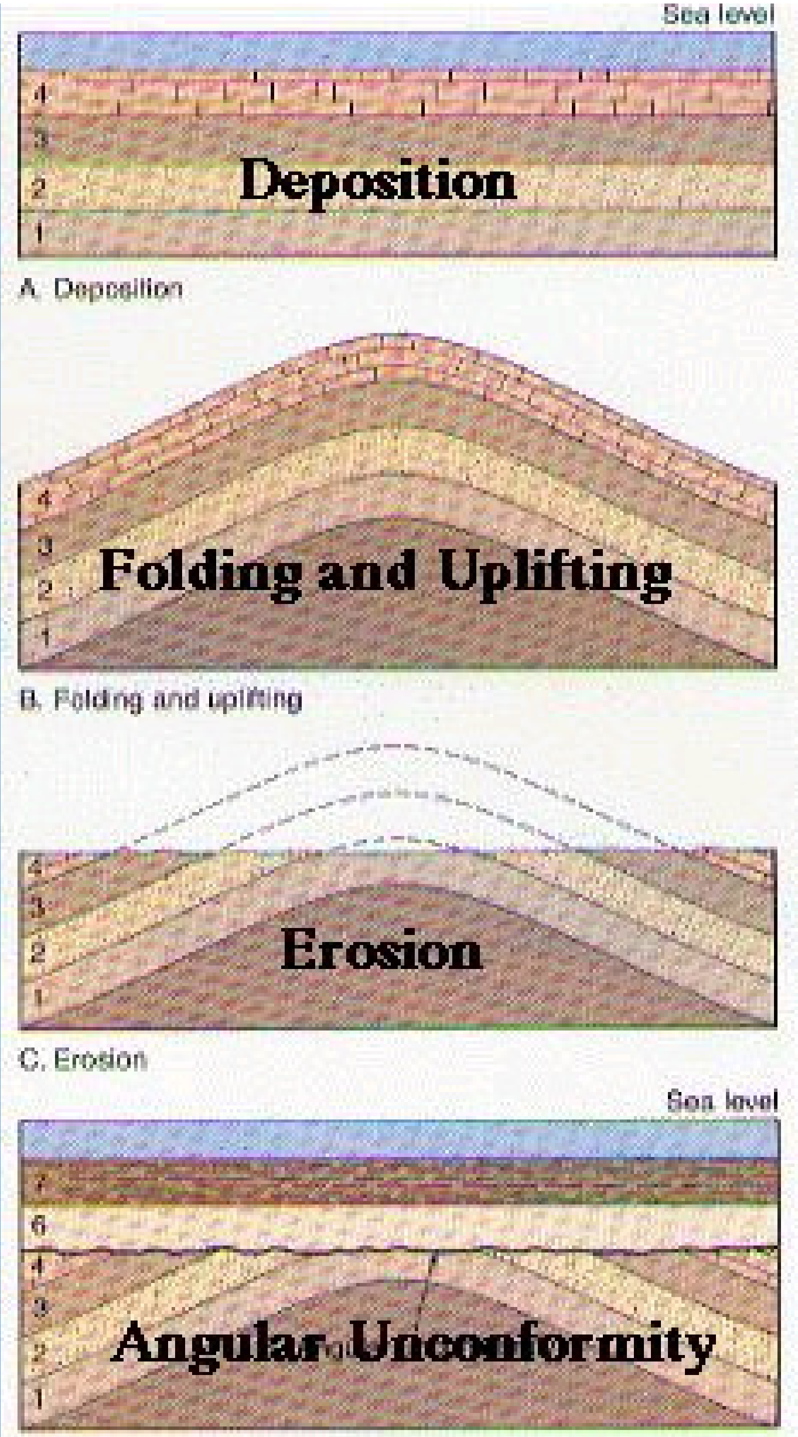

Water
C
B
A
Deposition
C
B
A
Uplift
B
A
Erosion
Water
D
Unconformity
B
A
New Deposition

types of unconformities

Angular Unconformity

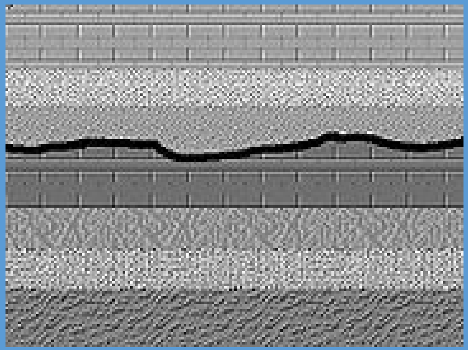
In this case sediments are both above and below the contact, but the ones below meet the contact at an angle. This is called an angular unconformity because the dips of beds above and below it are different. The angular discordance at angular unconformities, they are quite easy to recognize in the field. Their occurrence means that the sub-unconformity strata were deformed (tilted or folded) and then were truncated by erosion prior to deposition of the rocks above the unconformity. Therefore, angular unconformities are indicative of a period of active tectonism.




Sea level
4
3
2
1
Deposition
A. Deposition
4
3
2
1
Folding and Uplifting
B. Folding and uplifting
4
3
2
1
Erosion
C. Erosion
Sea level
7
6
4
3
2
1
Angular Unconformity

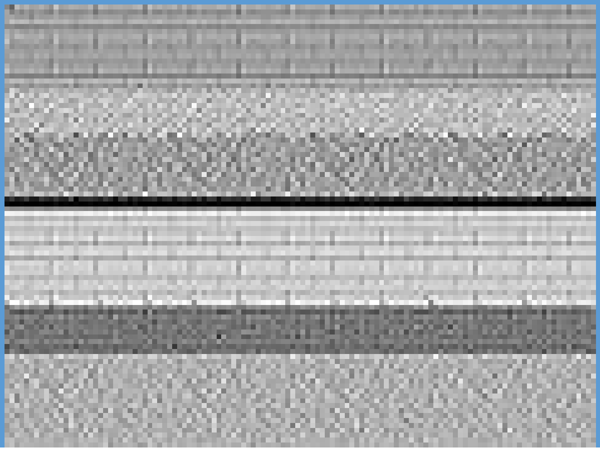
parallel unconformity

It is also known as Disconformity. A *parallel unconformity* is where the beds above and below the surface of unconformity have the same attitude.



Paraconformity

When the two sets of beds are parallel and the contact is a simple bedding plane, the unconformity is called “paraconformity”. In such cases, the unconformities is inferred by features like sudden change in fossil content or in lithological nature.



Erosion of the underlying sediment the disconformity is said to be an ***erosional disconformity***.

If there is no erosion, the presence of the disconformity is difficult or impossible to detect.

The break or small gap in time represented by a disconformity is called a ***hiatus*** or a ***diastem***.