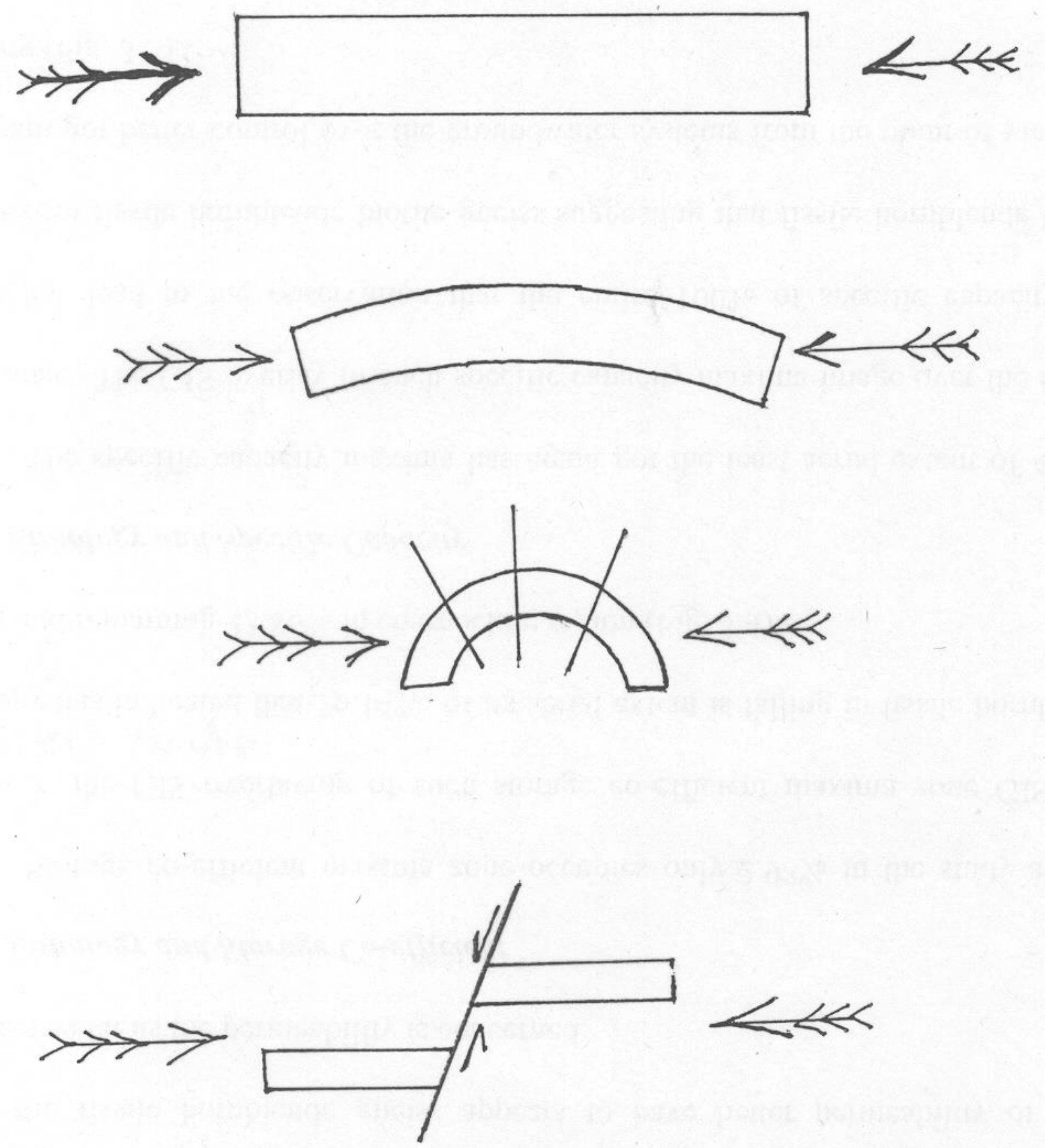
FAULT

FRATURES

Fractures are Structures developed by brittle failure and are extremely widespread in the upper 10 km of the crust where temperature & confining pressures are relatively low (0 - 300°C , 0 - 4 kb).

→Fracture cover all discrete breaks in a rock mass where cohesion is lost.

- ***Faults:*** **Where the two sides are displaced relative to each other.**
- ***Joints:*** **Where the two sides show no differential displacement.**



Stress and Strain

- **Stress is the force applied to a object.**
- **Stress is the force per unit area that is placed on the rock**
- **Strain is any change in the volume or shape of the object.**
- **In response to stress, the rock on the earth undergo deformation is known as strain.**

Responsibilities of rock to stress

Elastic deformation: The rock returns to its original shape when the stress removed.

Plastic deformation: Does not return to it's original shape after stress removal.

Fracture: The rock breaks

Stress and Strain Ellipsoids

Stress is a state or environment created in the rock due to the external force.

Deformative force at a point on the earth crust are resolved in three directions which are mainly perpendicular to one another

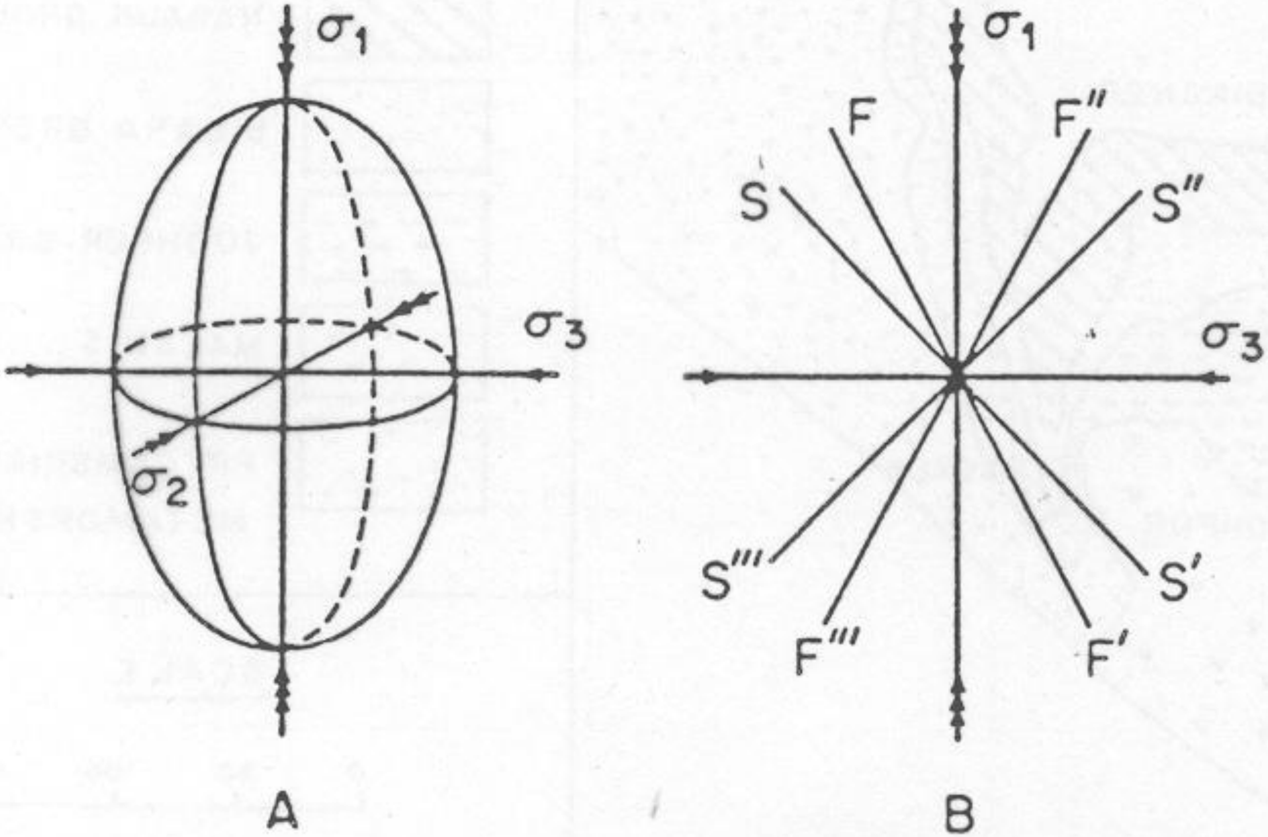
It shows that one of the force is highest(σ1), one is lowest (σ3) and third one is intermediate (σ2). The intensities of these three forces are unequal hence the form becomes ellipsoid. It is called stress ellipsoid.

Strain – Any Change in volume or shape

Tension – Pulls rock apart (leads to normal fault)

Compression – Pushes rock together (reverse or thrust fault)

Shear – Pushes one side of the rock body in one direction and another side of the rock body into another direction (strike slip fault)



Stress ellipsoid and rupture. (A) Stress ellipsoid. (B) Planes of maximum shearing stress (*SS′* and *S″S‴*) and planes of rupture (*FF′* and *F″F‴*).

STRESS STRAIN ANALYSIS ANDELLIPSOIDS

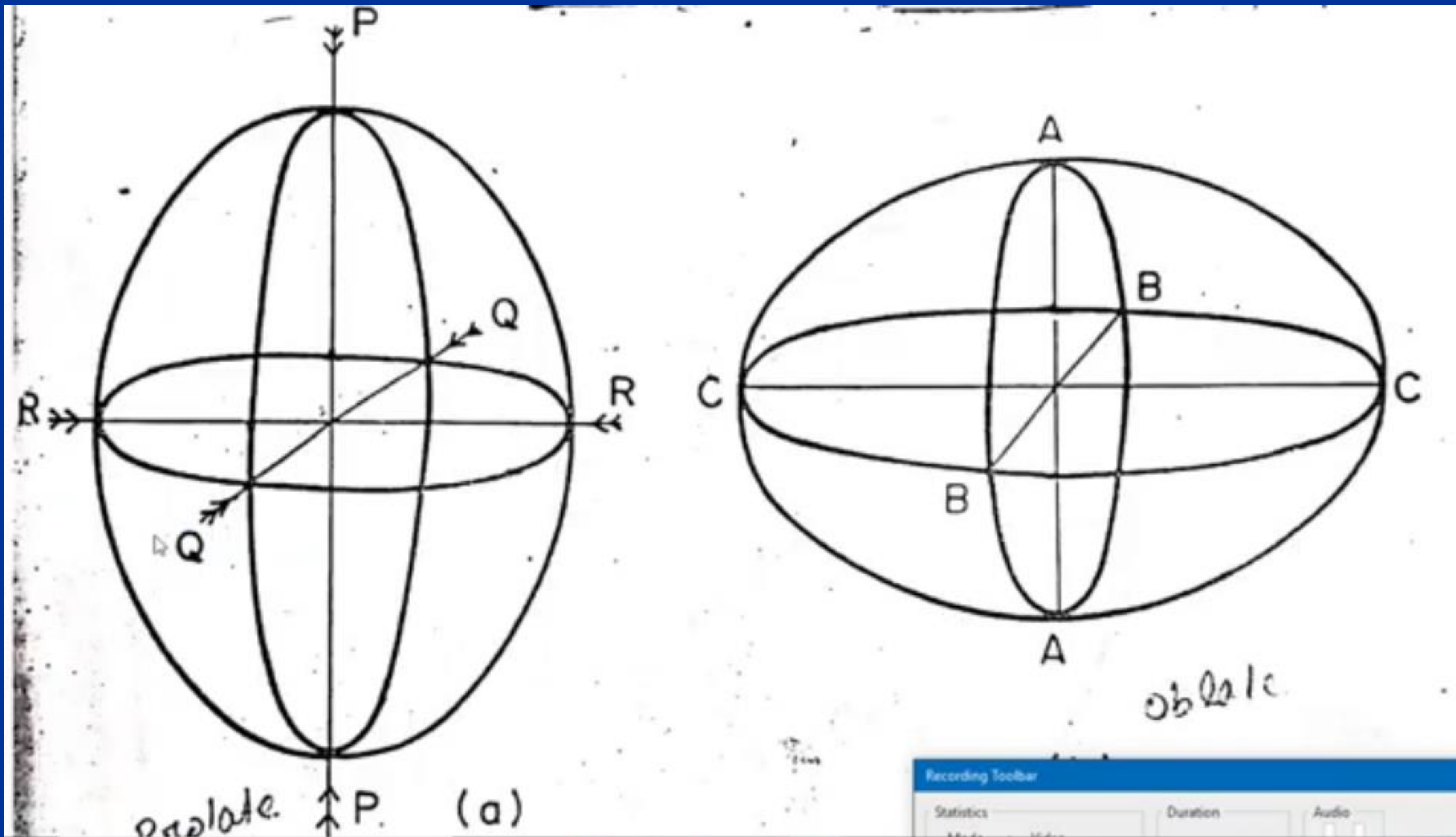
- When stress is impressed upon a rock body it is resolved into 3 mutually perpendicular directions.
- These directions are regarded as the **axes of stress (Principal axes of stress)**.
- The stress axes are usually unequal.

- **Greatest (P)**
- **Intermediate or mean (Q)**
- **Least (R)**

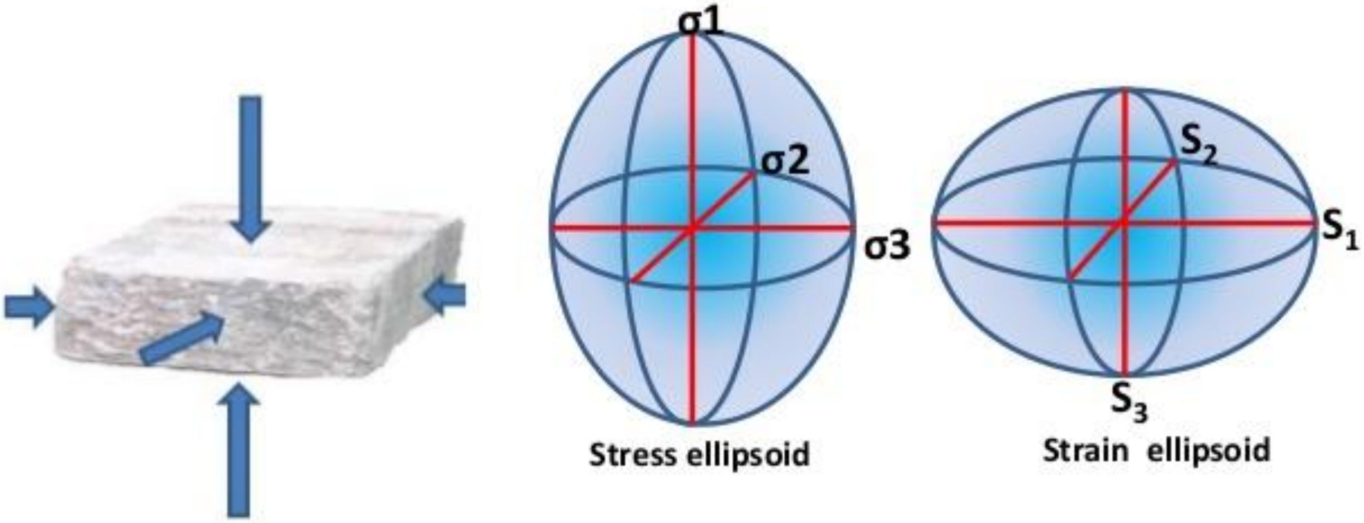
- Greatest axis of stress- greatest compression- axis of least strain
- Least axis of stress- least compression- greatest strain
- Intermediate axis coincide (Q=B)
- Stress Ellipsoid- **Prolate**
- Strain Ellipsoid- **Oblate**

Stress Ellipsoids

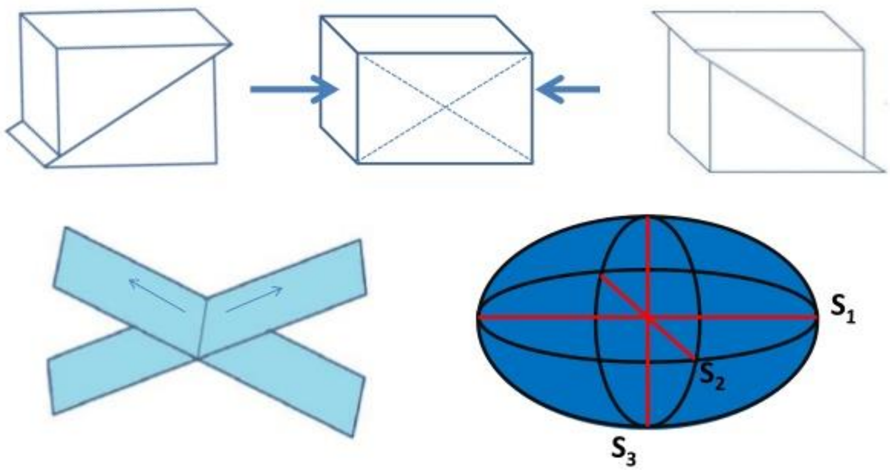
Strain Ellipsoids



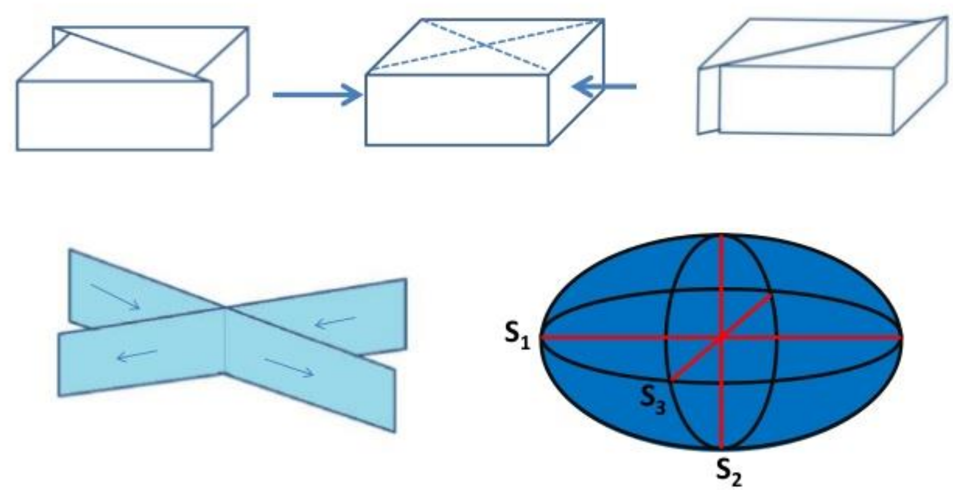
The relation is exactly opposite between these ellipsoids in respect to the position of greatest and least principle axis.



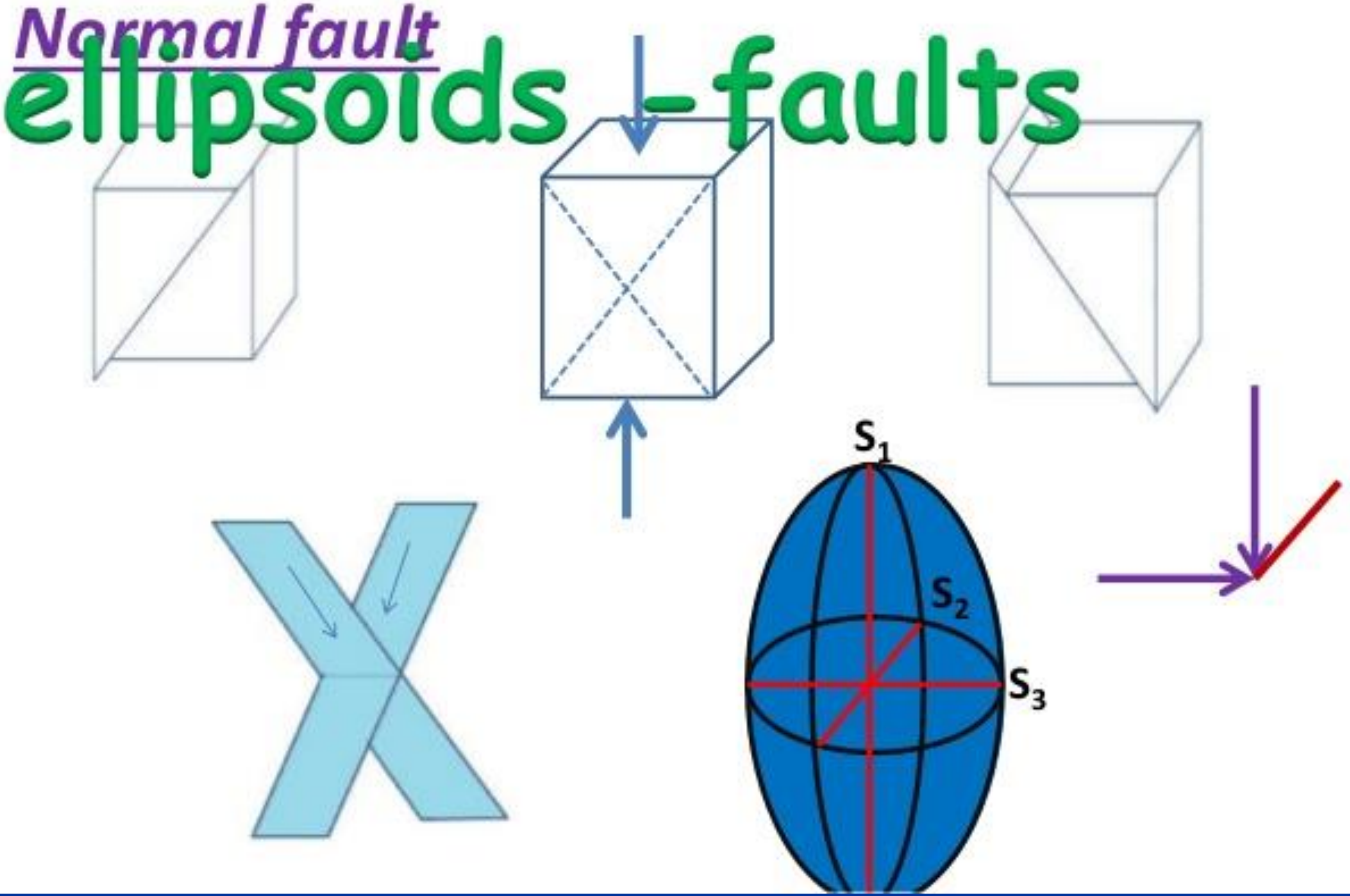
Thrust fault

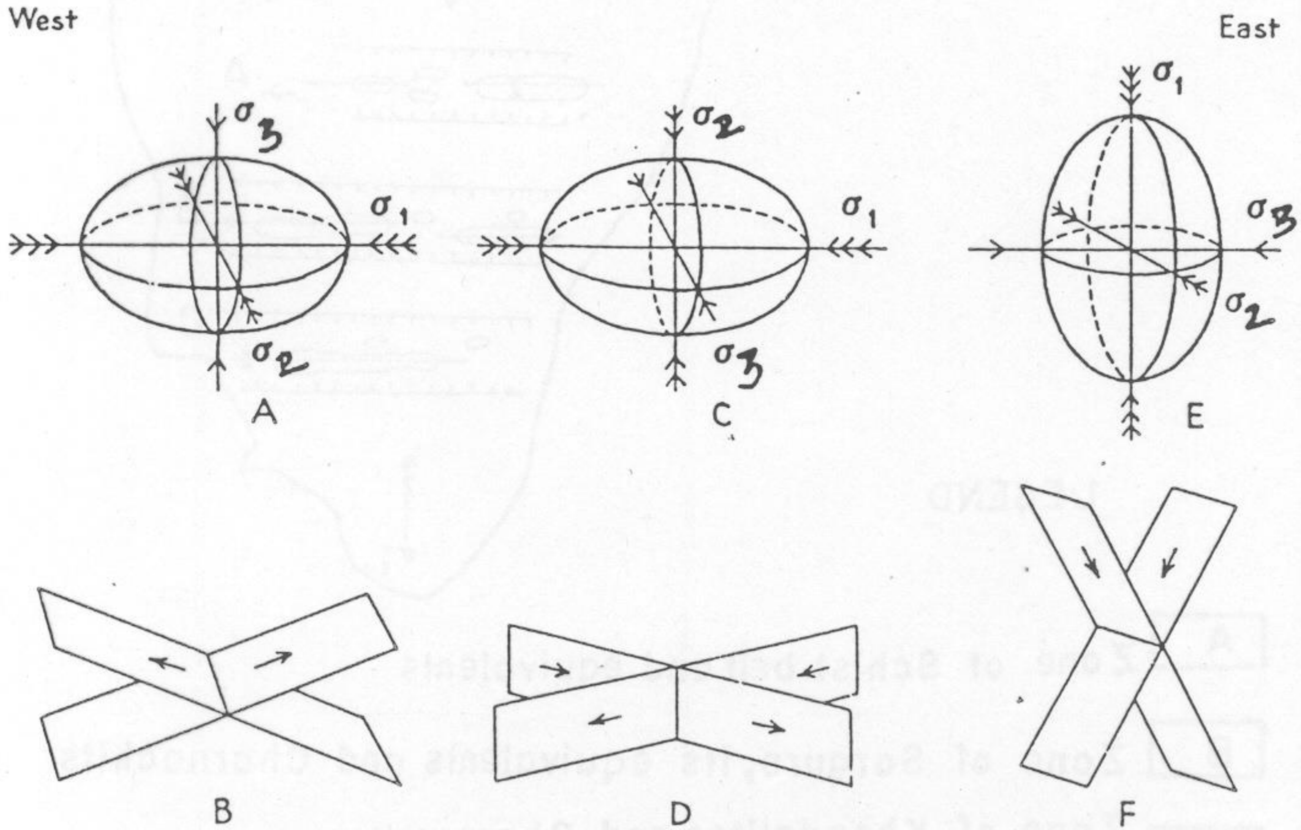


Strike-slip fault



Stress and strain ellipsoids - faults





Type of fault depends upon orientation of stress ellipsoid. σ_1, greatest principal stress axis; σ_2, intermediate principal stress axis; σ_3, least principal stress axis. (A) Least principal stress axis is vertical. (B) Thrusts form under conditions postulated in (A). (C) Intermediate principal stress axis is vertical. (D) Strike-slip faults form under conditions postulated in (C). (E) Greatest principal stress axis is vertical. (F) Normal faults form under conditions postulated in (E).

σ1 = Greatest Principal Stress Axis
σ2 = Intermediate Principal Stress Axis
σ3 = Least Principal Stress Axis

Structural Geology

3. Hade:

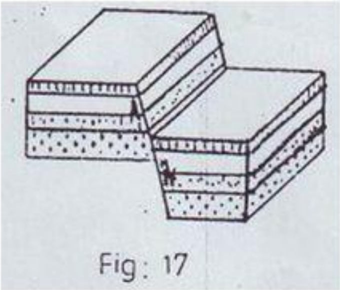
It is the inclination of the fault plane with the vertical as shown in Fig: 16, page 66(B).

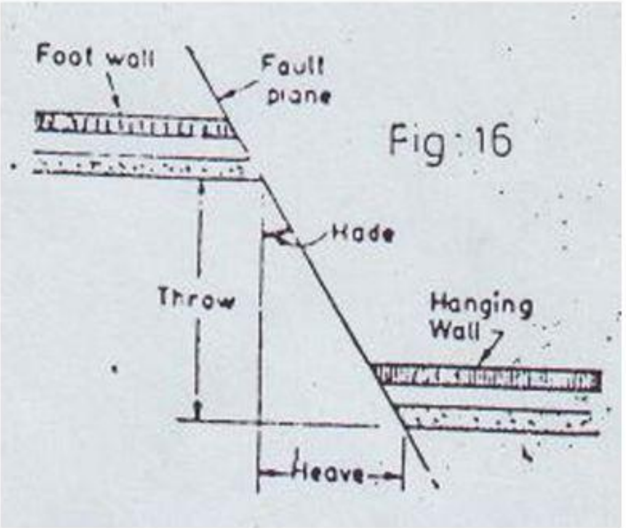
4. Throw:

It is the vertical displacement between the hanging wall and the foot wall as shown in Fig: 16, page 66(B).

5. Heave:

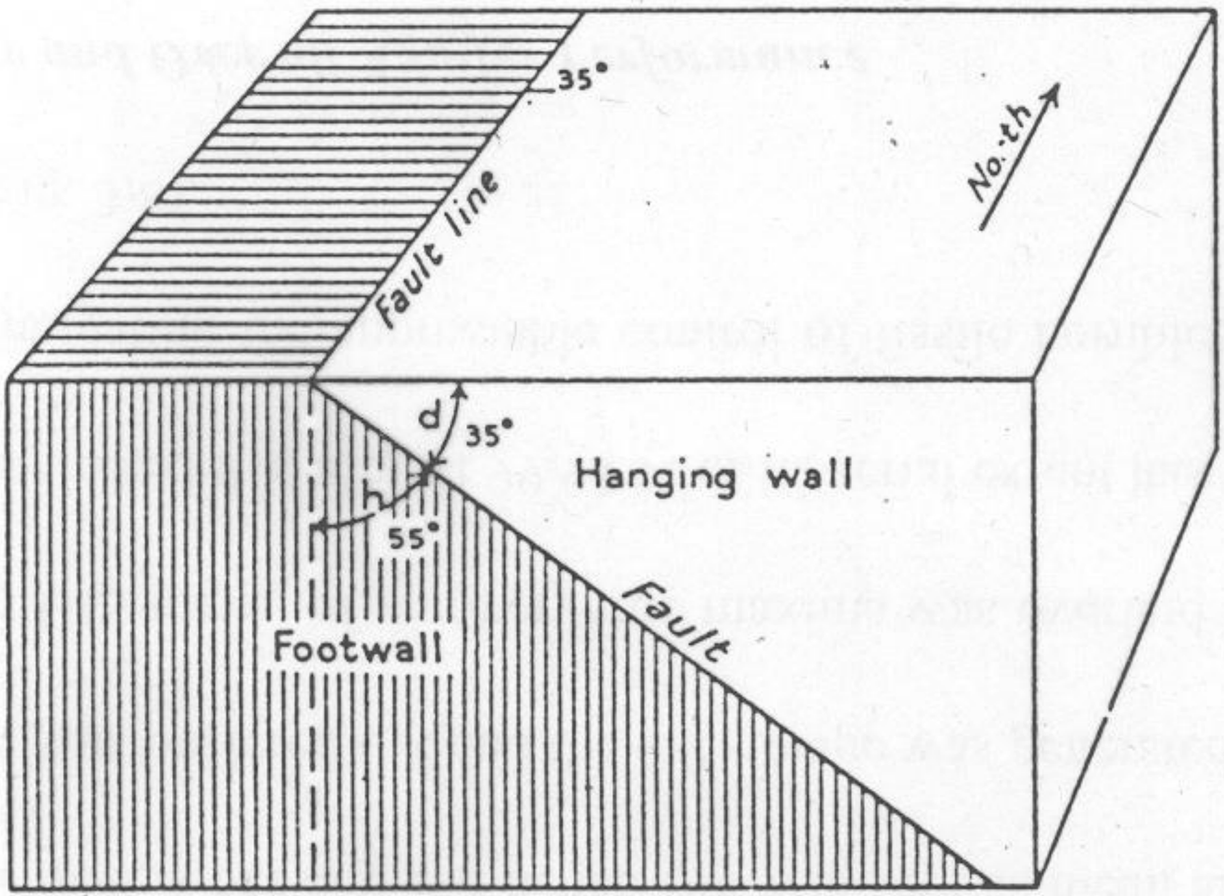
It is the horizontal displacement between the hanging--wall and the foot-wall as shown in Fig: 16, page 66(B).



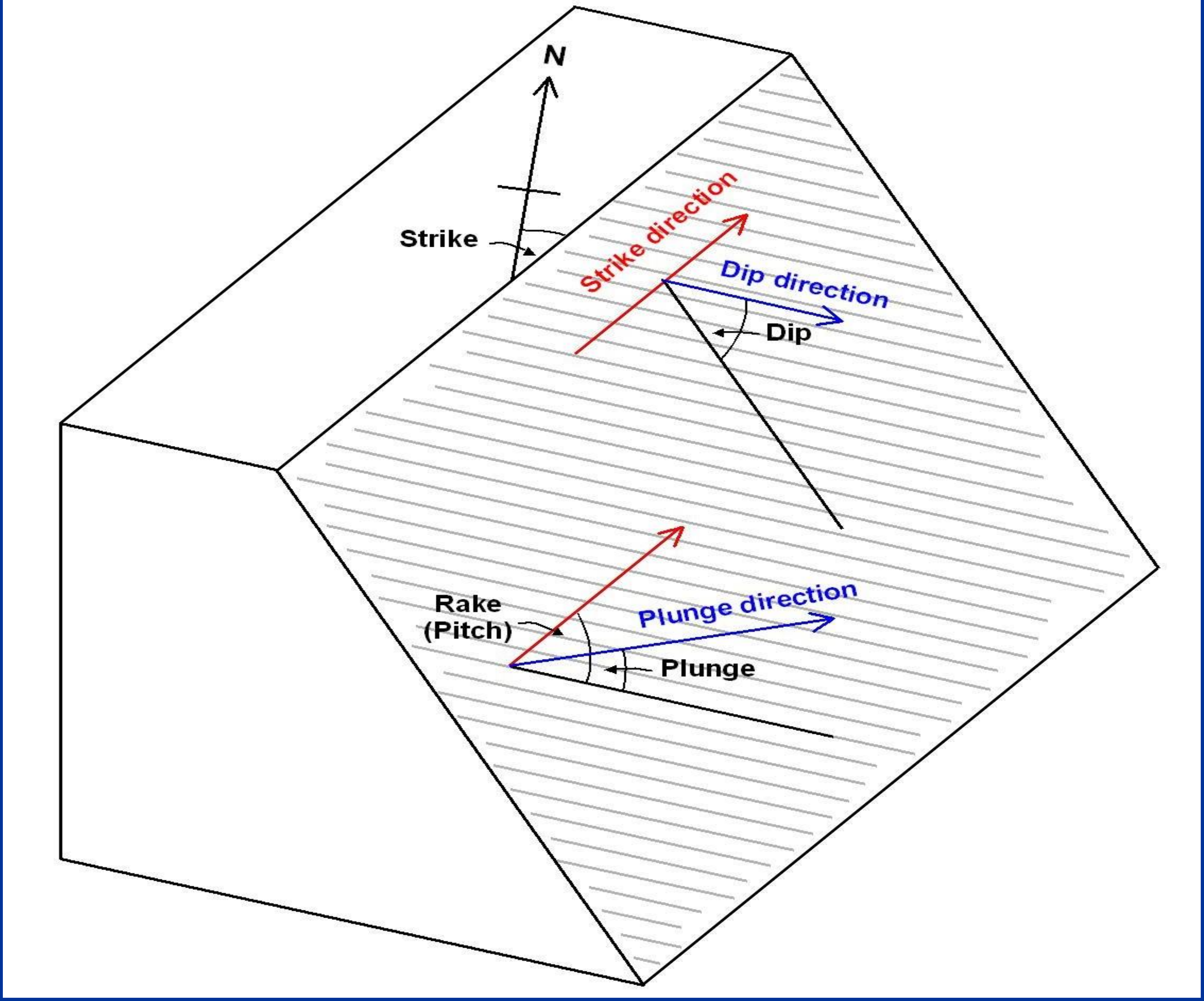


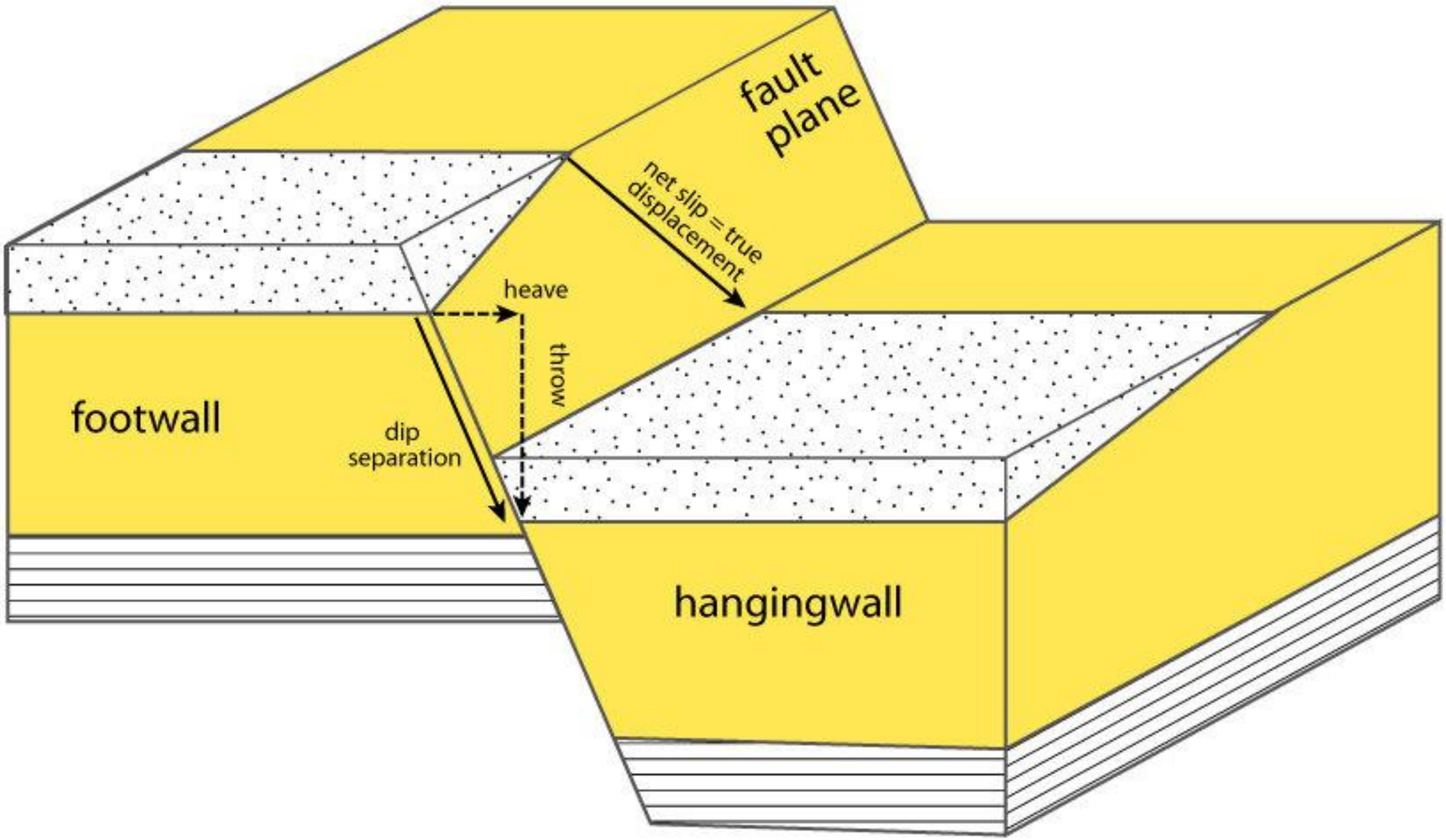
PARTS OF FAULTS

Nature of Movement Along Faults

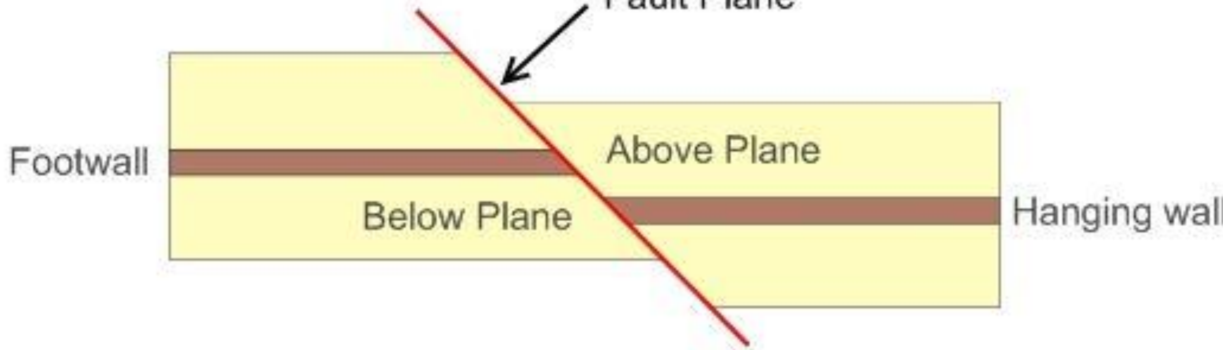


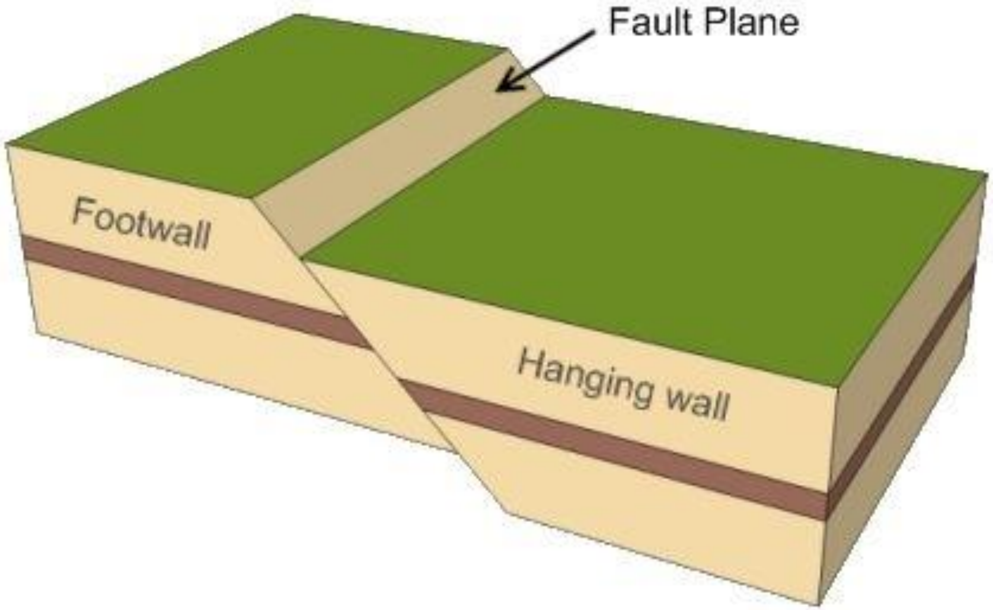
Terminology for a fault plane. *d*, dip; *h*, hade.

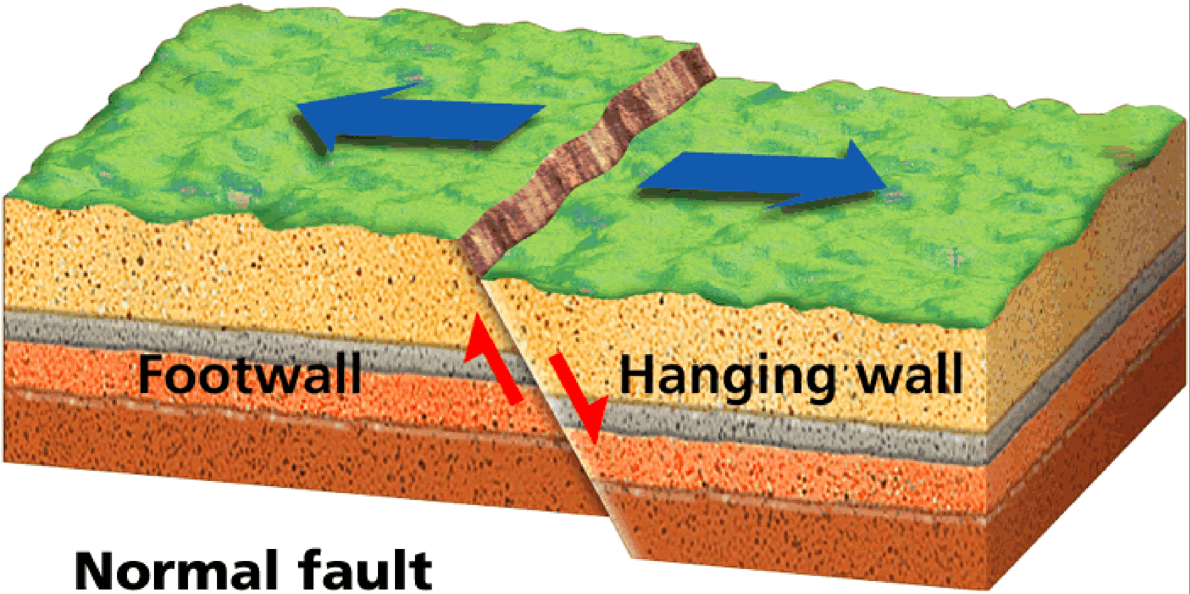

N
Strike
Strike direction
Dip direction
Dip
Rake
(Pitch)
Plunge direction
Plunge


fault
plane
net slip = true
displacement
heave
throw
footwall
dip
separation
hangingwall

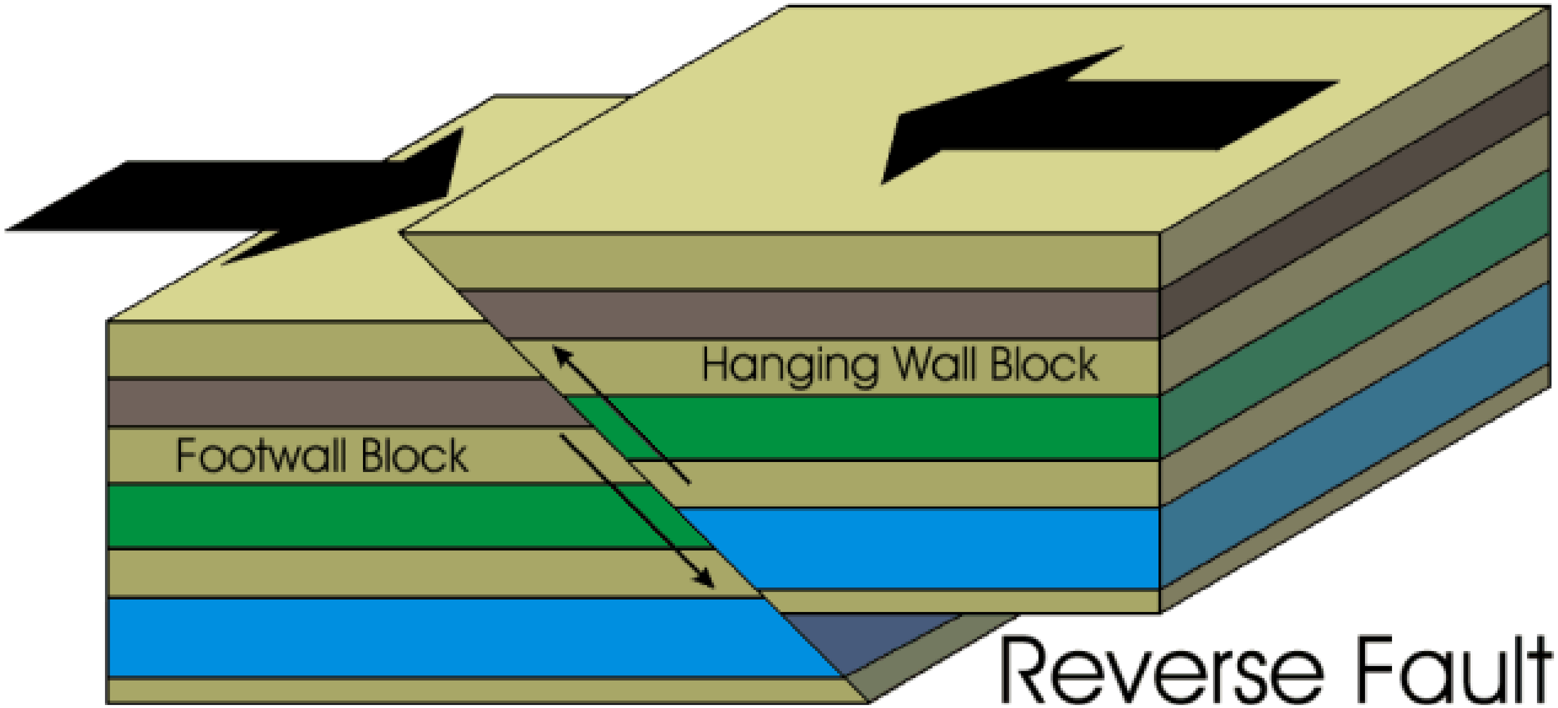
Footwall **Hanging wall**

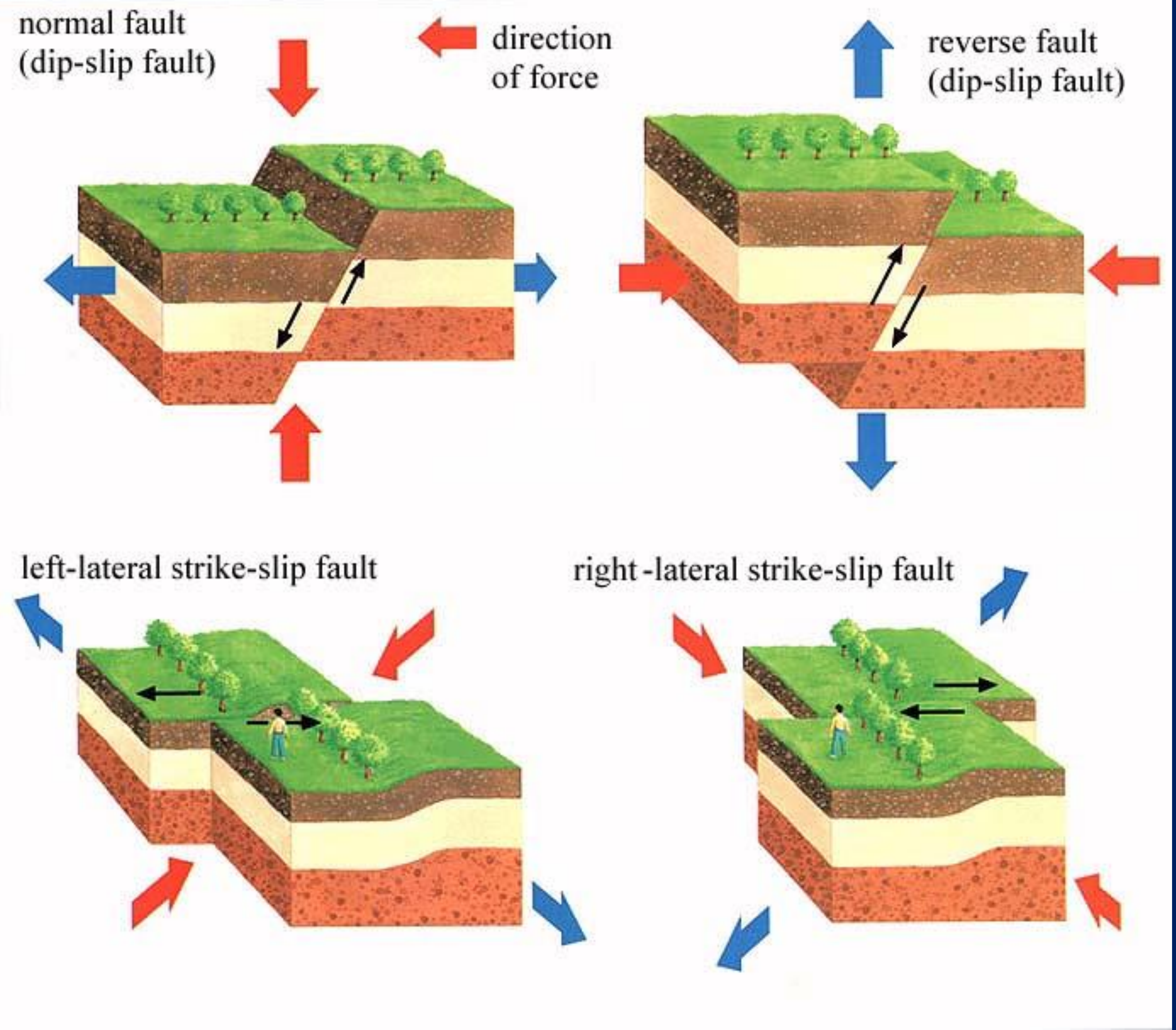


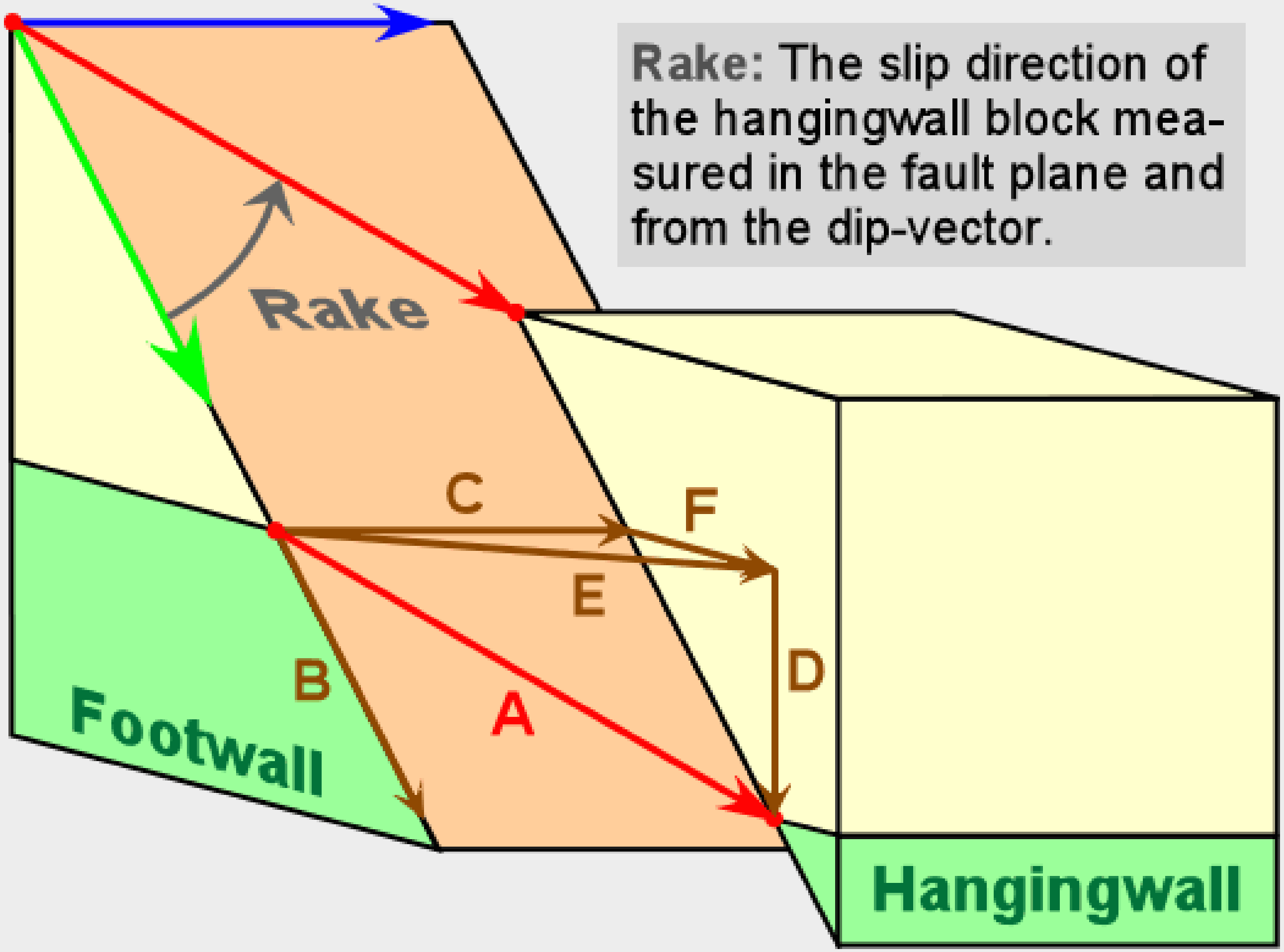




Normal fault
In a normal fault, the hanging wall slips down relative to the footwall.




normal fault
(dip-slip fault)
direction
of force
reverse fault
(dip-slip fault)
left-lateral strike-slip fault
right -lateral strike-slip fault



Rake: The slip direction of the hangingwall block measured in the fault plane and from the dip-vector.

Slip amount

A. *Net-slip:* The total slip on the fault.

B. *Dip-slip:* The dip-parallel slip component.

C. *Strike-slip:* The strike-parallel slip component.

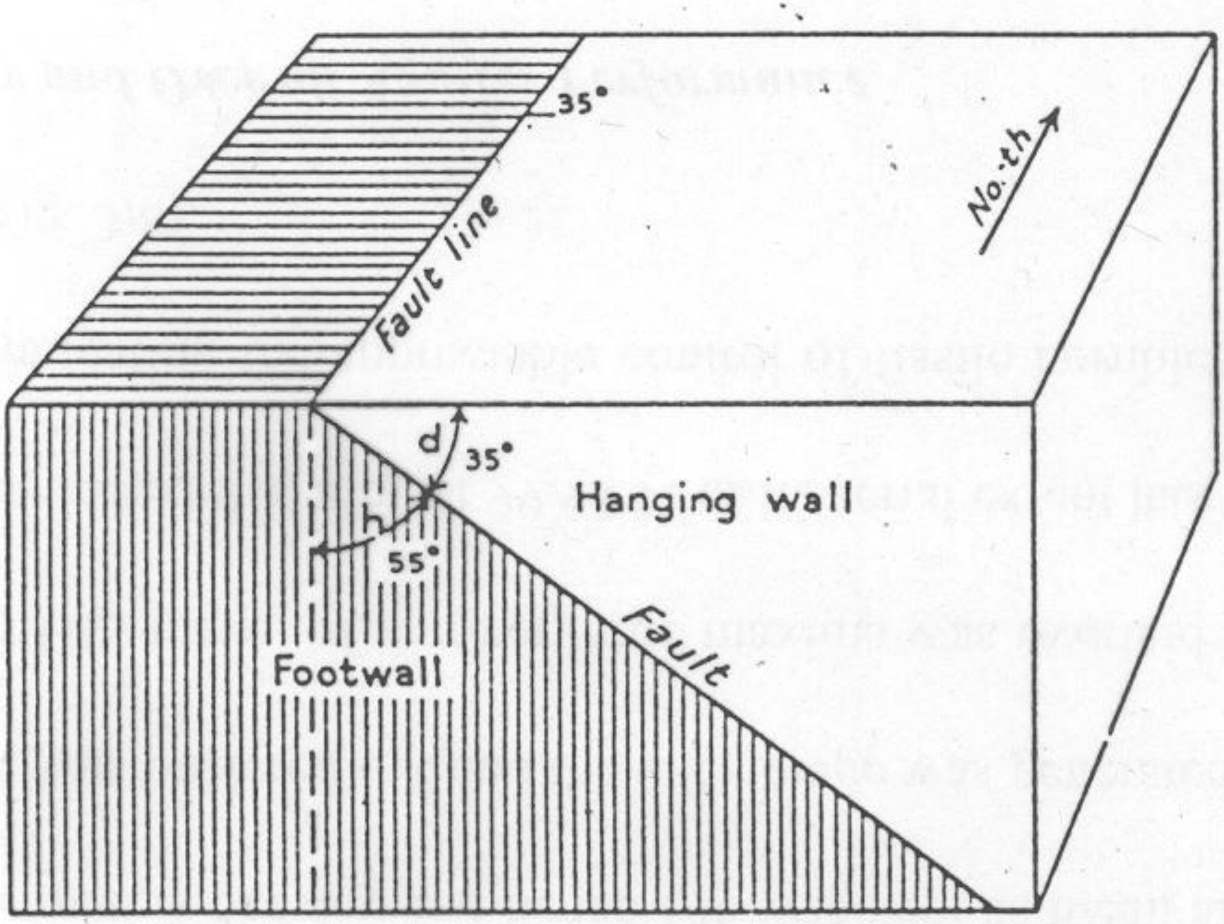
D. *Vertical throw:* The vertical component of the net-slip.

E. *Horizontal throw:* The total horizontal component of the net slip.

F. *Heave, Stratigraphic heave:* The apparent horizontal component of the net-slip.

PARTS OF FAULTS

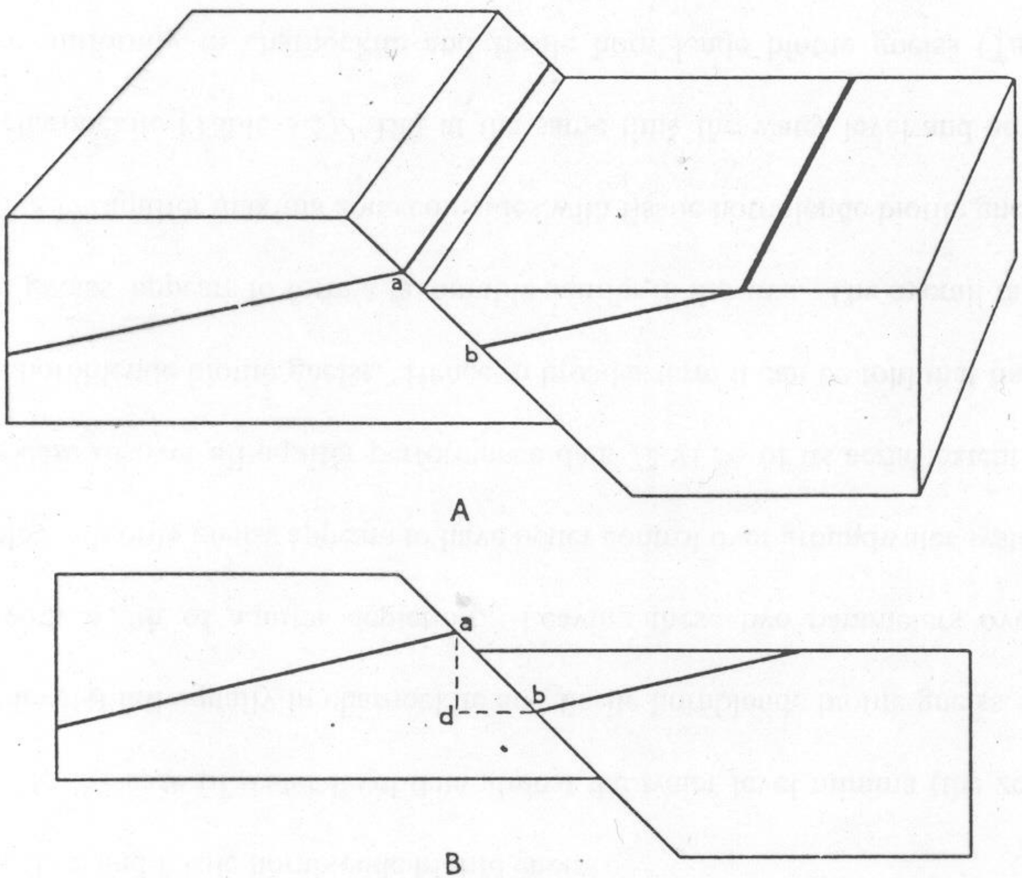
Nature of Movement Along Faults



Terminology for a fault plane. *d*, dip; *h*, hade.

PARTS OF FAULTS

Classifications



Throw and heave. Heavy black layer is disrupted stratum. (A) Block diagram; *ab* is the net slip, which in this case equals the dip slip. (B) Vertical cross section perpendicular to strike of fault. Same as front of block diagram above. *ab* is the net slip, which in this case equals the dip slip; *ad*, throw, *db*, heave.

CLASSIFICATION OF FAULTS:-

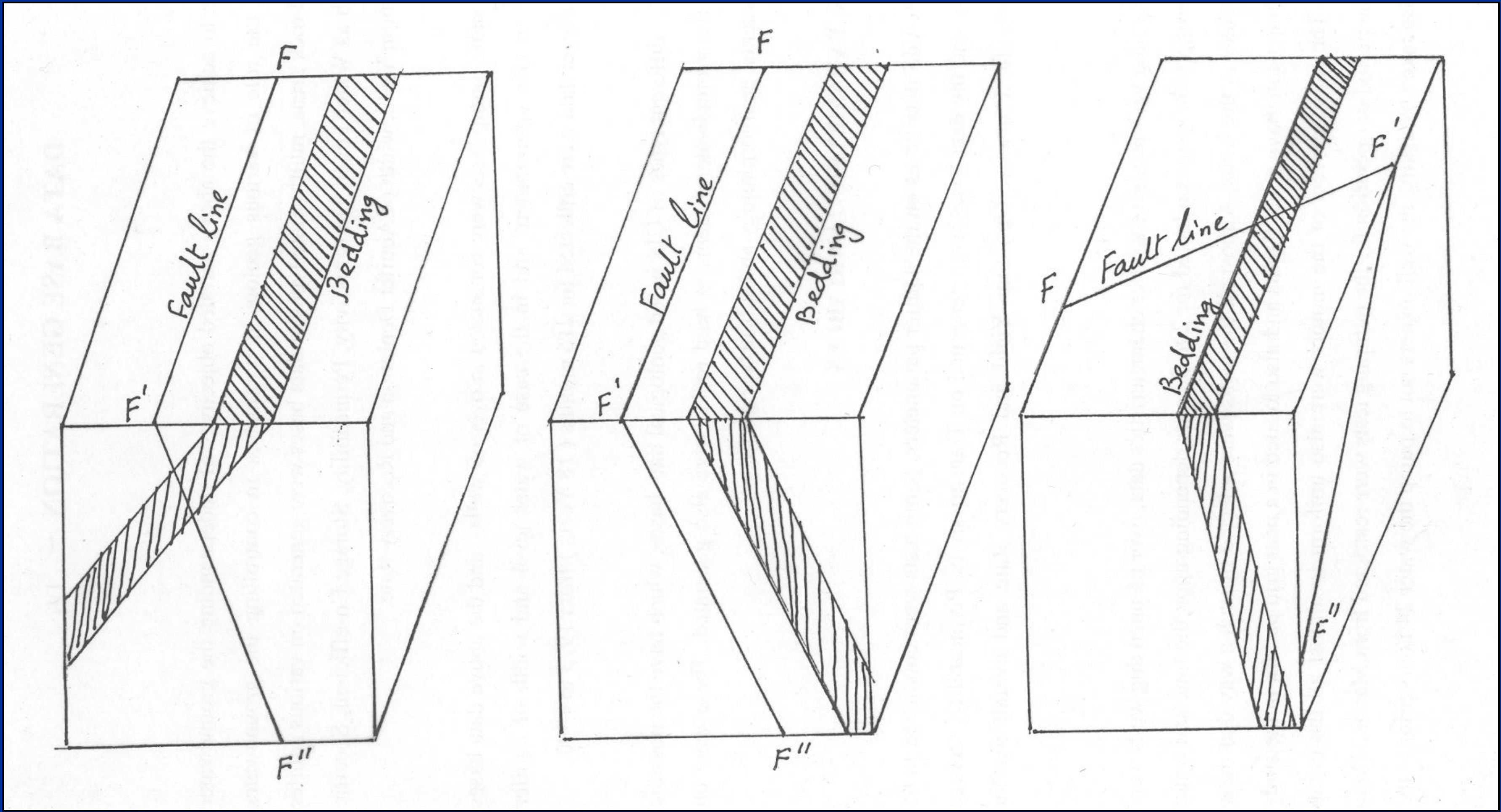
a) On the Basis of Orientation of Faults

- Strike fault
- Dip fault
- Oblique fault

b) On the Basis of Dip Amount of Beds:

- High angle fault > 40°- Straight line
- Low angle fault < 40°- Curvilinear in Strike

Strike Fault Dip Fault Oblique Fault



c) On the basis of Movement:

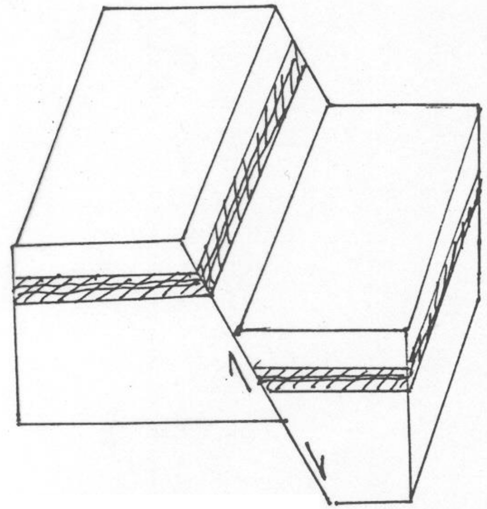
Hanging wall down
Footwall Upwards - Gravity - All boundary faults

Normal Gravity Faults:

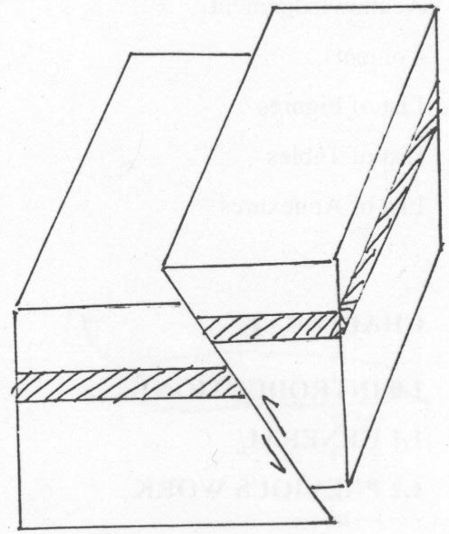
- Grabben
- Horst
- Block faulting

Reverse Faults:

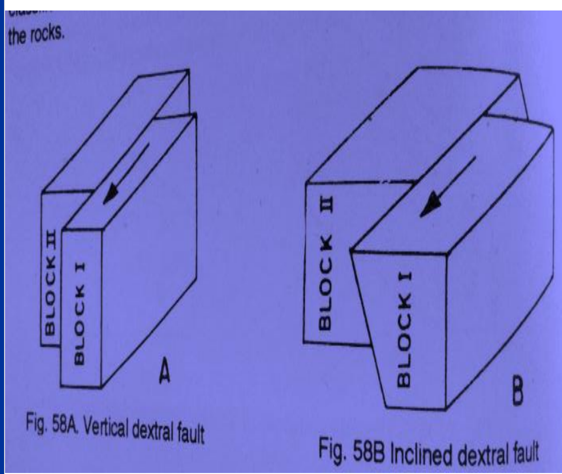
H.W - Upward Eastern boundary of Cuddapah basin
F.W - Downward



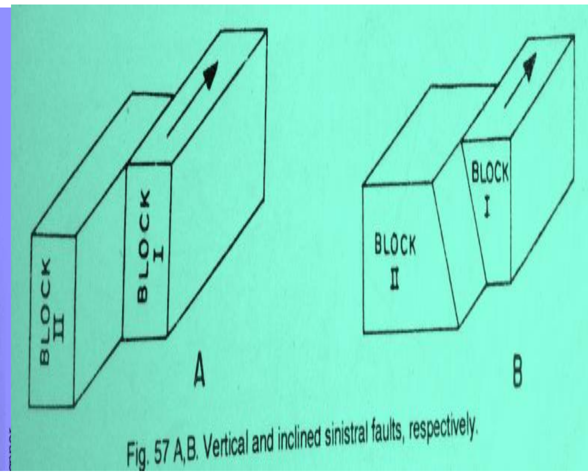
Gravity Fault



Reverse Fault

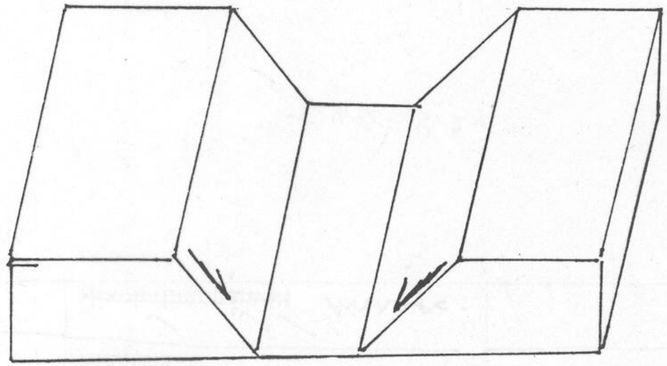


Dextral Fault

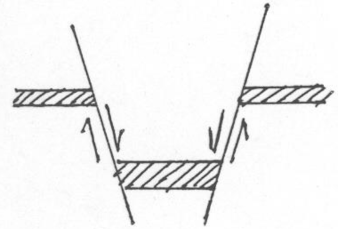


Sinistral Fault

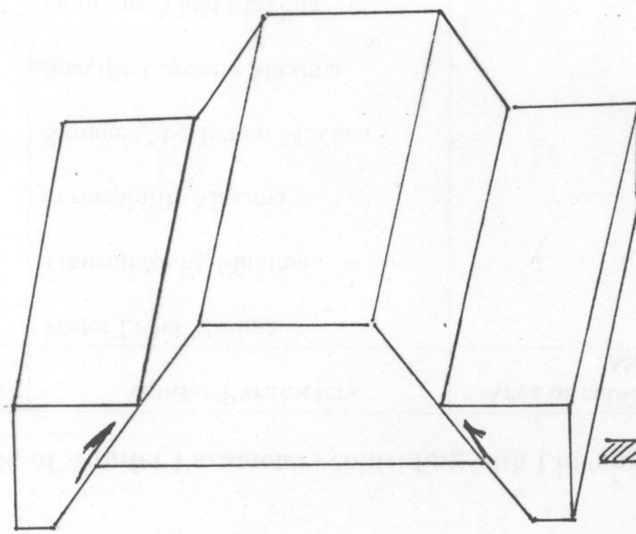
Graben (Block)



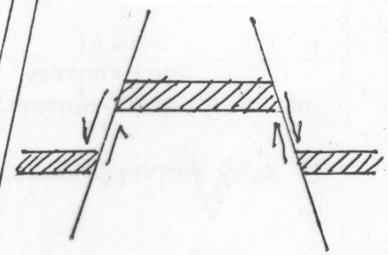
Graben Section

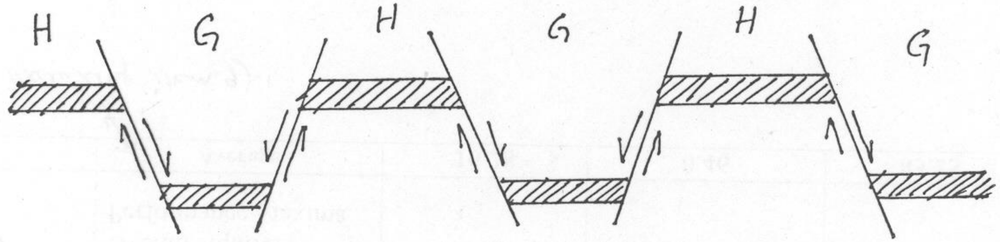


Horst (Block)

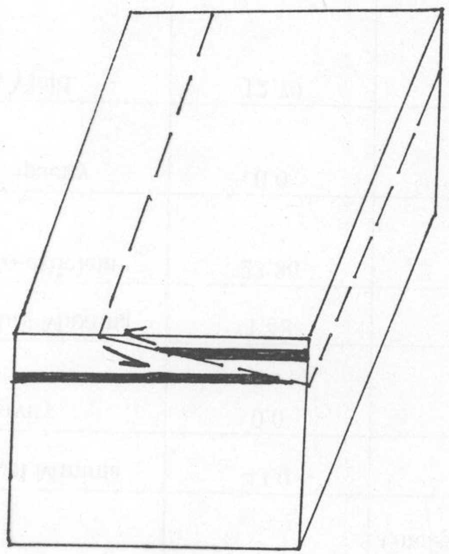


Horst Section





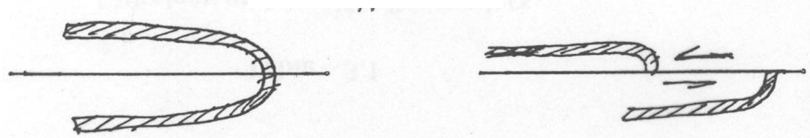
Block Fault (Horst &Graben)



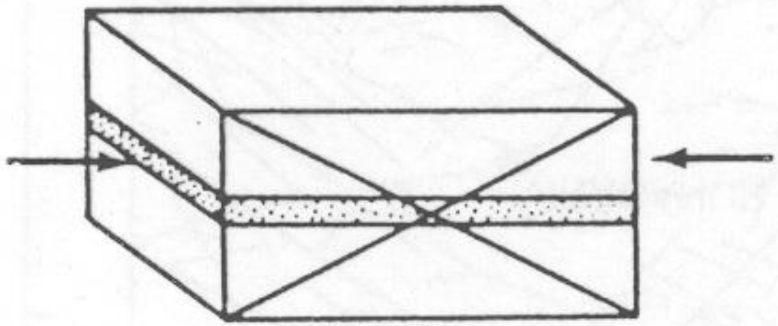
Thrust Fault

(Low angle reverse fault)

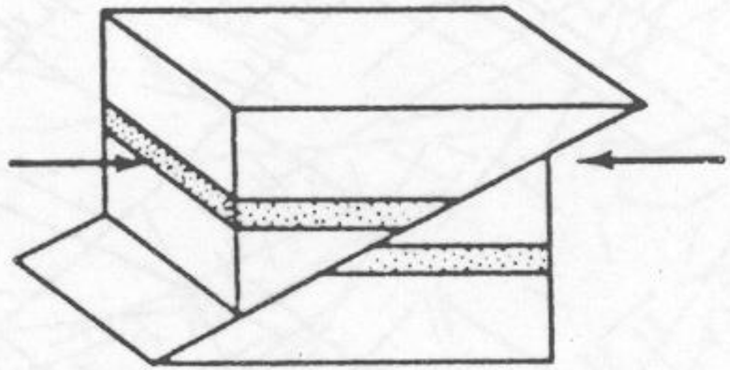
Nappe



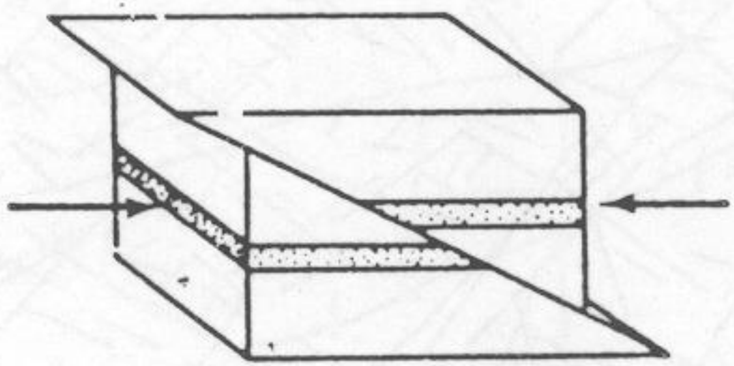
Reverse Faults, Thrust Faults, and Overthrusts



A



B



C

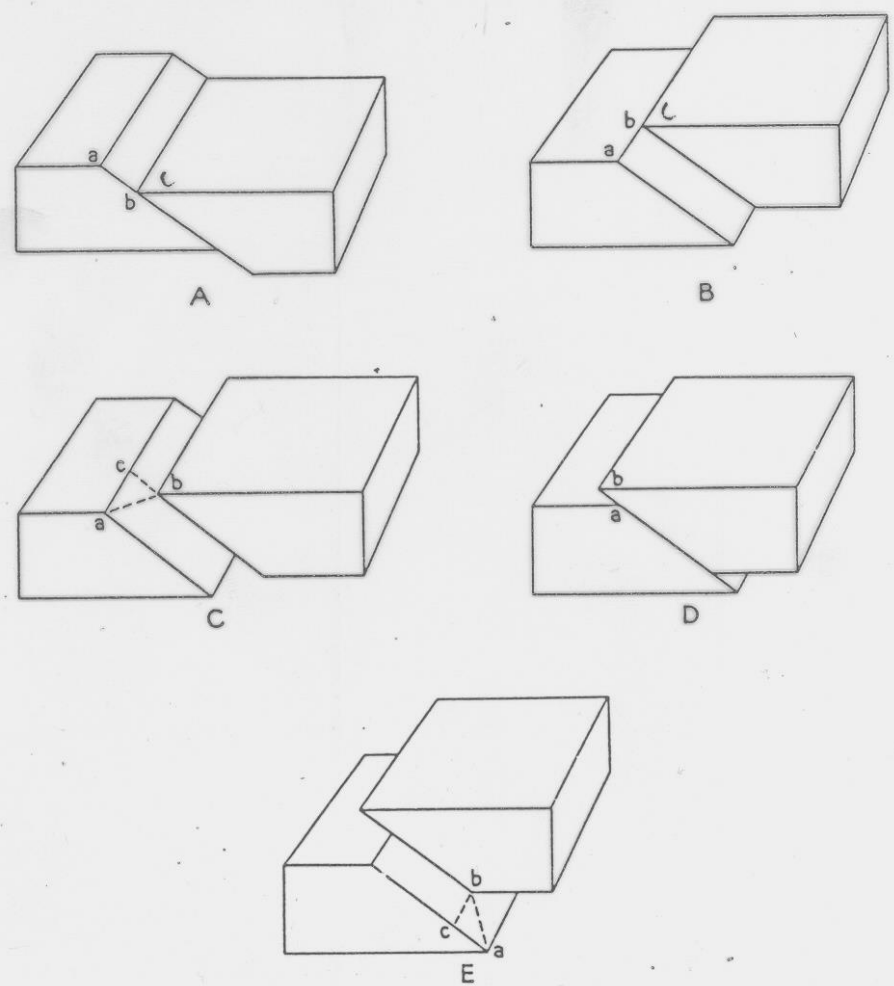
Thrust faults dipping 30° ± form when greatest and intermediate principal stress axes are horizontal.

d) On the basis of Slip of Faults:-

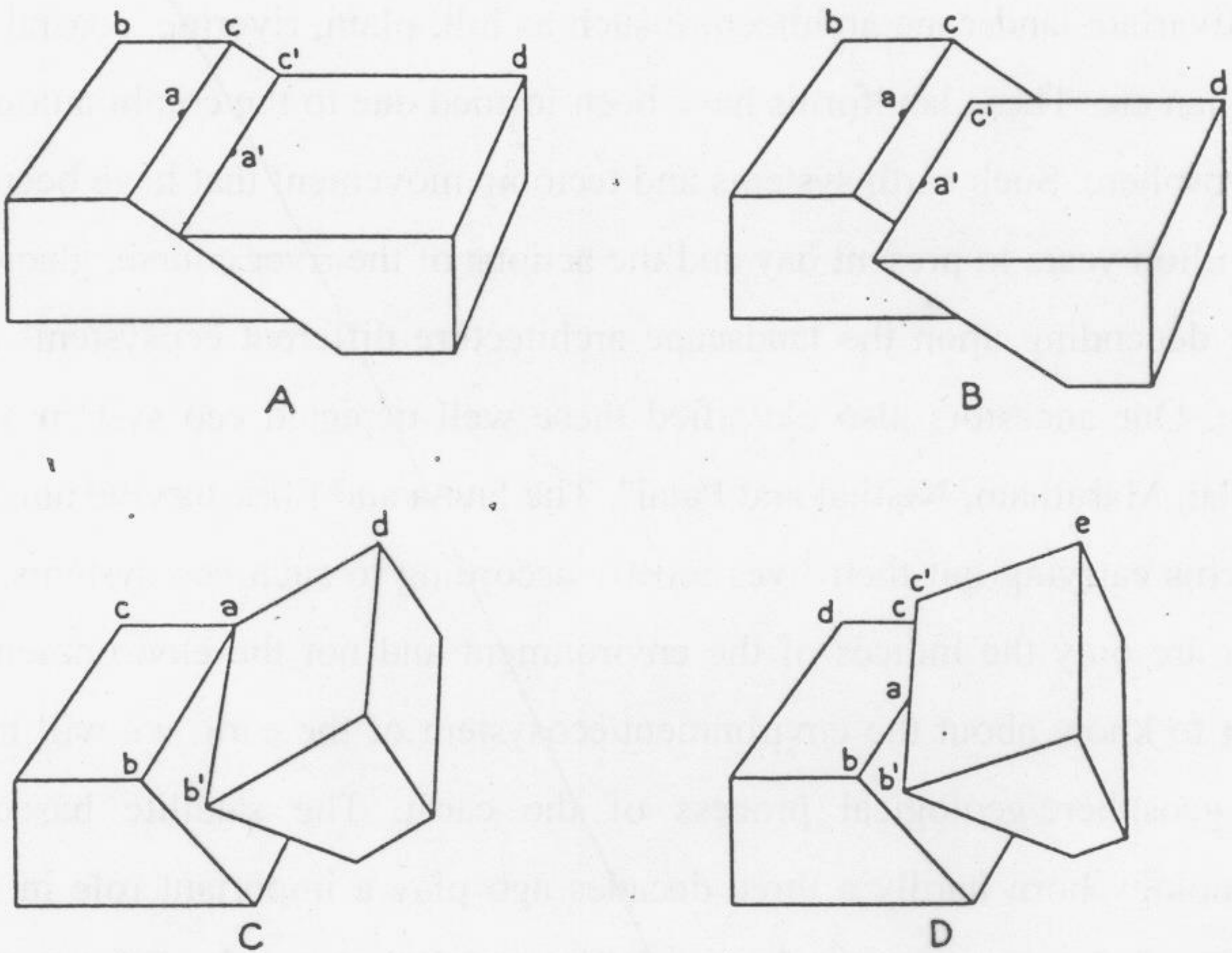
- **Strike slip fault**
- **Dip slip fault**
- **Oblique slip fault**

e) On the basis of mode of occurrences:

- **Parallel fault**
- **Step fault**
- **En-echelon fault**
- **Peripheral fault**
- **Radial fault**



Net slip, dip slip, and strike slip. (A) *ab* is the net slip, which in this case equals the dip slip; the strike slip is zero. (B) *ab* is the net slip, which in this case equals the strike slip; the dip slip is zero. (C) *ab* is the net slip; *cb* is the dip slip; *ac* is the strike slip. (D) *ab* is the net slip, which in this case equals the dip slip; the strike slip is zero. (E) *ab* is the net slip; *bc* is the strike slip; *ac* is the dip slip.



Translational and rotational movements. (A) and (B), translational movements, (C) and (D), rotational movements. Lowercase letters are referred to in the text.

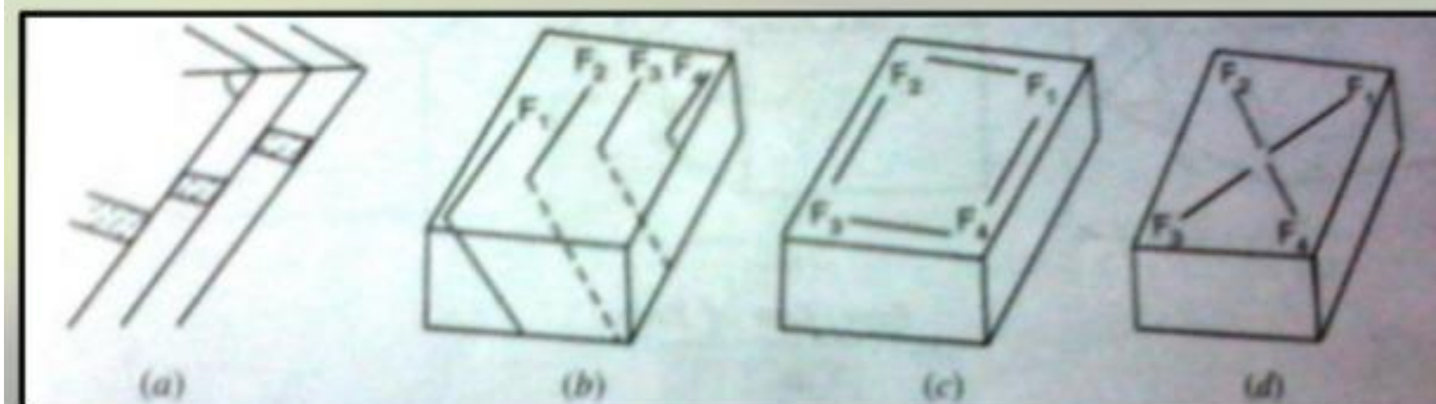
Mode of occurrences as basis

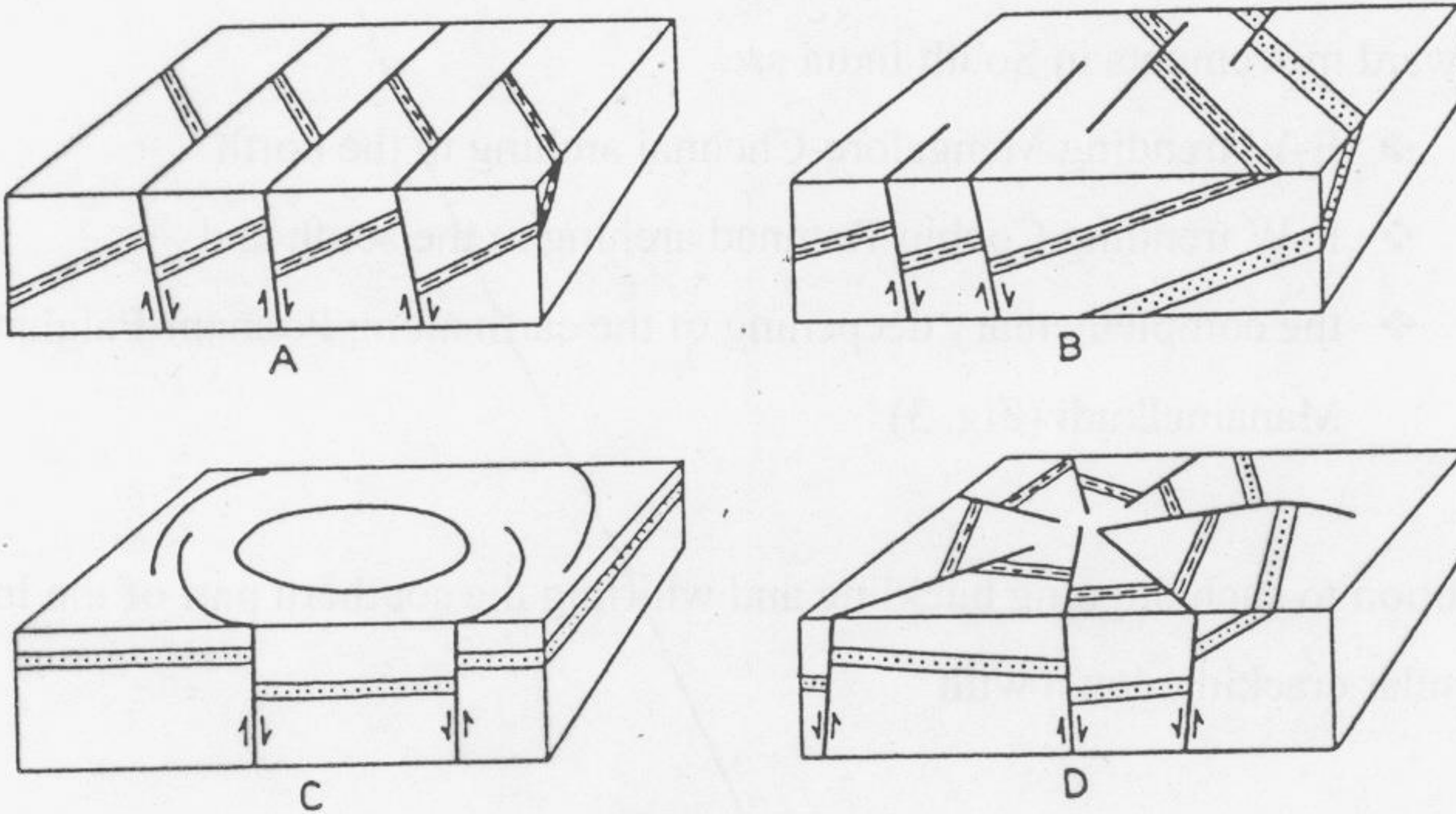
a. Parallel faults: a group of normal faults occurring in the close proximities having same dips and strikes. when this group gives step like stricture in the structure then it is called step faults. (figure a)

b. Enechelon faults: Faults that are approximately parallel one another but occur in short unconnected segments, and sometimes overlapping. (figure b)

c. Peripheral faults: when in any region the majority of faults are concentrated along the border or margin of the area. (figure c)

d. Radial faults: the group of fault that appear emerging outward from a common point is called radial faults. (figure d)

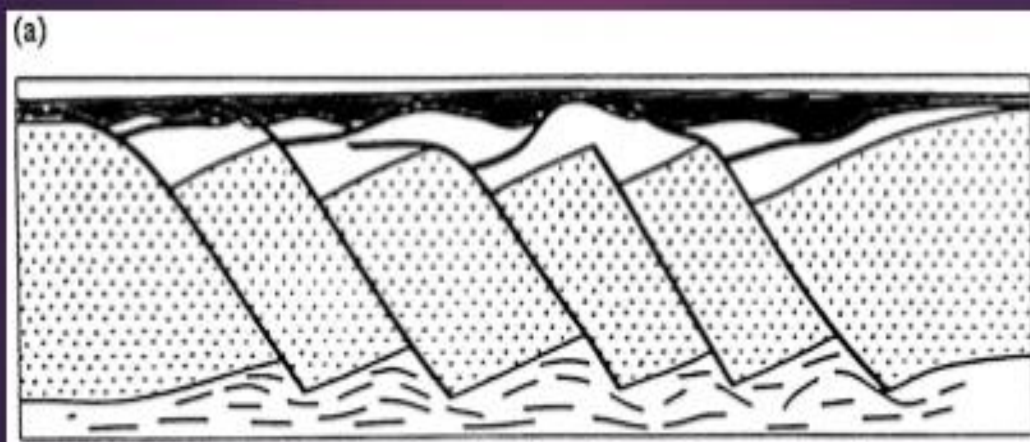


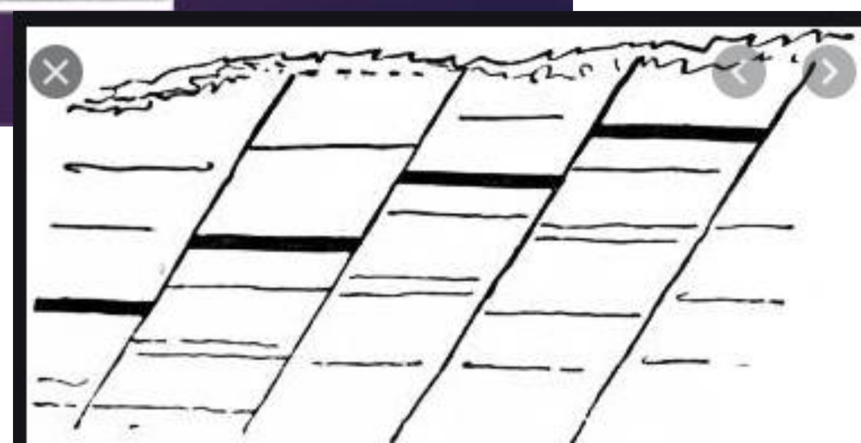


Geometrical classification of faults by pattern. (A) Parallel faults. (B) *En échelon* faults. (C) Peripheral faults. (D) Radial faults.

Parallel Faults

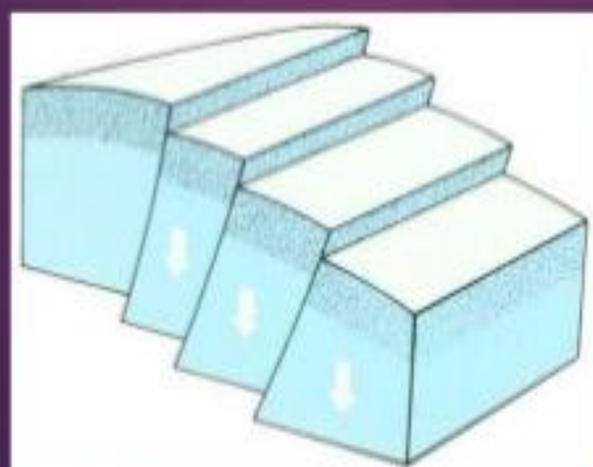
- A series of faults running more or less parallel to one another and hading in the same direction.





Step Fault

- Step fault is a type of parallel fault where down throw is all in the same direction a it gives a step like arrangement.



Step Faults

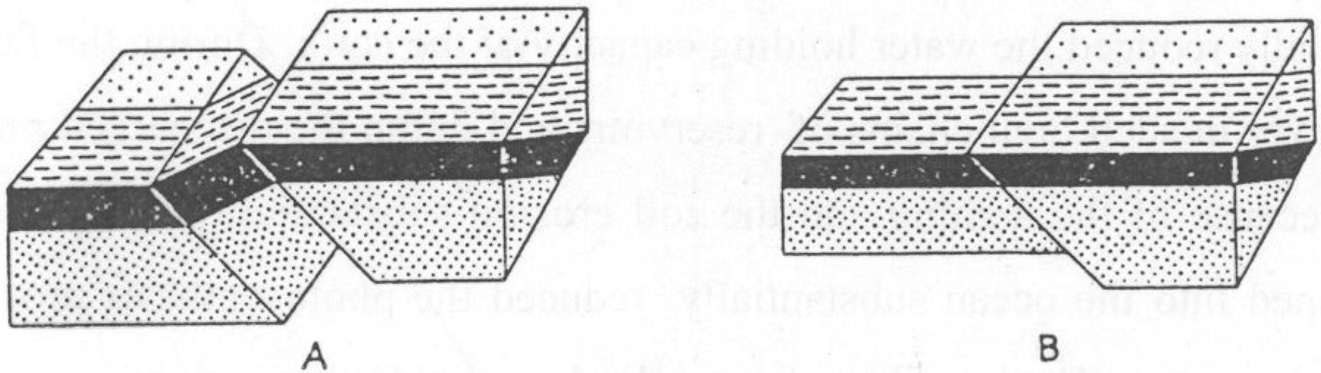
- When a set of parallel normal faults occur at a regular interval, they give a step-like appearance and are called step faults.

Parallel Faults

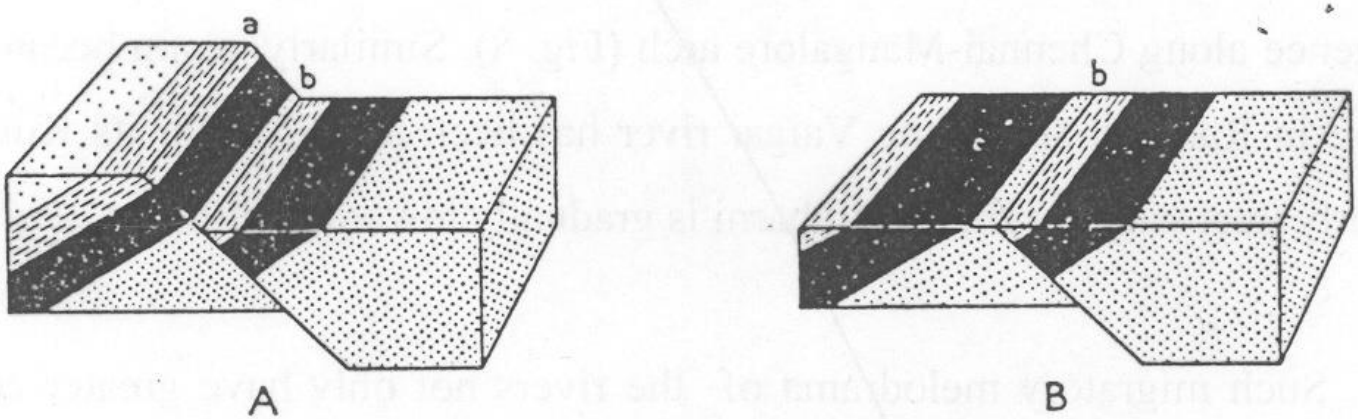
- As the name indicates, these are a set of parallel normal faults with the same strike and dip. They are like step faults but may or may not have a regular interval.

EFFECT OF FAULT ON THE OUTCROP:-

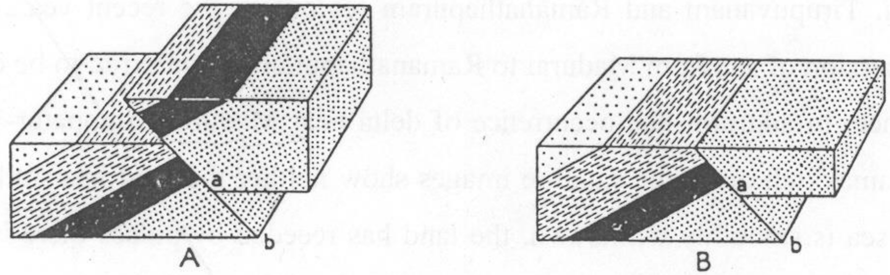
- **Repetition of outcrops**
- **Omission of outcrops**
- **Off setting of outcrops**



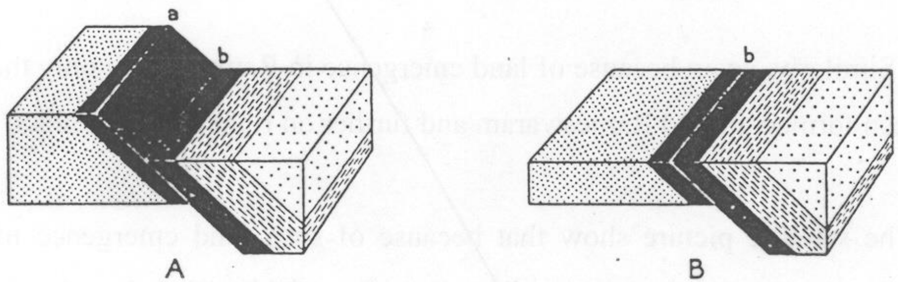
Net slip parallel to trace of bedding on fault. Apparent movement in a vertical section and in map is zero. (A) Immediately after faulting. (B) After removal of top and front of footwall block.



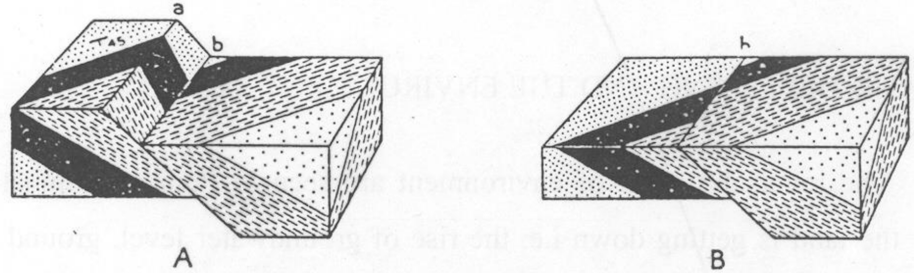
Apparent movement in vertical section equals net slip. (A) *ab* is the net slip, which in this case equals the dip slip. (B) After removal of top of footwall block.



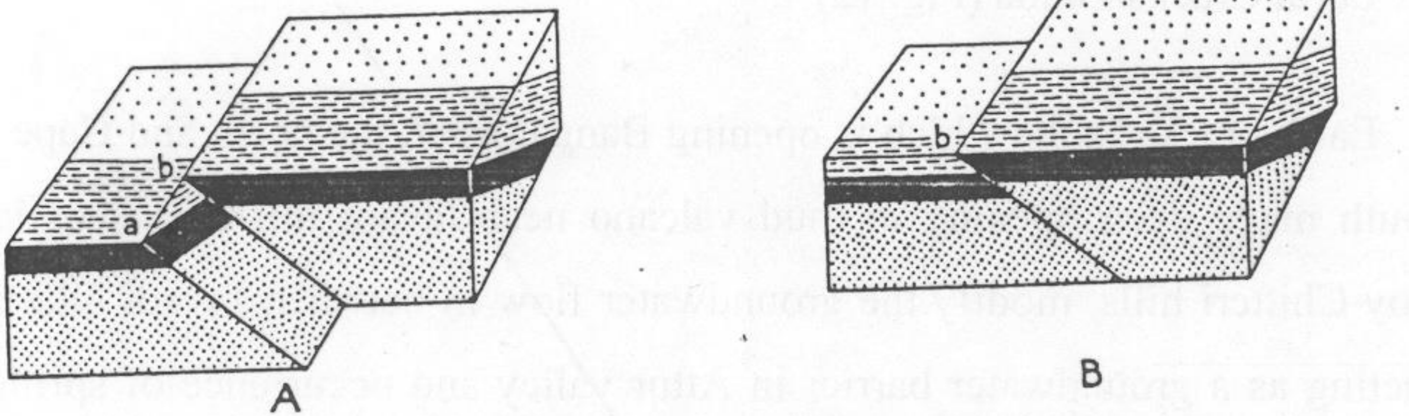
Apparent movement in vertical section equals net slip. (A) *ab* is the net slip, which in this case equals the dip slip. (B) After removal of top of hanging wall block.



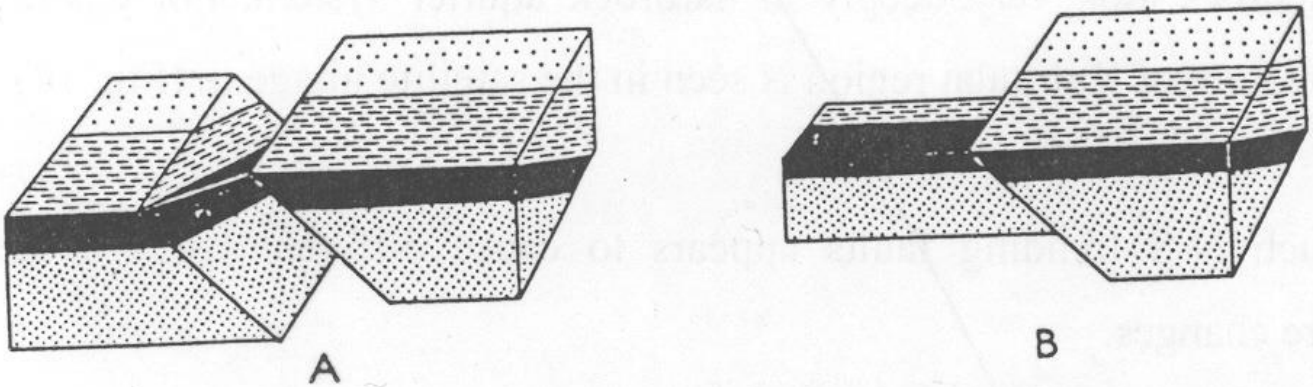
Fault is parallel to bedding, and hence there is no apparent movement. (A) *ab* is the net slip, which in thi: case equals the dip slip. (B) After removal of top of footwall block.



Apparent movement on map does not equal the net slip. (A) *ab* is the net slip, which in this case equals the dip slip. (B) After removal of top of footwall block.

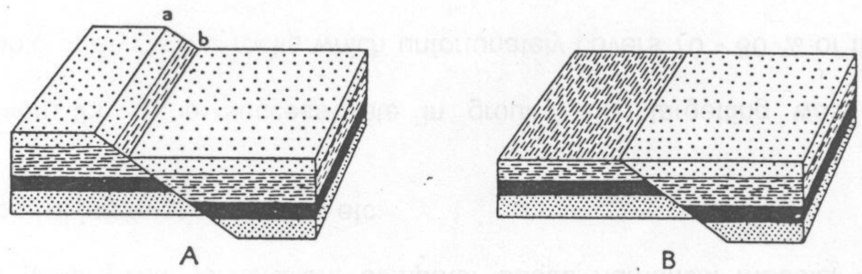


Apparent movement in a vertical section gives the erroneous impression that the hanging wall has gone up. (A) *ab* is the net slip, which in this case equals the strike slip. (B) After removal of front of footwall block. A left separation.

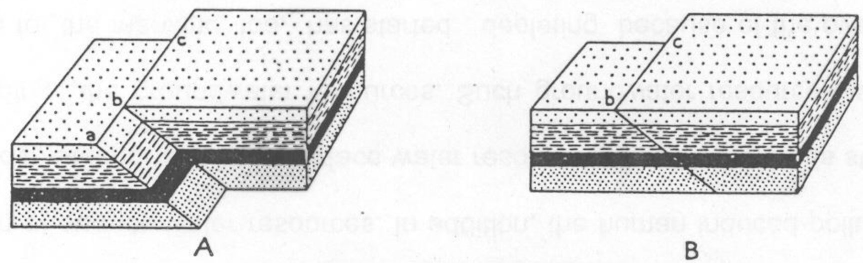


Apparent movement in vertical section is less than net slip. (A) *n* is the net slip. (B) After removal of top of footwall block.

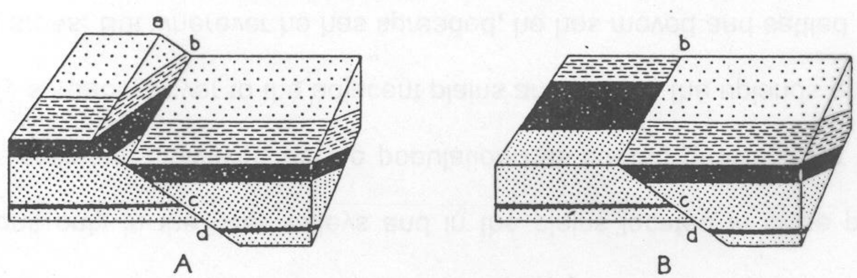
Effects on Disrupted Strata



Apparent movement in a vertical section equals the net slip. (A) Before erosion ; *ab* is the net slip, which in this case equals the dip slip. (B) After erosion of top of footwall block.

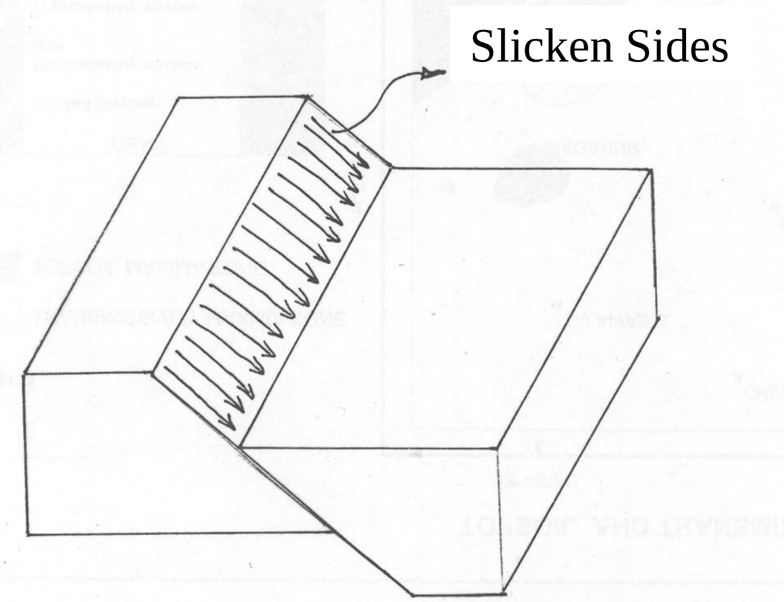


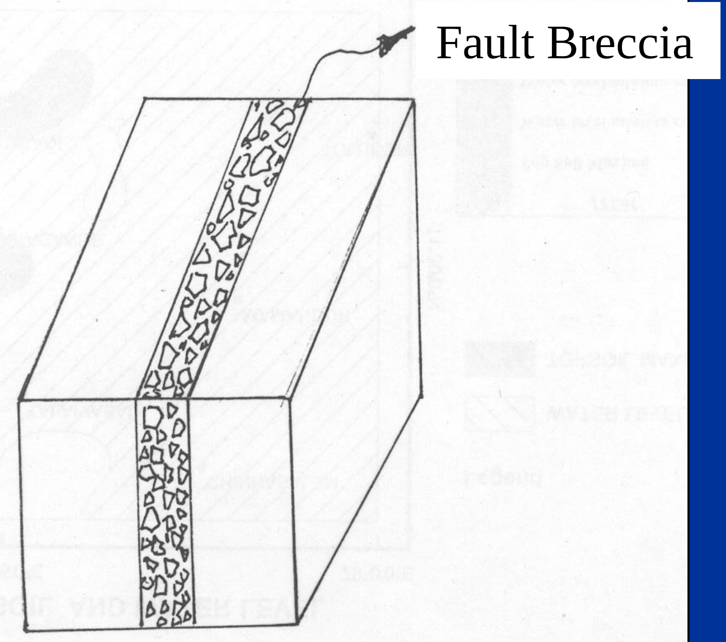
Apparent movement in a vertical section is zero. (A) *ab* is the net slip, which in this case equals the strike slip. (B) After removal of front of footwall block.



Apparent movement in vertical section equals the net slip. (A) *ab* is the net slip, which in this case equals the dip slip. (B) After erosion of top of footwall block. A right separation.

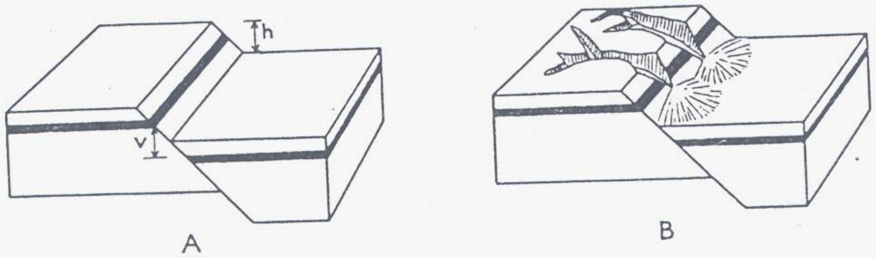
EVIDENCES OF FAULTS



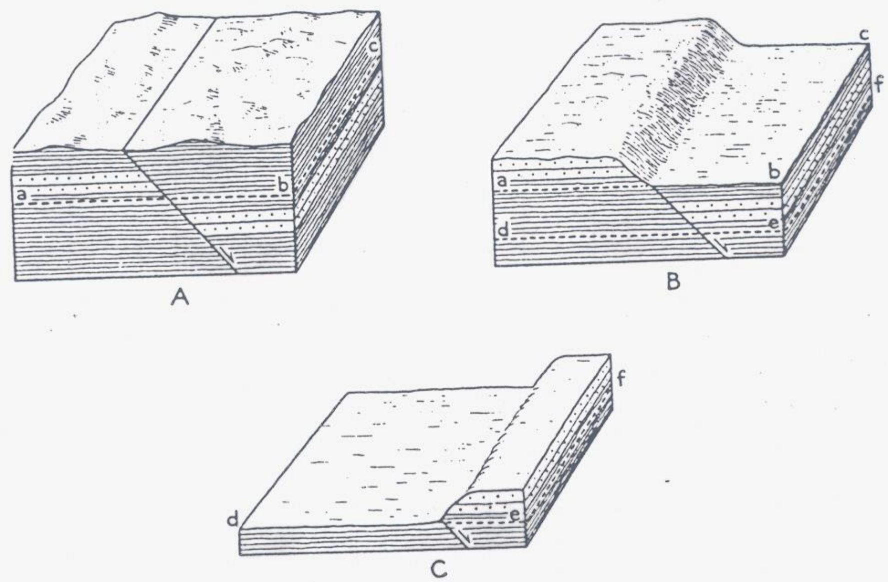


EVIDENCES OF FAULTS

Criteria for Faulting

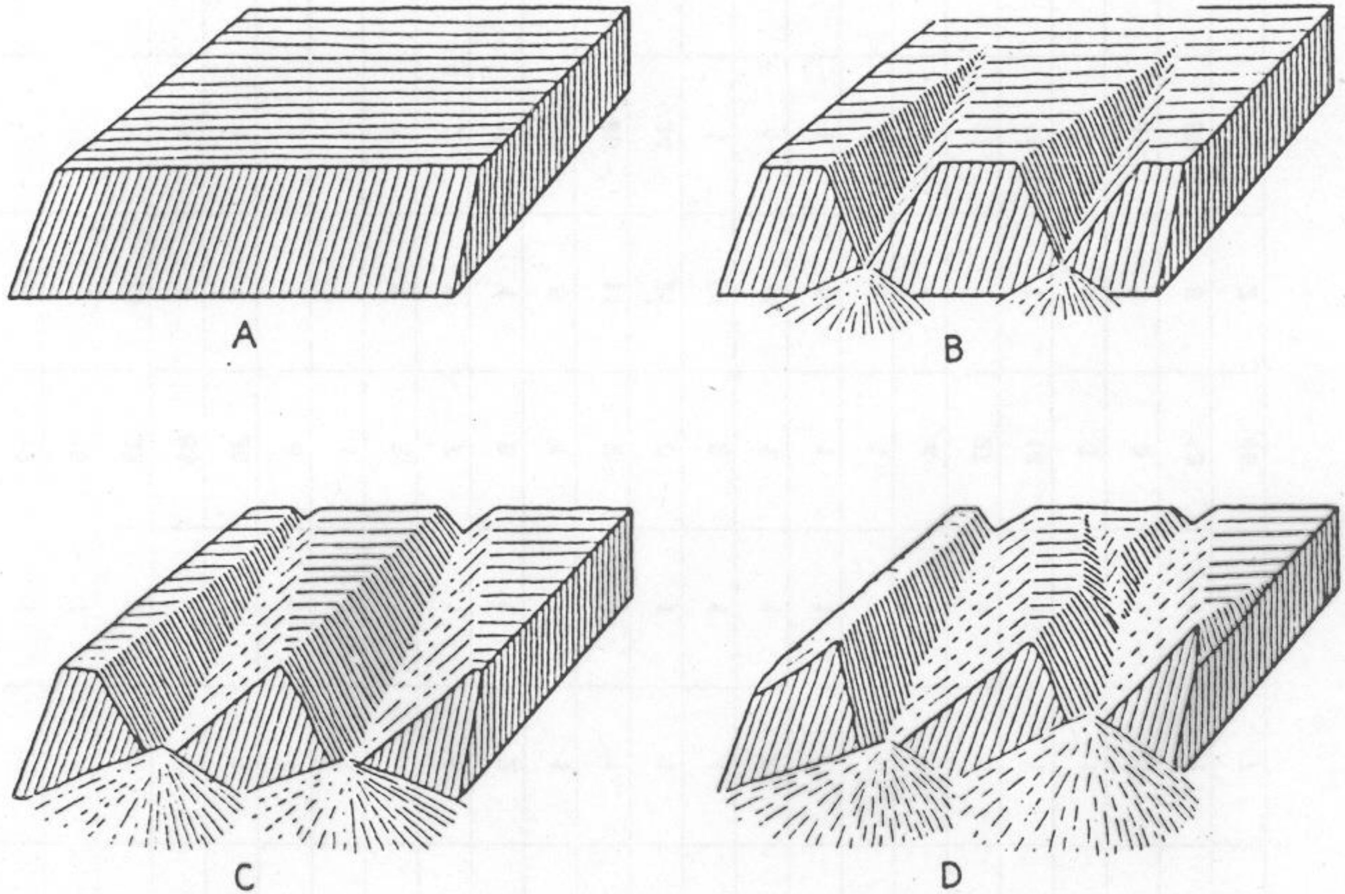


Fault scarp. (A) Before erosion; *h*, height of scarp, equals *v*, the vertical slip. (B) After some erosion the material removed from deep valleys on the footwall block has been deposited as alluvial fans on hanging-wall block.



Fault line and fault-line scarp. (A) Fault line without scarp. Dotted formation is resistant to erosion; formations shown by parallel lines are not resistant to erosion; *abc* new baselevel of erosion. (B) Easily eroded rocks on hanging-wall block have been reduced to new baselevel; rocks resistant to erosion on footwall have been only partially eroded; the plane *def* represents a new baselevel. (C) Scarp developed on relatively downdropped block.

EVIDENCES OF FAULTS



Evolution of triangular facets. (A) Fault scarp prior to erosion. (B) Partially eroded fault scarp. (C) Triangular facets representing remnants of original fault scarp. (D) Triangular facets that represent the original fault scarp driven back somewhat by erosion.