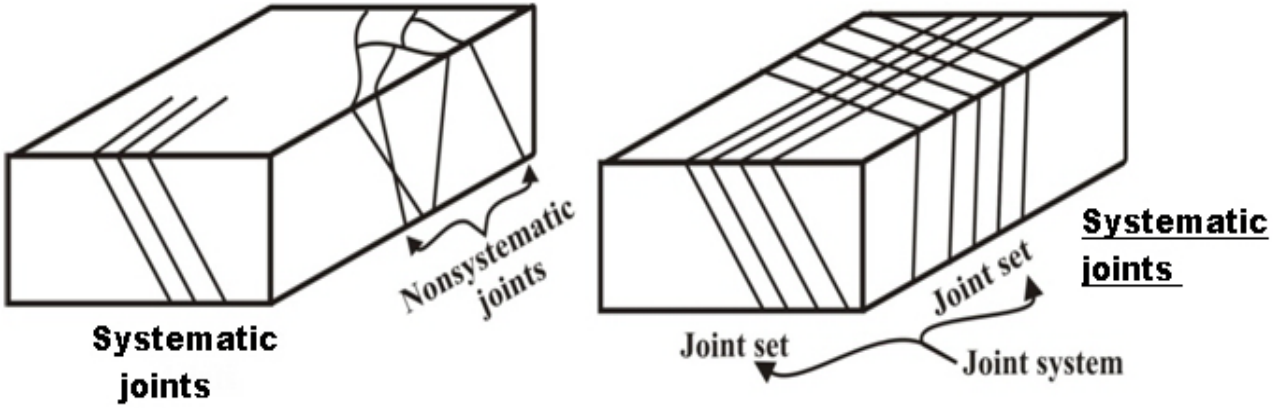
Joints

I- Basic terminology

- Joints are fracture planes or surfaces that no displacement occurs along them.
- Closely spaced Joints (with distance between them less than 2 cm) are regarded as a type of foliation termed "fracture cleavage".
- Joints may be primary in origin, such as the columnar joints in volcanic rocks. Joints are mainly secondary in origin formed by the effect of compressional or tensional stresses.
- Joints occur in groups and can be formed at any scale.



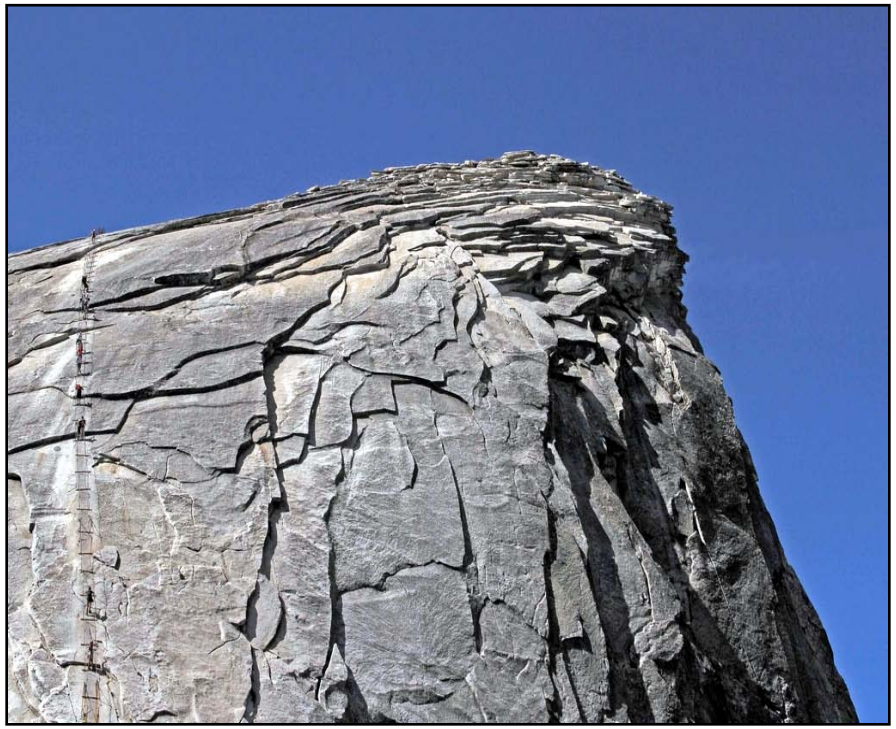
- **Systematic joints** are planar in geometry and are of regular parallel orientation.
- **Nonsystematic joints** are curved and irregular in geometry and usually not parallel.
- **Joint set** is a group of parallel joints. **Joint system** consists of more than on set of joints.
- Joints may be open or closed. Open joints are frequently filled with a secondary material. This secondary material is mostly carbonates (calcite).
- Many terms are used with joints, such as : **strike joints, dip joints, bedding joints, diagonal joints, oblique joints, cross joints, longitudinal joints**, ….etc. For the definitions of these terms refer to the course ESR-211 (Introduction to structural geology).

II- Non-tectonic joints

1-**Columnar joints** in volcanic igneous rocks, formed due to cooling of magma.

2- **Mud cracks** in soils, formed due to shrinkage due to evaporation of water..

3- **Exfoliation** in rocks of high compressive strength due to temperature changes formed parallel to the present land surface .



III- Tectonic joints

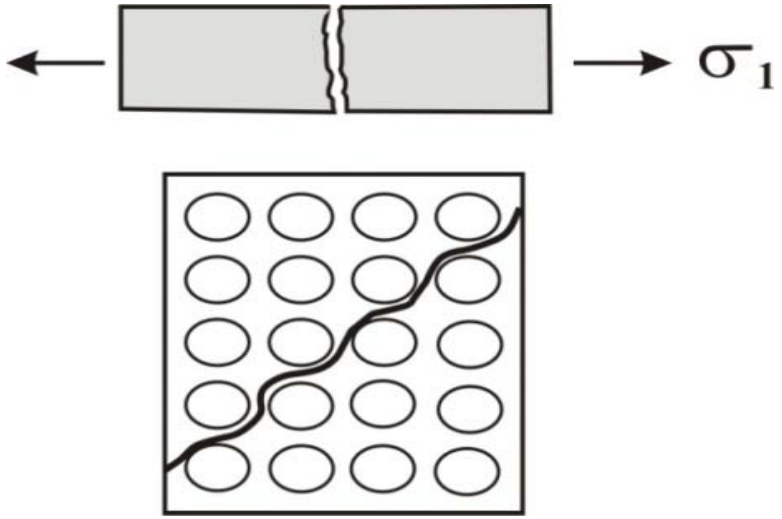
❖ **Genetic classification of joints :**

Joints are genetically classified into two types: tensional and shear joints.

1- **Tensional joints** :

Tensional joints are characterized by :

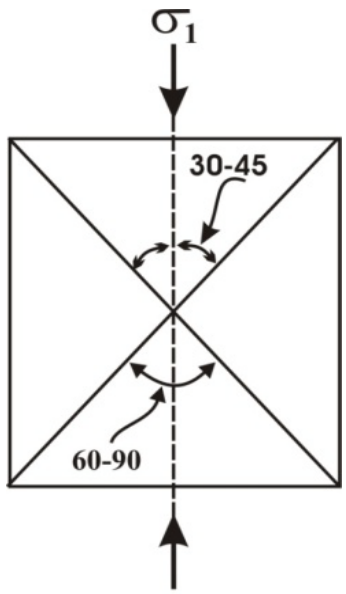
- joints are formed by tensional stresses.
- joints are formed as one set normal to the direction of tension.
- joints are open and irregular.
- joint plane does not cut across the pebbles of conglomerates, but it deviate around them.

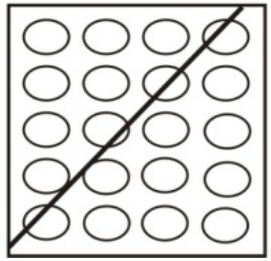


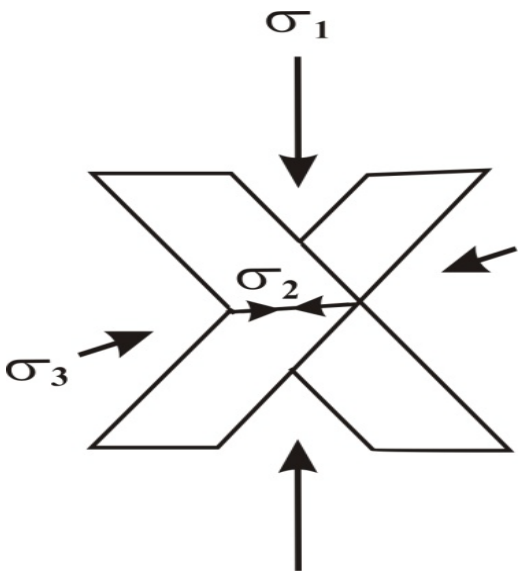
2- <u>Shear joints</u> :

Shear joints are characterized by :

- joints are formed by compressive stresses.
- joints are formed as two sets termed as "conjugate joints". The two conjugate sets make an acute angle with the maximum stress (σ_1), ranging between 60° – 90° depending on the cohesion of the material.
- The angle between the joint plane and the maximum stress (σ_1) ranges between 30°- 45°.
- The maximum stress (σ_1) bisects the acute angle between the two conjugate joints. The minimum stress (σ_3) bisects the obtuse angle. The intermediate stress (σ_2) represents the line of intersection of the two conjugate joints.







❖ Fracture sets that can be produced by compressive stresses :

The following results are reached through experiments done on square prisms :

1- A compressive stress is applied on a square prism; while its sides are unconfined (i.e. no stresses are applied on its sides). The following fracture sets are produced:

a- Four sets of **shear joints** are formed. Each two of the four sets are conjugate (sea Fig. !).

b- Due to the effect of the applied compression, an extension in the horizontal direction took place, and **extensional joints** are formed parallel to the sides of the prism (Fig. 2).

c- When the stress is removed, an extension in the vertical direction occurs, and **release joints** are formed in a direction normal to the removed of compression (Fig. 3).

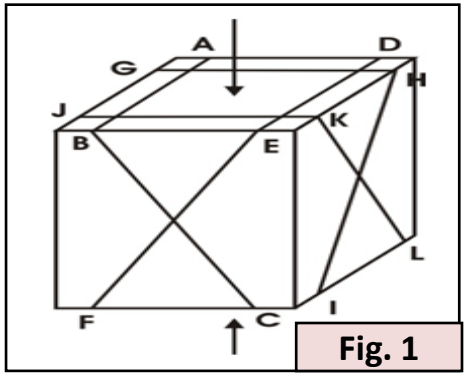


Fig. 1

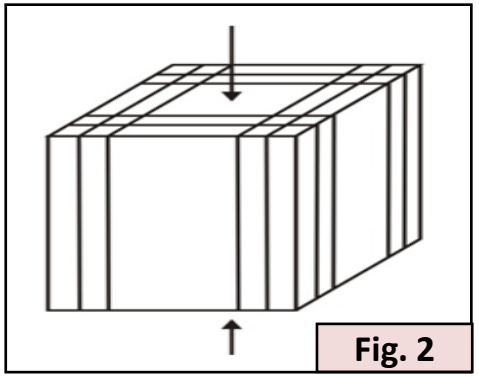


Fig. 2

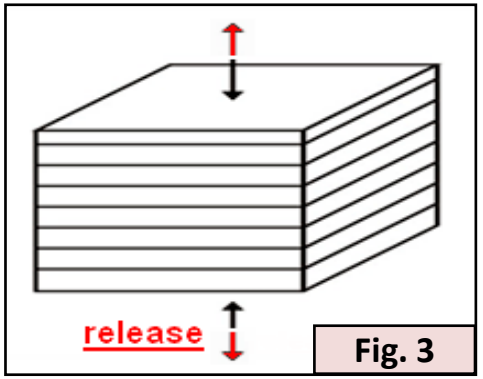


Fig. 3

2- If the front and back sides of the prism are confined, the shear and extensional joints are only formed normal to the confined sides (Figs. 4 & 5).

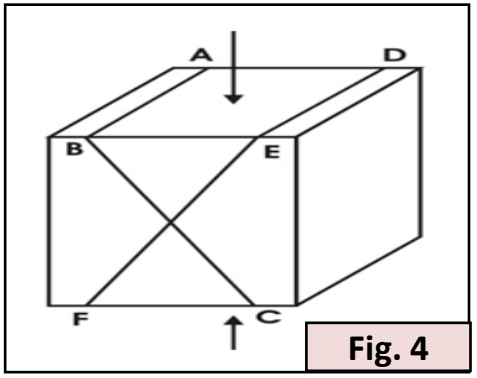


Fig. 4

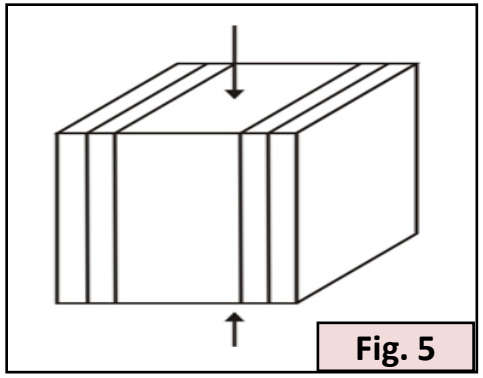


Fig. 5

❖ **In conclusion:**

- **Tensional stresses produce one set of joints.**
- **Compressional stresses produce at least two sets of conjugate shear joints, and may produce up to seven sets of joints.**
- **Most of the vertical joints are extension joints.**
- **Most of the horizontal joints are release joints.**
- **Conjugate joints are mostly shear joints.**

IV- The joint spacing and Joint frequency:

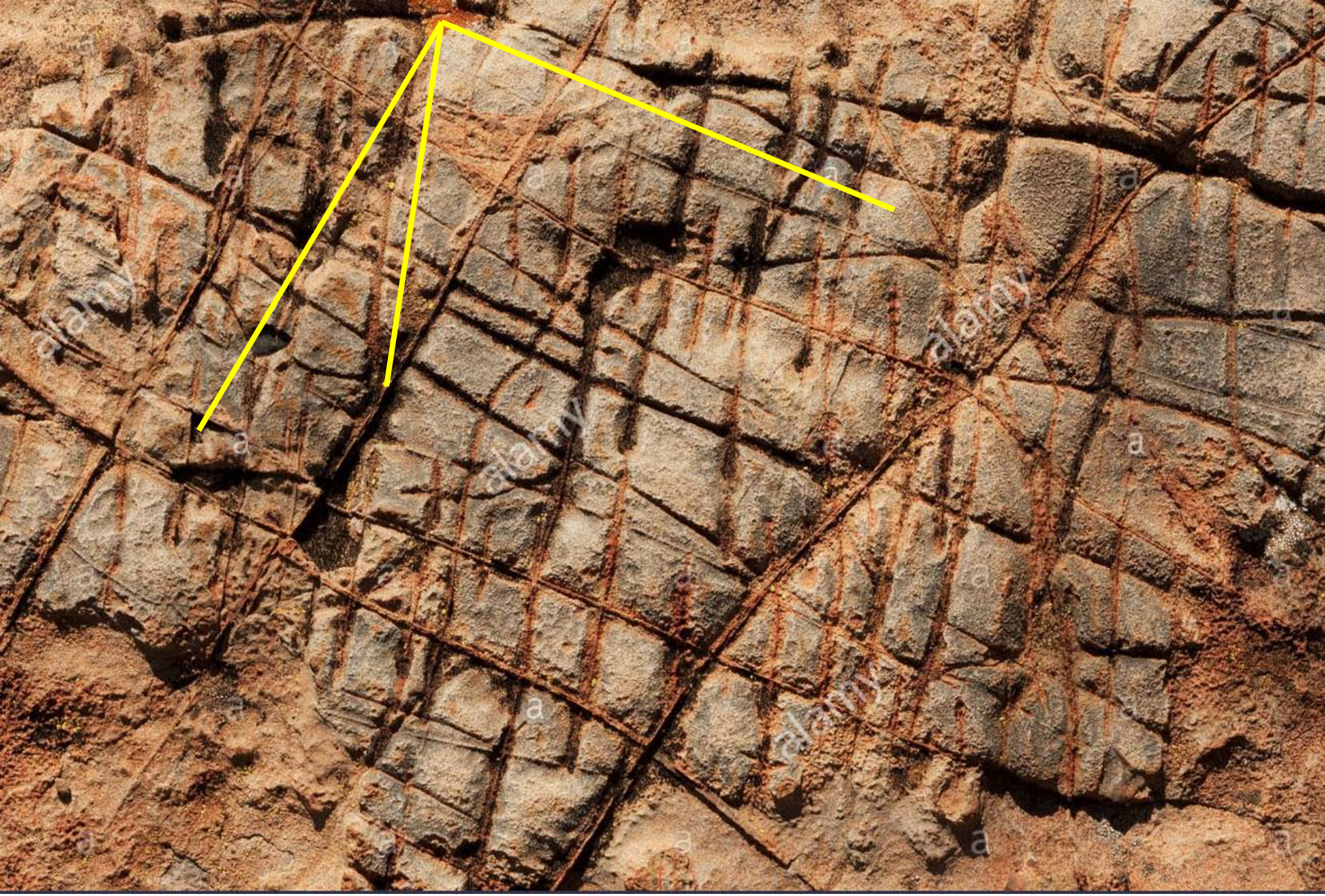
- **The joint spacing** is the average distance between joints measured normal to the fractures within a certain distance.
- **The joint frequency** is the average of the number of joints found in one meter normal to the fractures.

Two conjugate sets of shear joints in limestone beds

Two conjugate sets of shear joints in granite

Two conjugate sets of shear joints filled with carbonates

Two conjugate sets of joints filled with carbonates



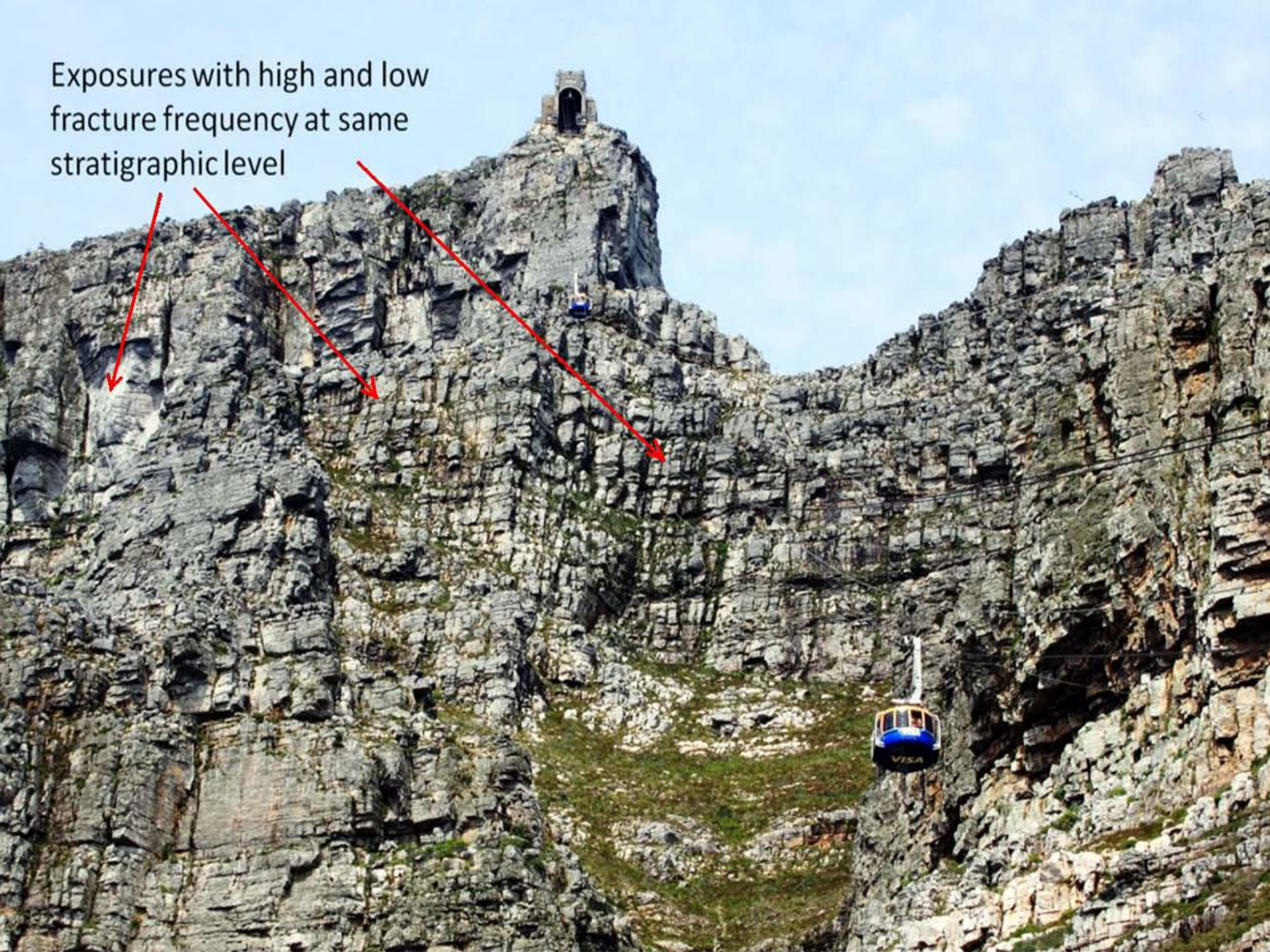
Three sets of joints filled with secondary material


MARKLINE
Permanent Marker

Vertical dyke swarm emplaced along a set of extensional joints in granitic rocks

Vertical set of extensional joints and a horizontal set of release joints in granitic rocks

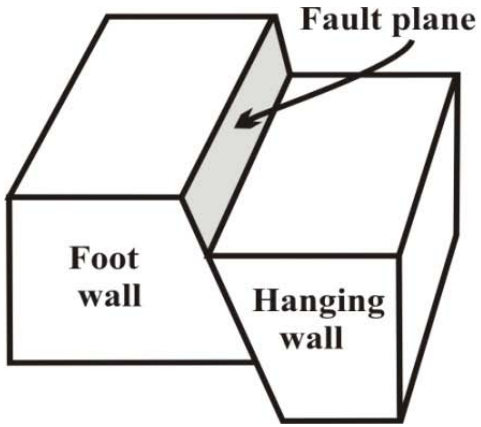
Vertical set of extensional joints in sedimentary rocks causing failure of the free face parts

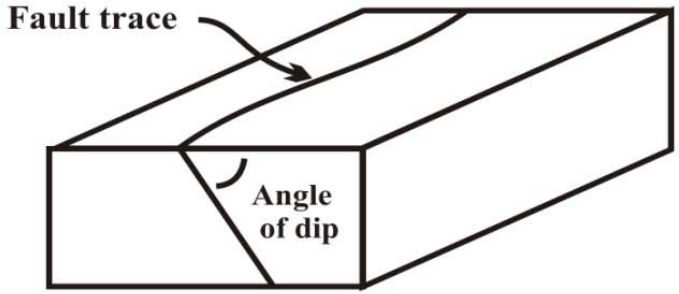

Exposures with high and low fracture frequency at same stratigraphic level

Open fracture formed due to recent tectonics during earthquake activity

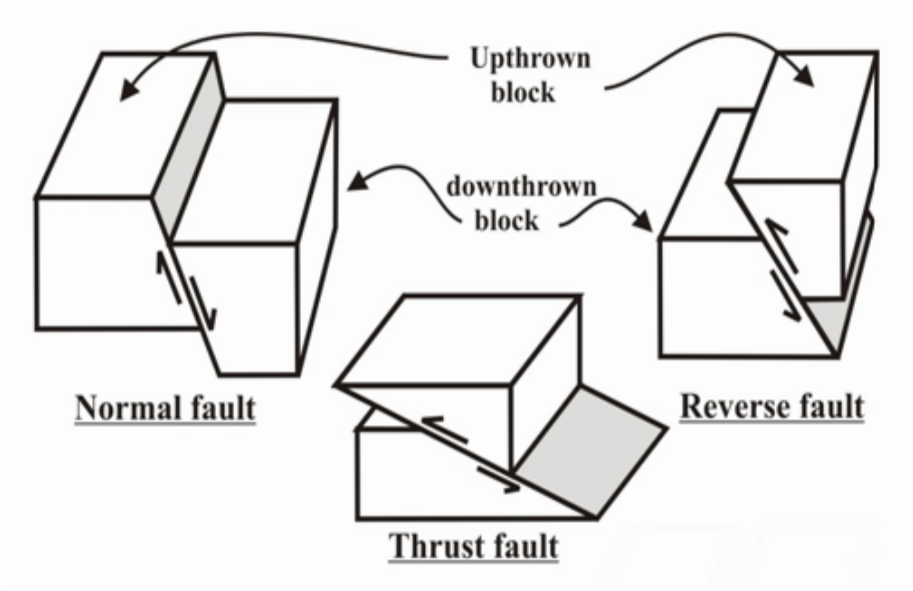
Faults

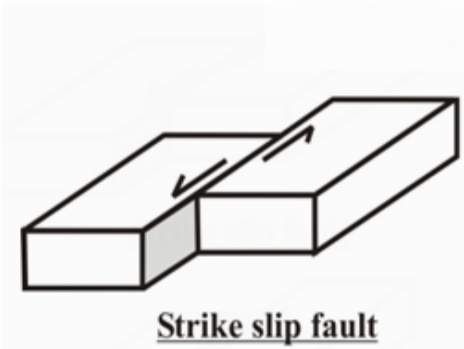
Terminology :

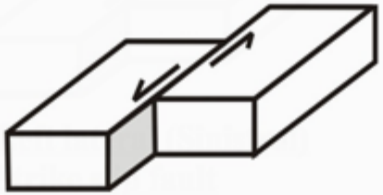


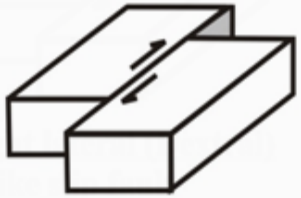


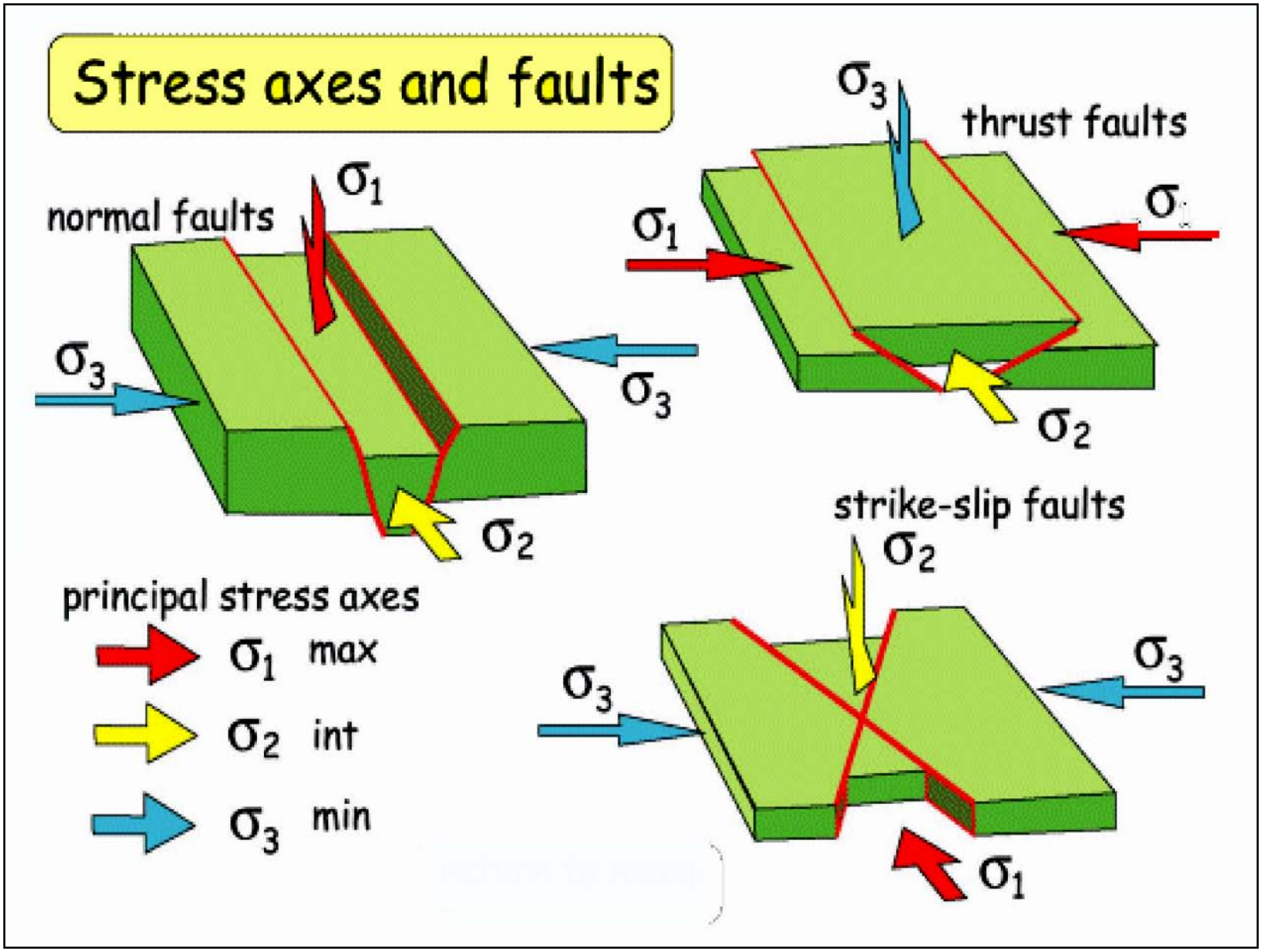
Types of faults :










Stress axes and faults
normal faults
σ1
σ3
σ3
σ2
thrust faults
σ3
σ1
σ
σ2
strike-slip faults
σ2
σ3
σ3
σ1
principal stress axes
σ1 max
σ2 int
σ3 min

Fault breccia formed in the damage zone of a fault plane in limestone

Conjugate normal Faults in sandstone and shale layers causing dragging of beds

Normal Fault in sandstone and shale layers causing dragging of beds and shale smearing

C conjugate normal faults in sedimentary succession

- **Tables, diagrams, some photos and definitions of scientific terms are used after the following references for teaching purpose.**

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