Lineaments: Fractures and Faults

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.*

LINEAMENTS:

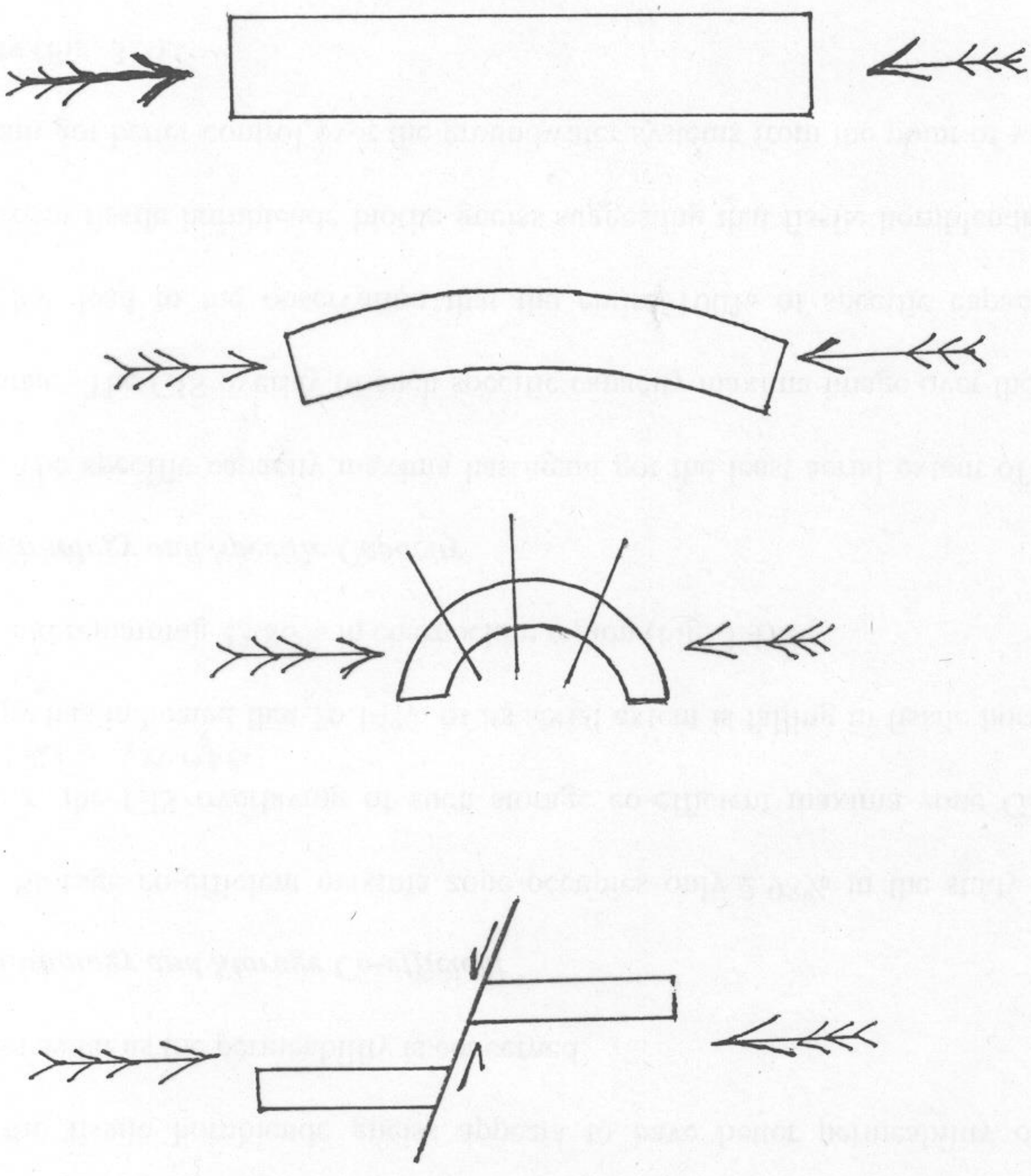
→ Fractures of tectonic origin

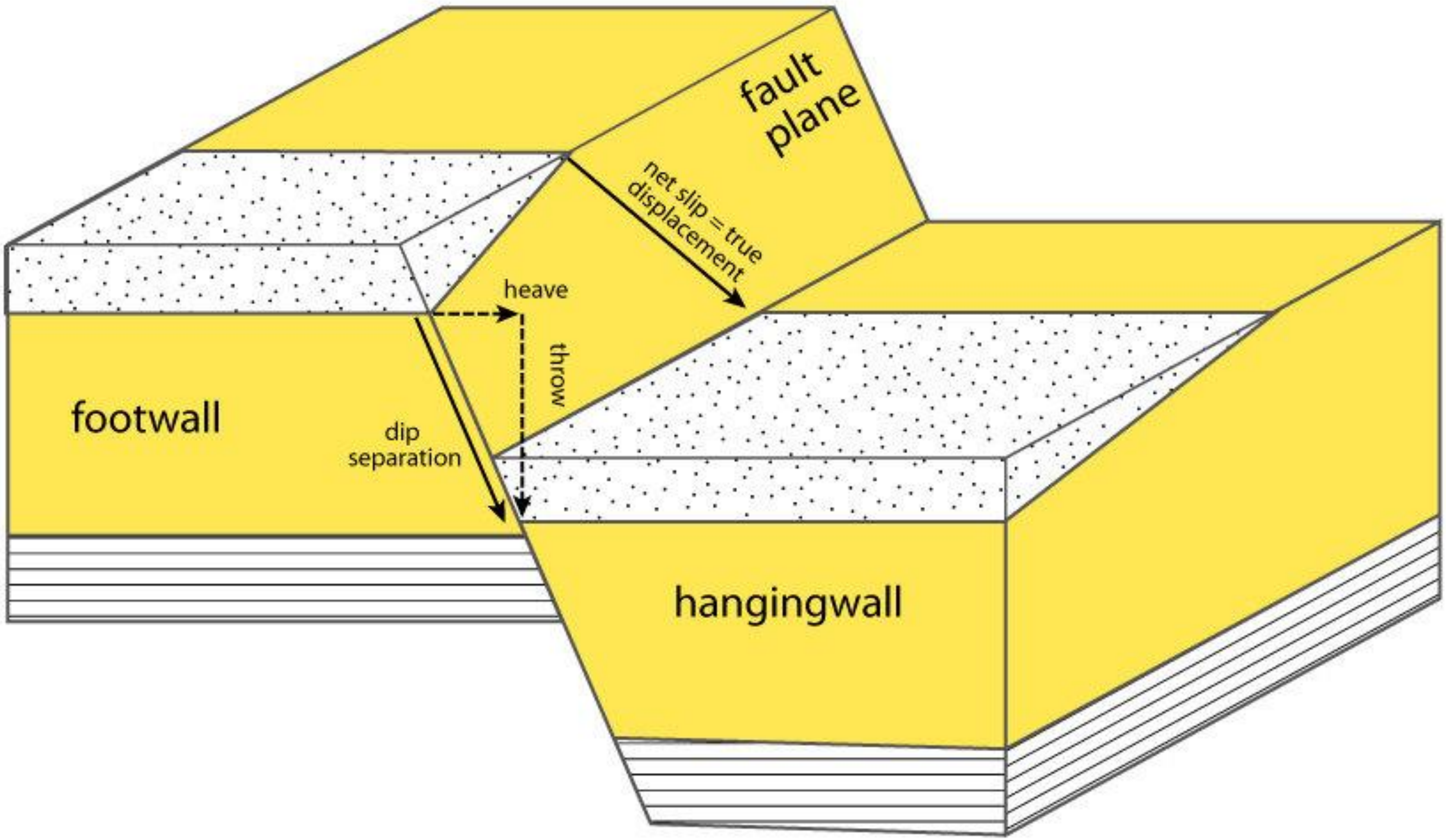
→ Always studied in relation with deformation history

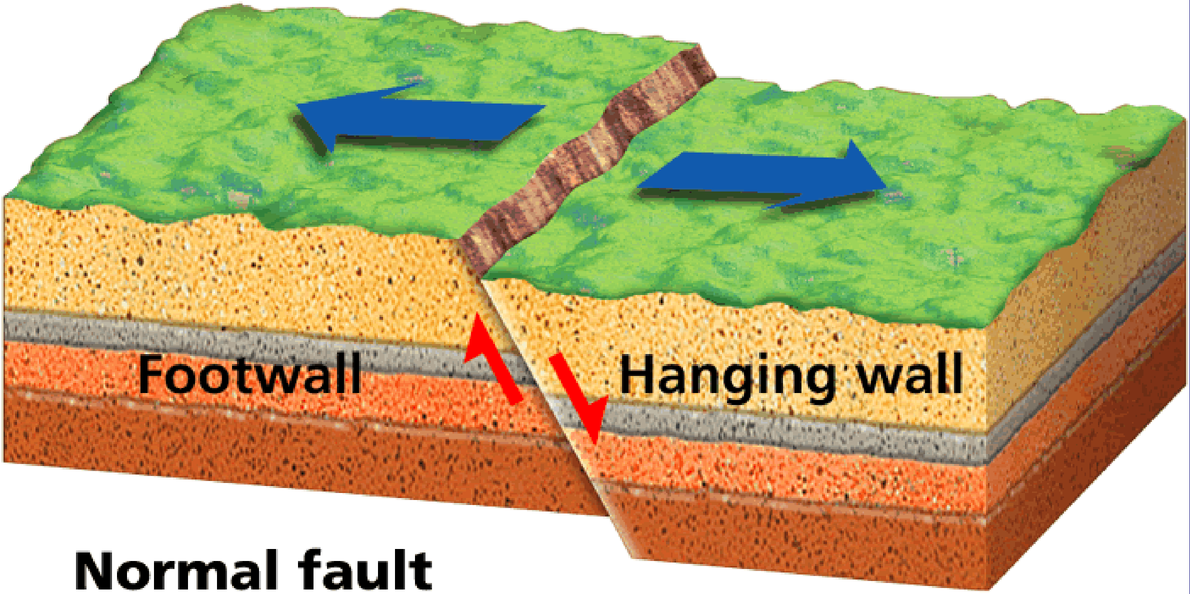
→ It can be linear or curvilinear

→ It can be shorter (minor) or longer (major)

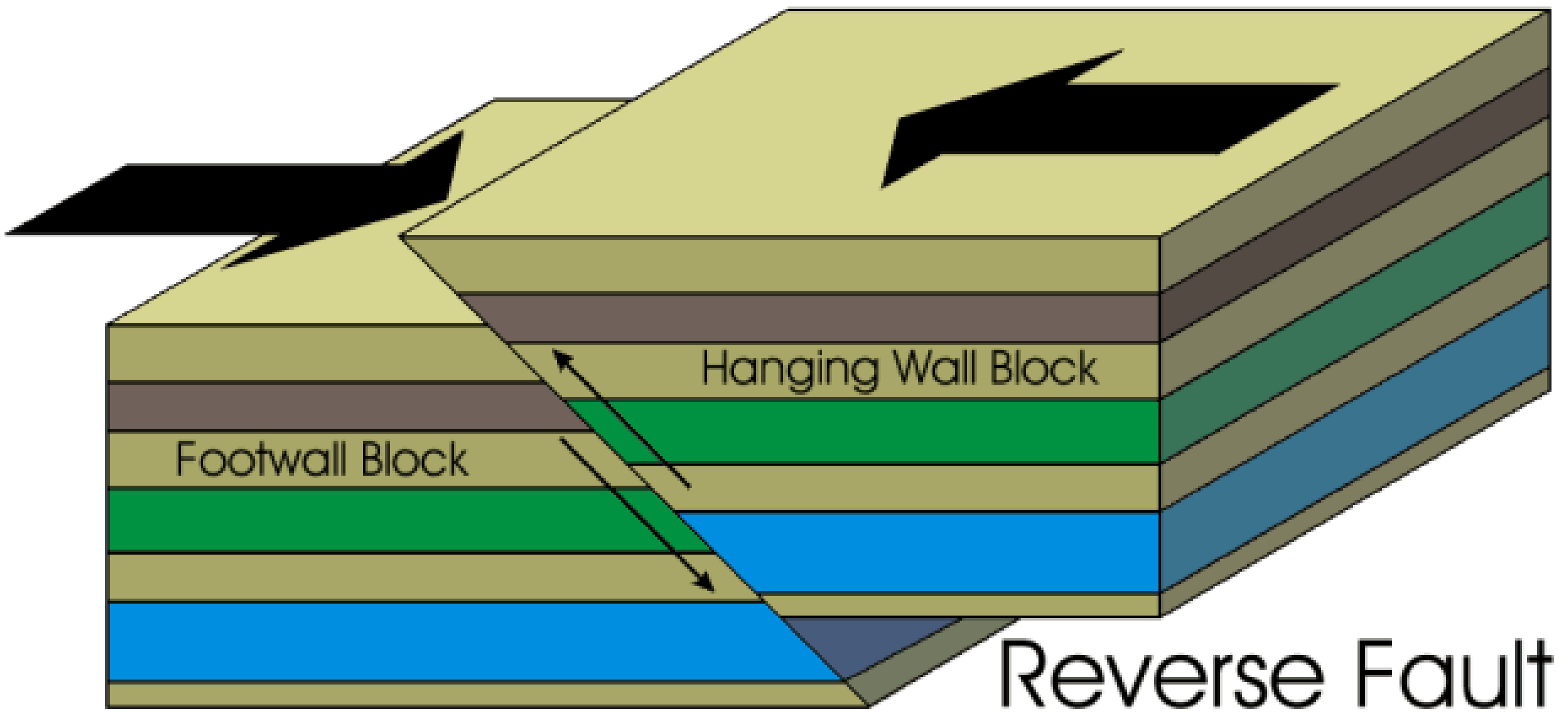
→ It can be a fault or a Joint

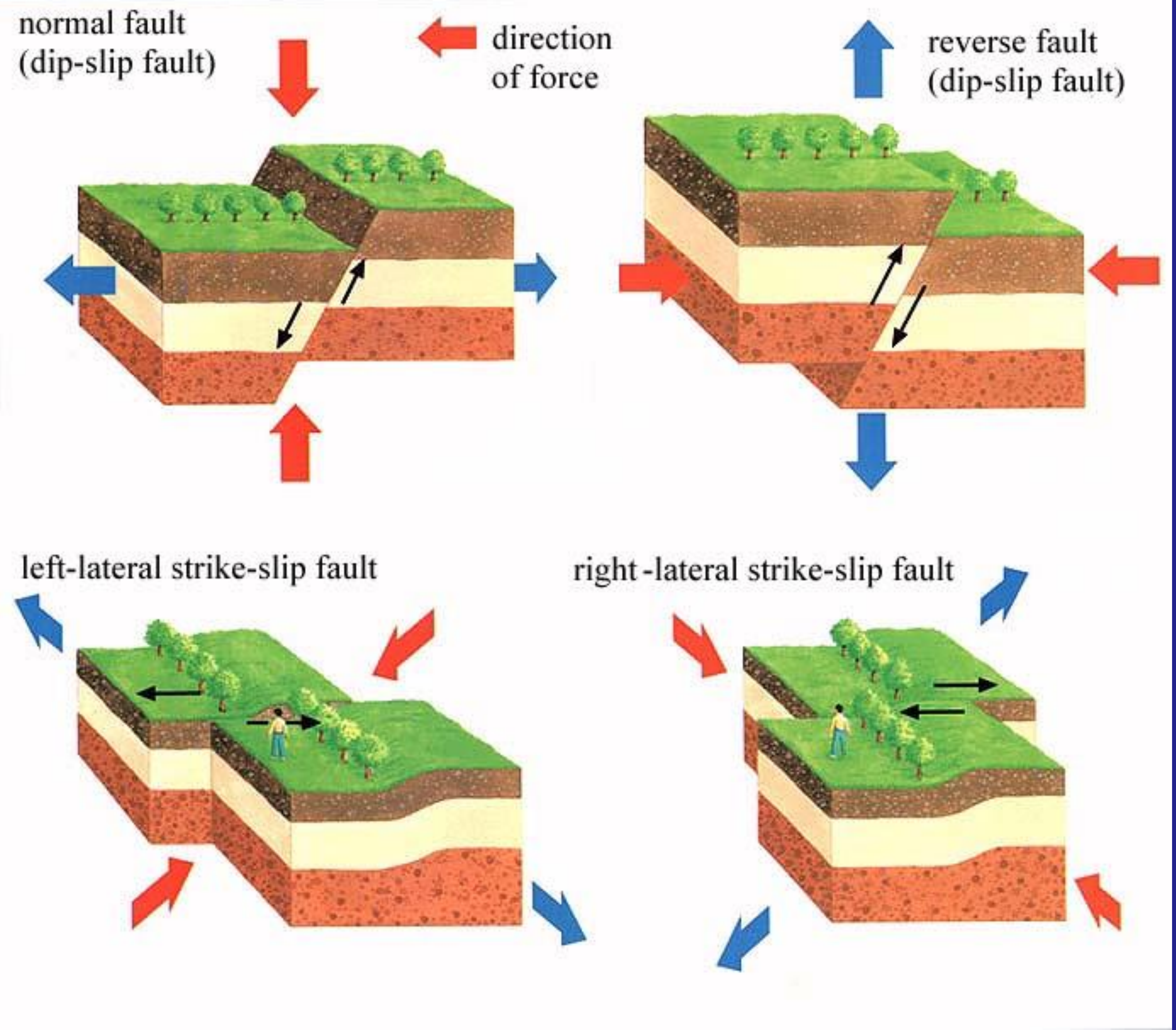


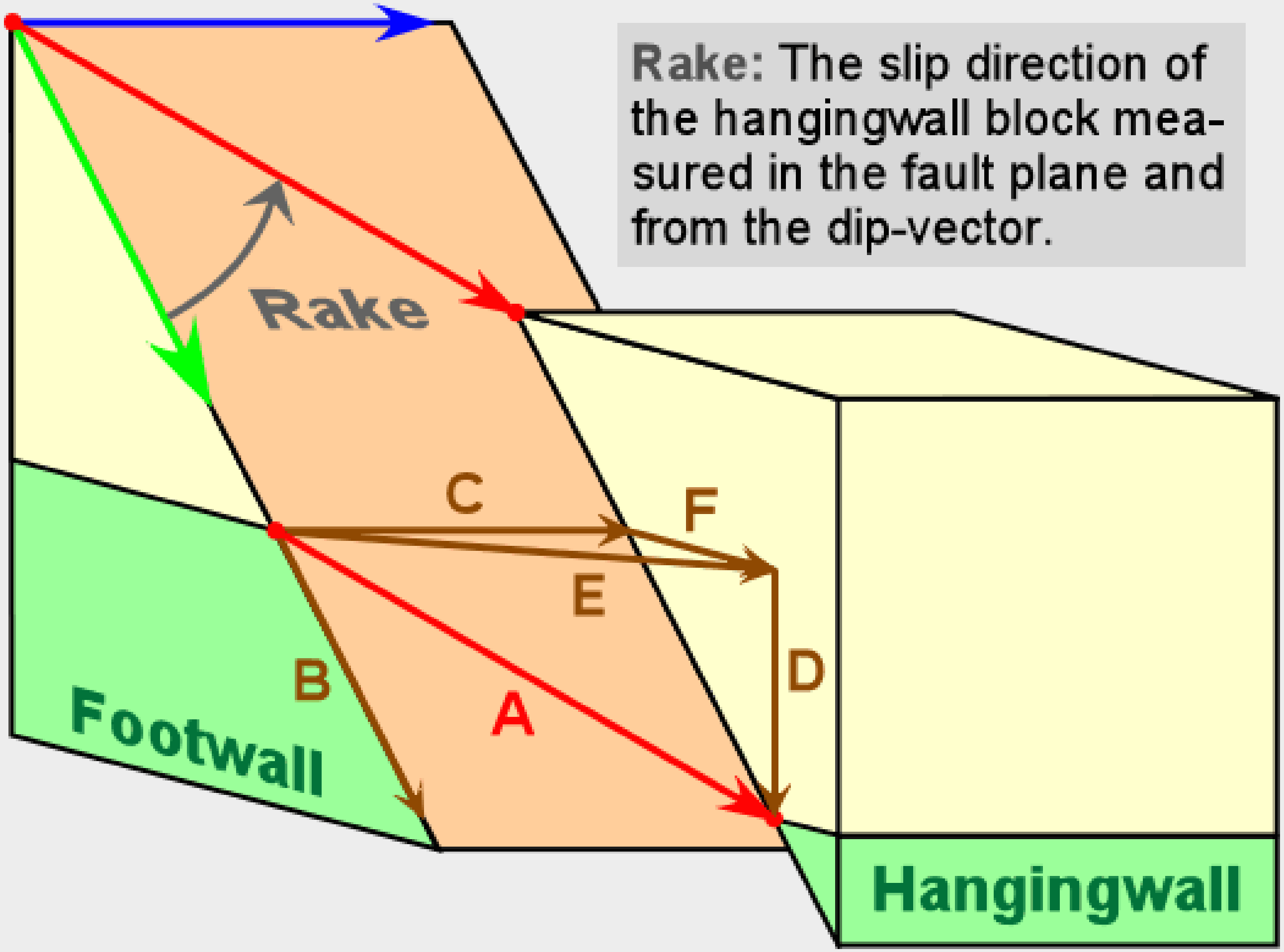

fault plane
net slip = true displacement
heave
throw
footwall
dip separation
hangingwall



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.

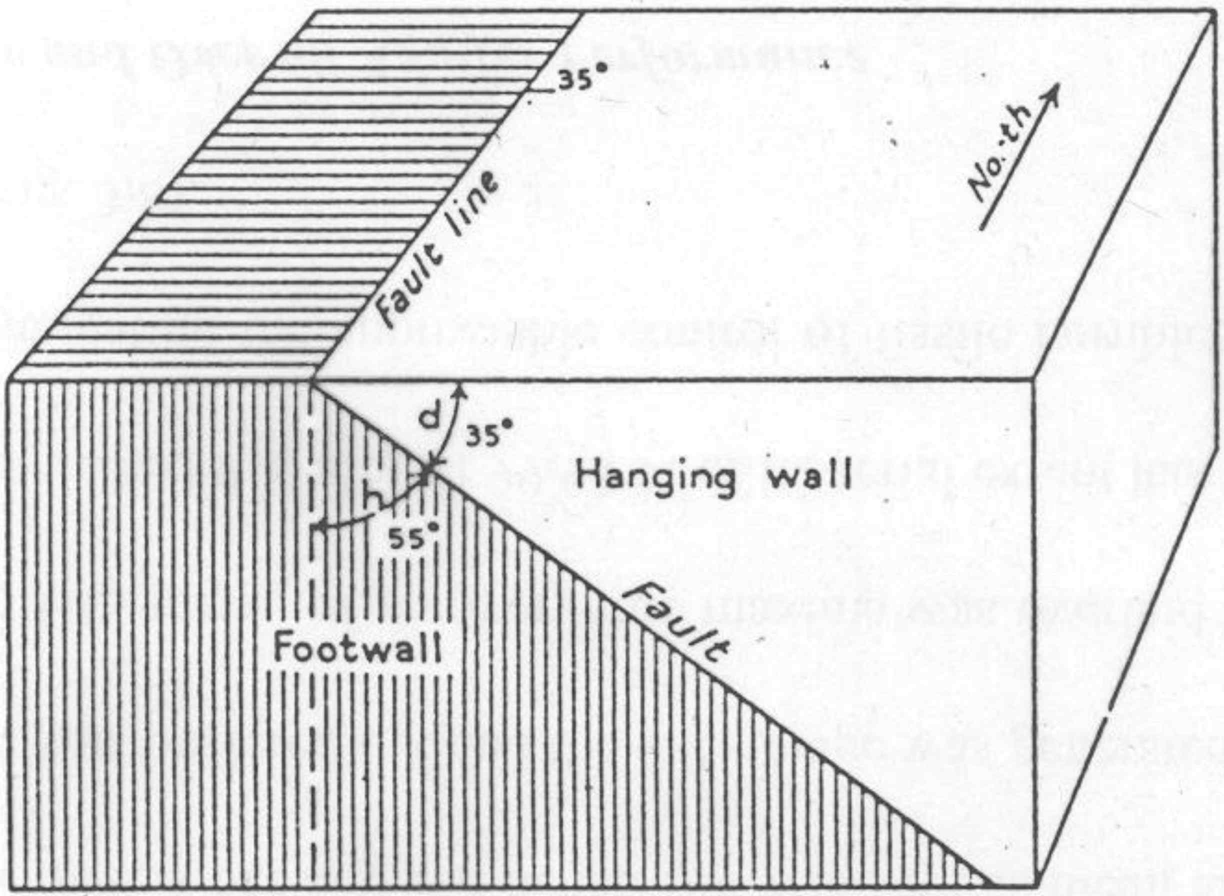
D. *Vertical throw:* The vertical component of the net-slip.

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

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

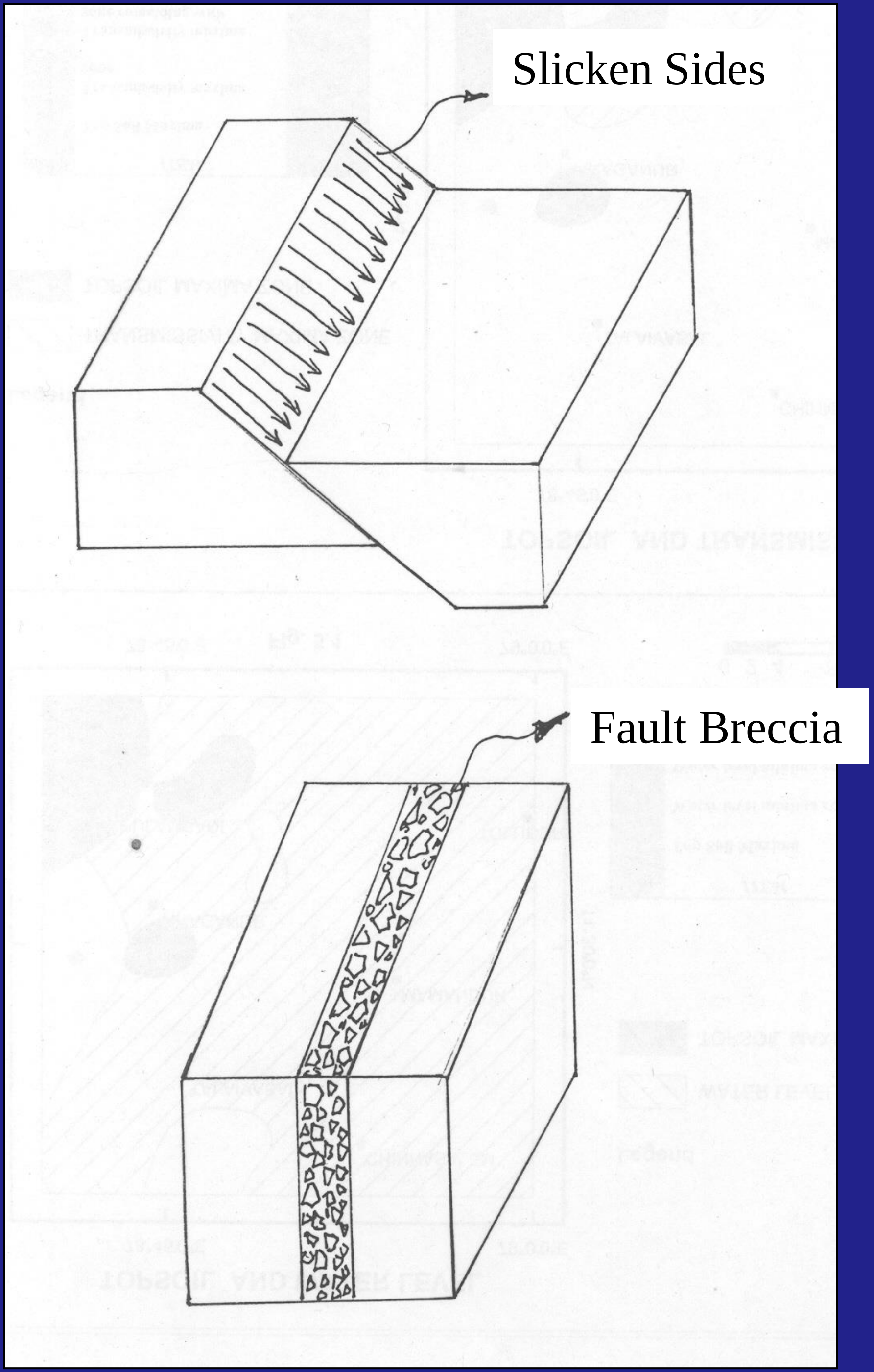
PARTS OF FAULTS

Nature of Movement Along Faults



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

EVIDENCES OF FAULTS



CLASSIFICATION OF FAULTS:-

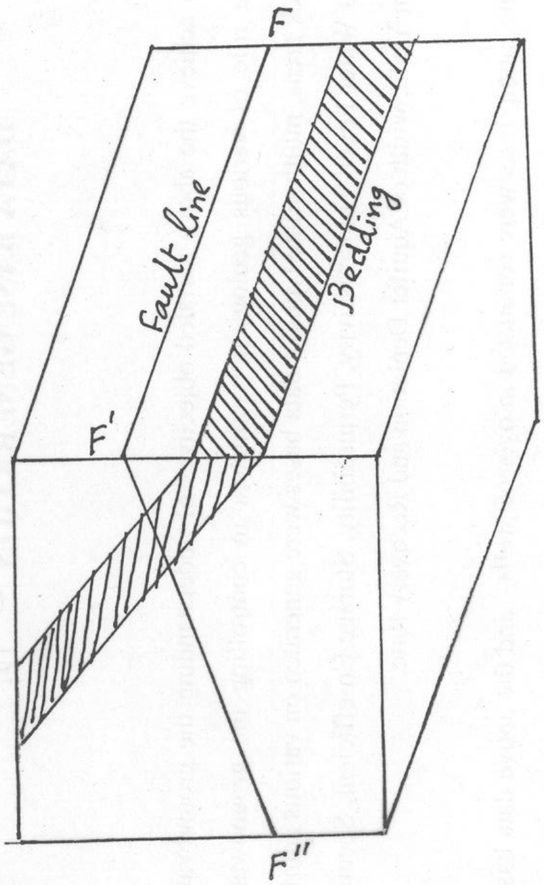
a) On the Basis of Orientation of Faults

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

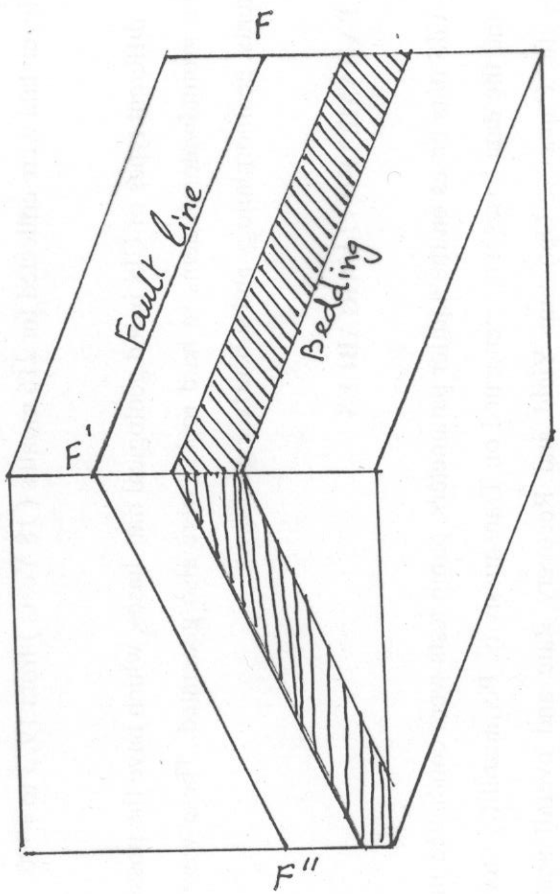
b) On the Basis of Dip Amount of Beds:

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

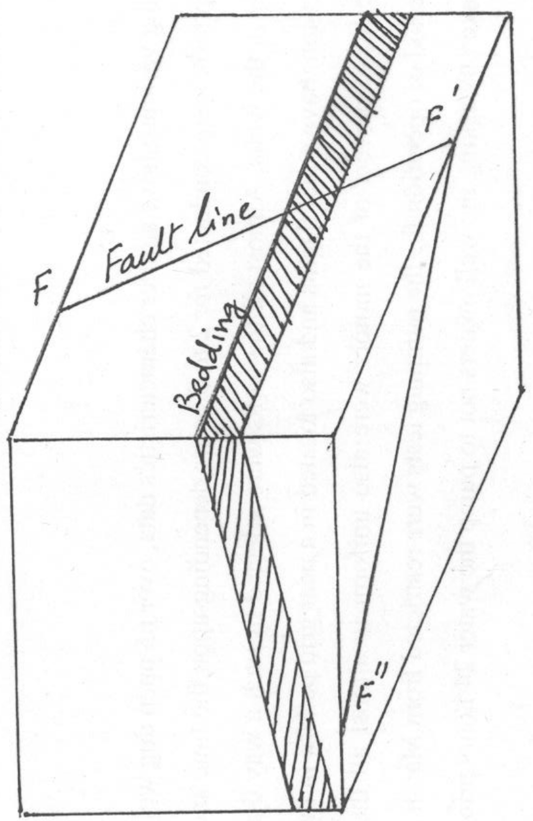
Strike Fault



Dip Fault



Oblique Fault



c) On the basis of Movement:

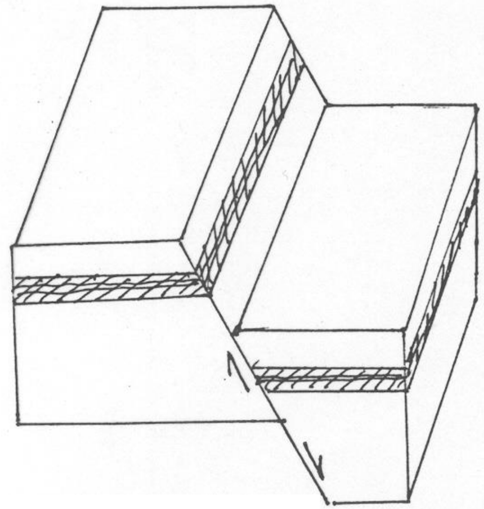
Hanging wall down
Footwall Upwards - Gravity - All boundary faults

Normal Gravity Faults:

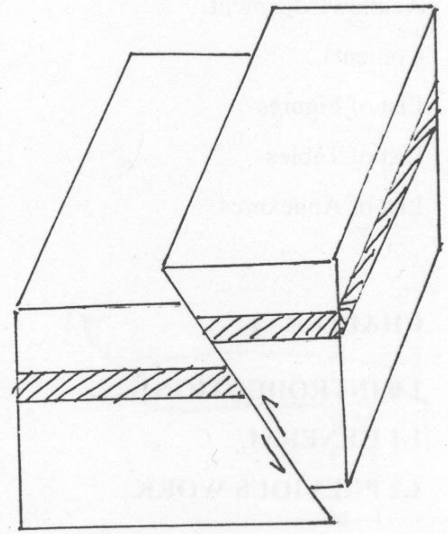
- **Grabben**
- **Horst**
- **Block faulting**

Reverse Faults:

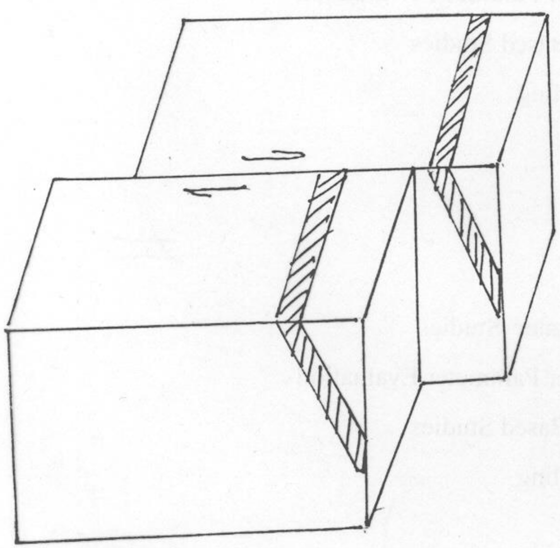
H.W - Upward Eastern boundary of Cuddapah basin
F.W - Downward



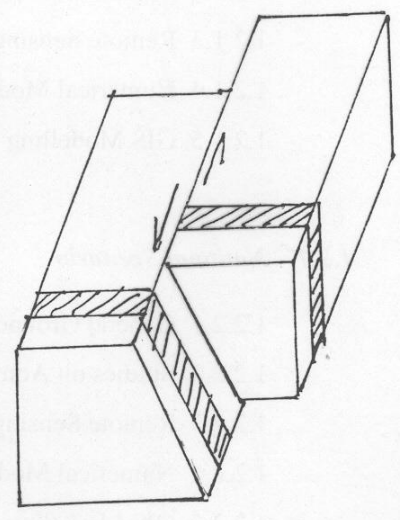
Gravity Fault



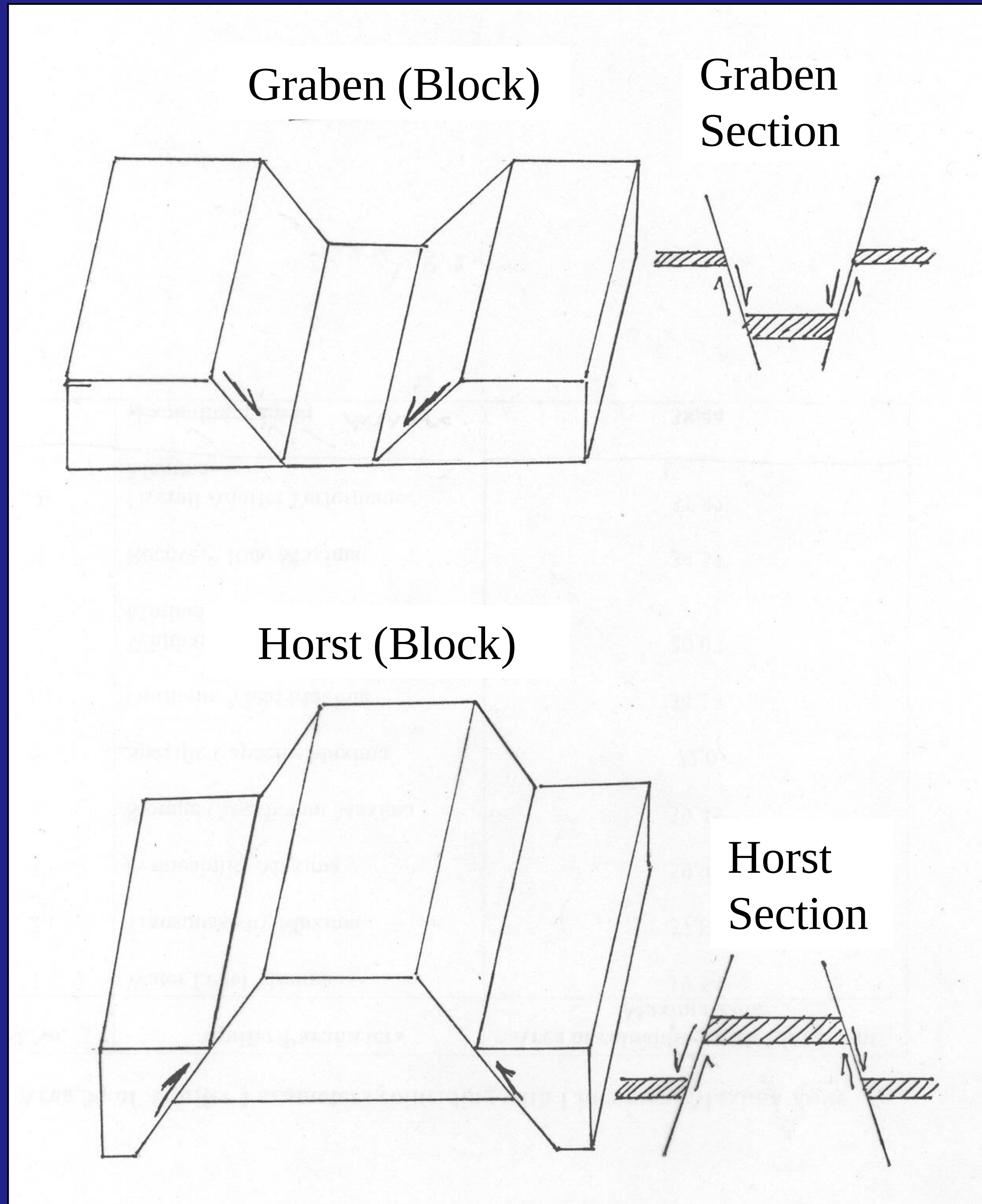
Reverse Fault

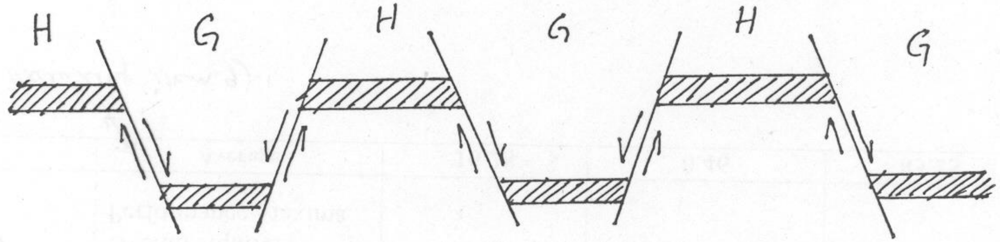


Dextral Fault

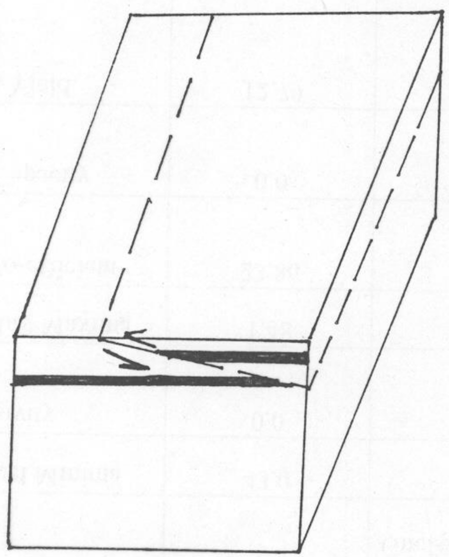


Sinistral Fault


Graben (Block)
Graben
Section
Horst (Block)
Horst
Section



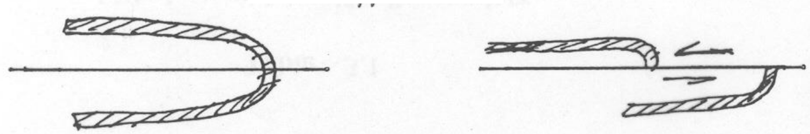
Block Fault (Horst &Graben)



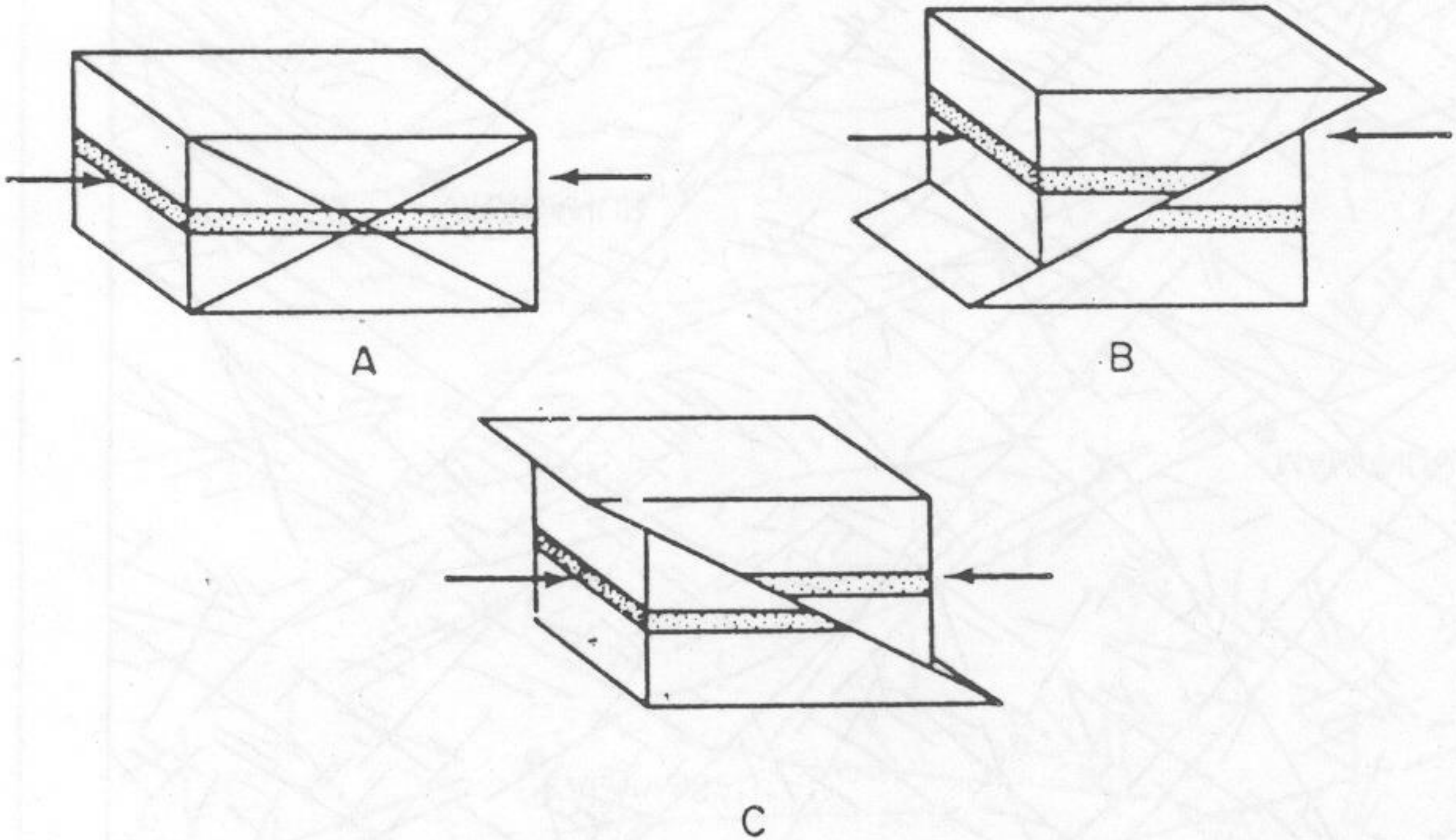
Thrust Fault

(Low angle reverse fault)

Nappe



Reverse Faults, Thrust Faults, and Overthrusts



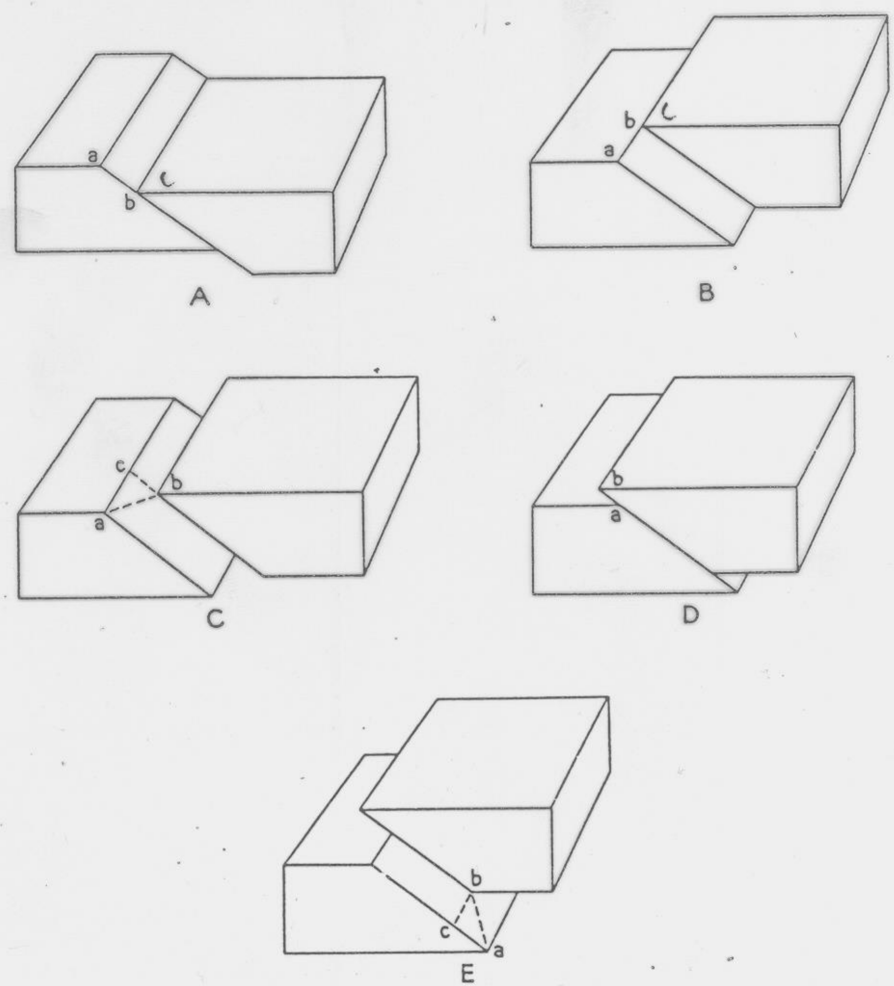
Thrust faults dipping 30° ± form when greatest and intermediate principal stress axes are horizontal.

d) **On the basis of Slip of Faults:-**

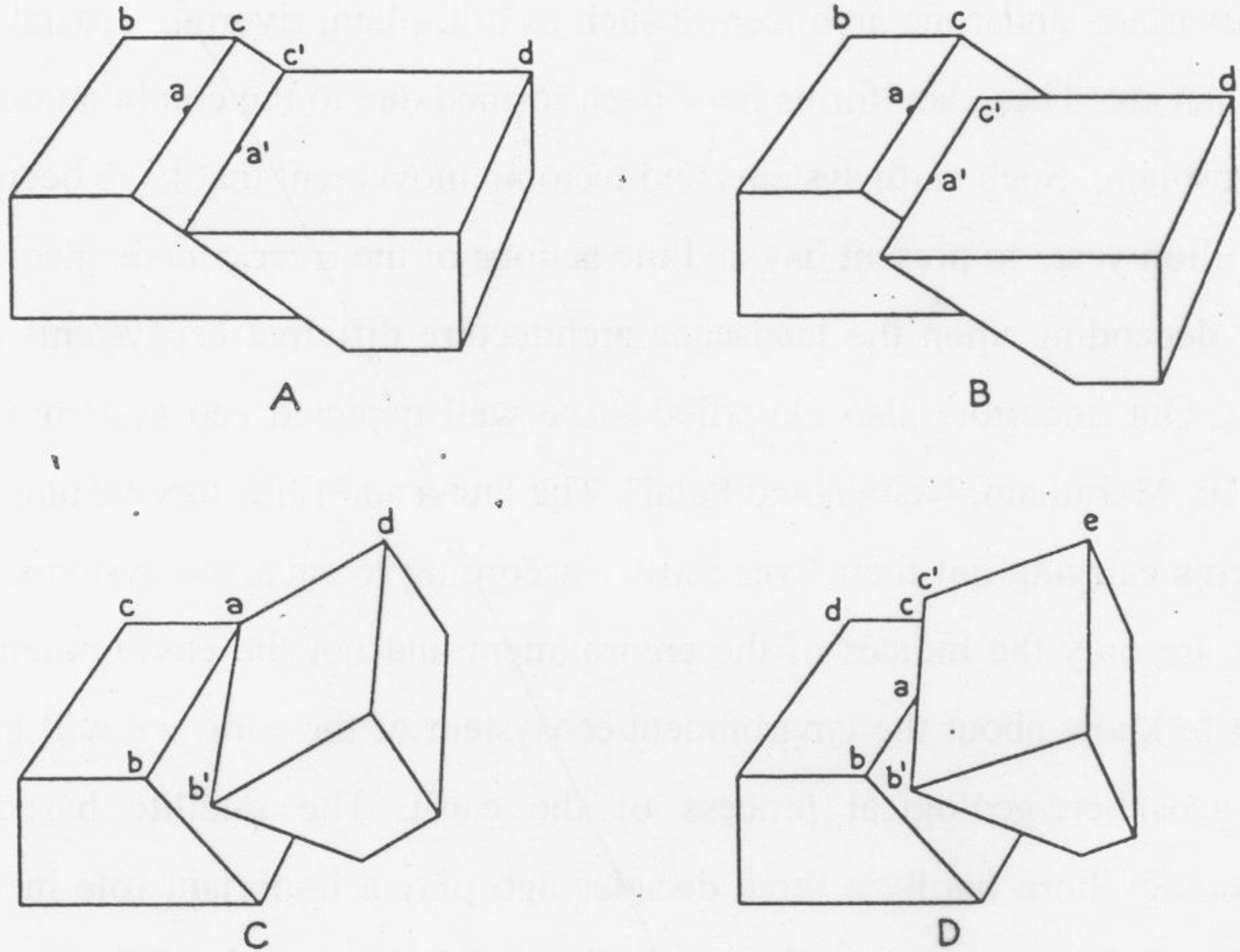
- **Strike slip fault**
- **Dip slip fault**
- **Oblique slip fault**

e) **On the basis of mode of occurrences:**

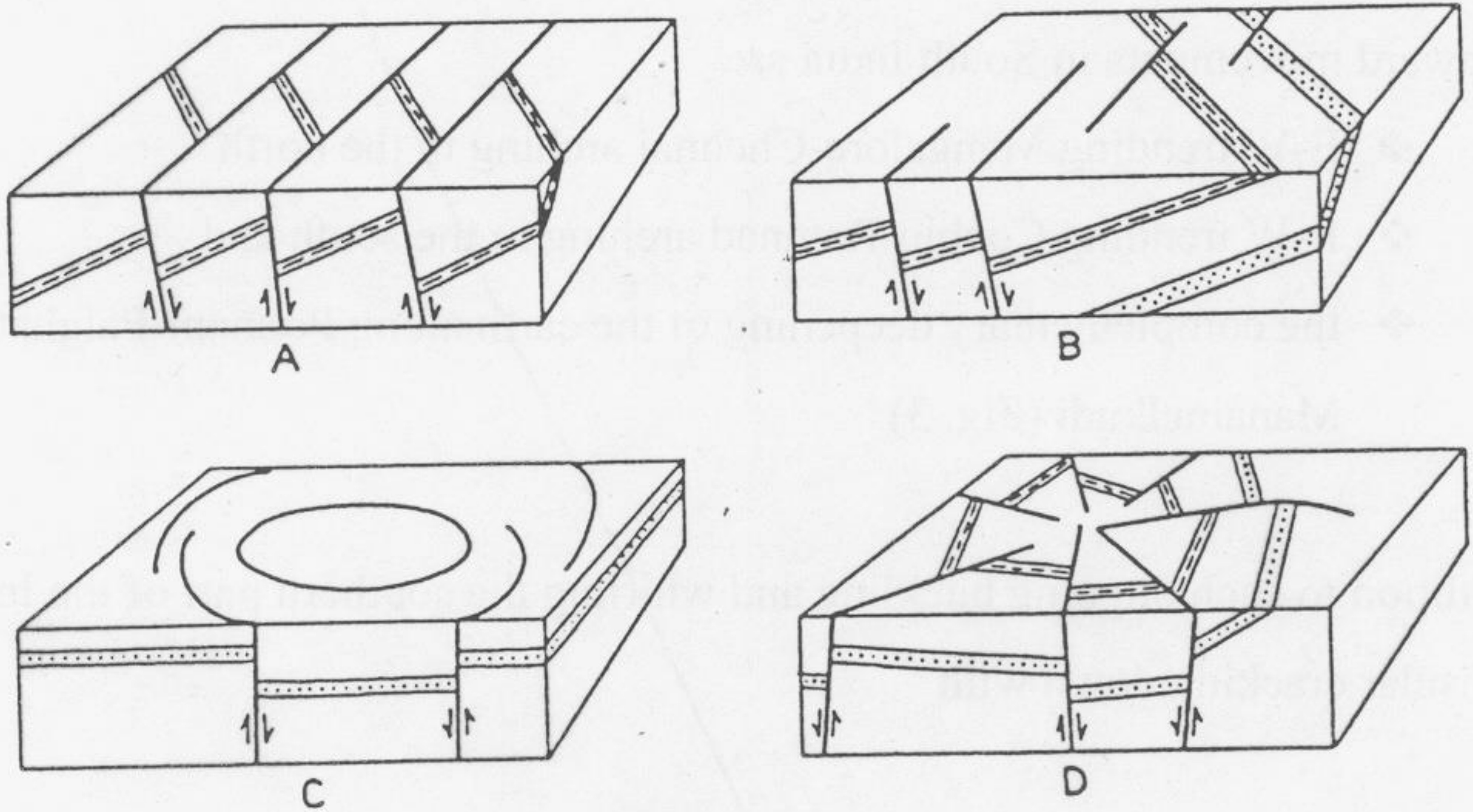
- **Parallel fault**
- **Step fault**
- **En-echelon fault**
- **Peripheral fault**
- **Radial fault**



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.



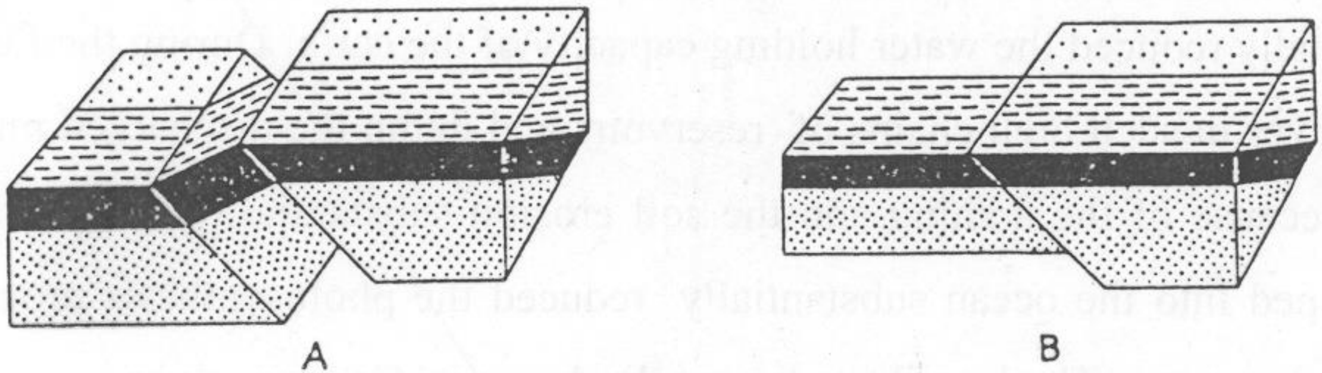
Translational and rotational movements. (A) and (B), translational movements, (C) and (D), rotational movements. Lowercase letters are referred to in the text.



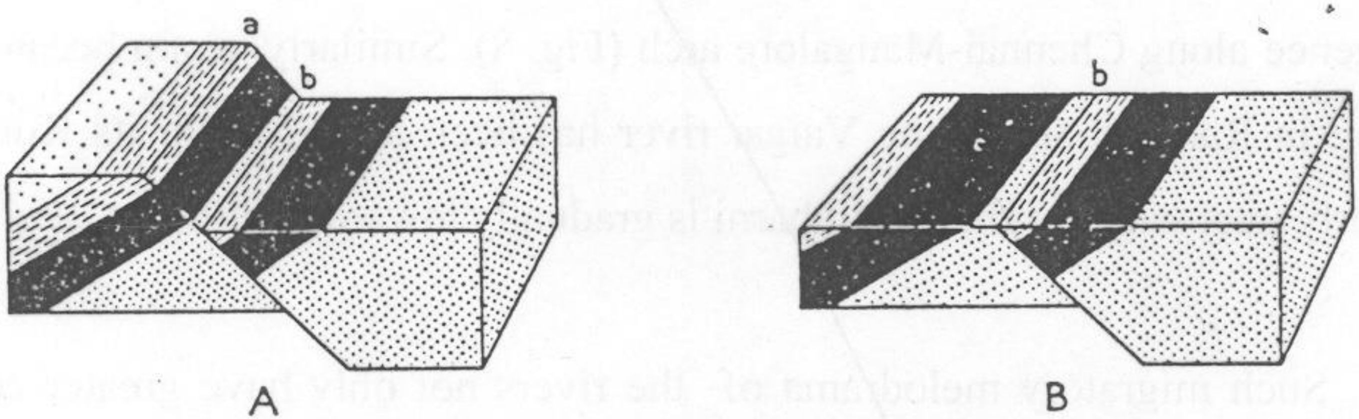
Geometrical classification of faults by pattern. (A) Parallel faults. (B) *En échelon* faults. (C) Peripheral faults. (D) Radial faults.

EFFECT OF FAULT ON THE OUTCROP:-

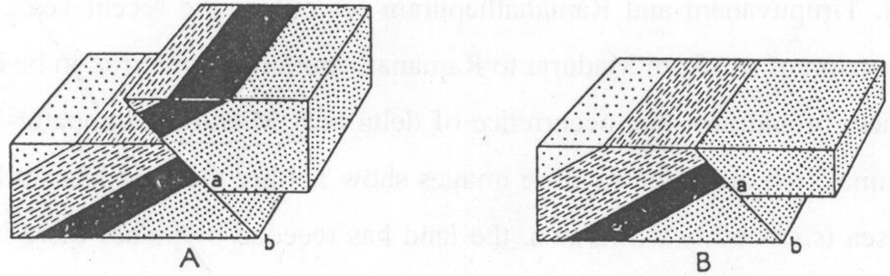
- **Repetition of outcrops**
- **Omission of outcrops**
- **Off setting of outcrops**



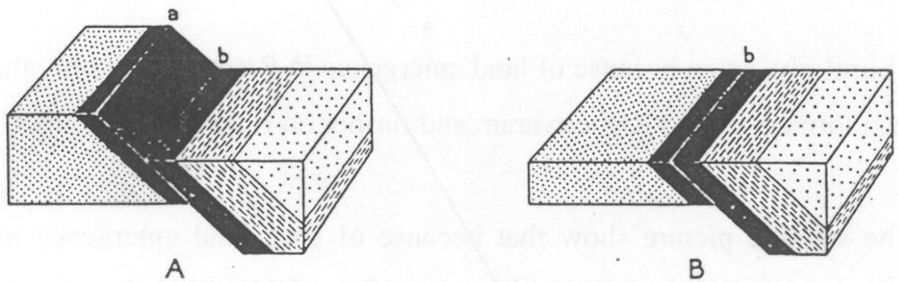
Net slip parallel to trace of bedding on fault. Apparent movement in a vertical section and in map is zero. (A) Immediately after faulting. (B.) After removal of top and front of footwall block.



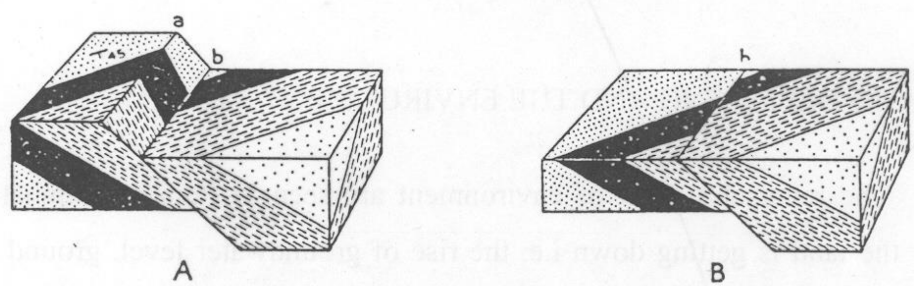
Apparent movement in vertical section equals net slip. (A) *ab* is the net slip, which in this case equals the dip slip. (B) After removal of top of footwall block.



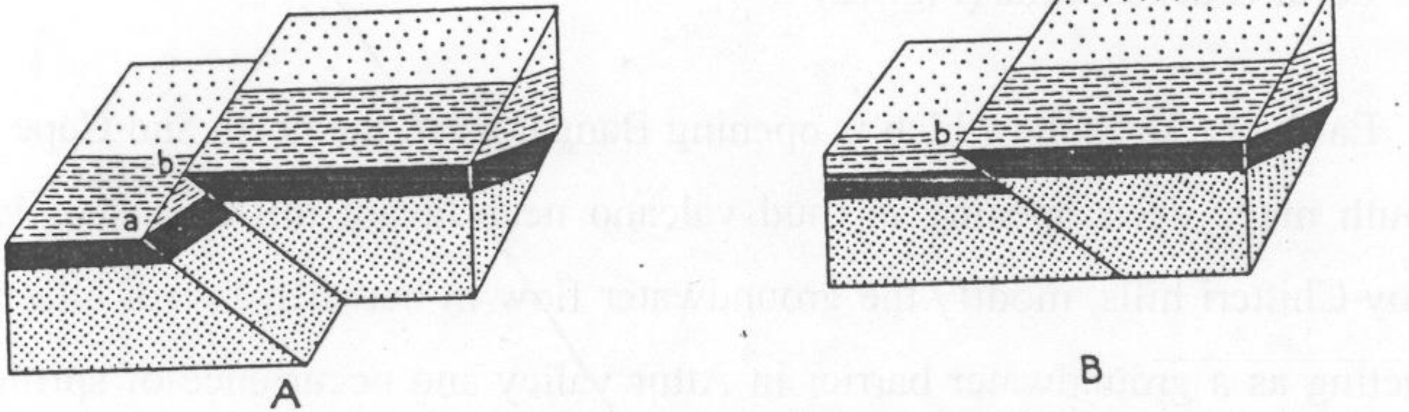
Apparent movement in vertical section equals net slip. (A) *ab* is the net slip, which in this case equals the dip slip. (B) After removal of top of hanging wall block.



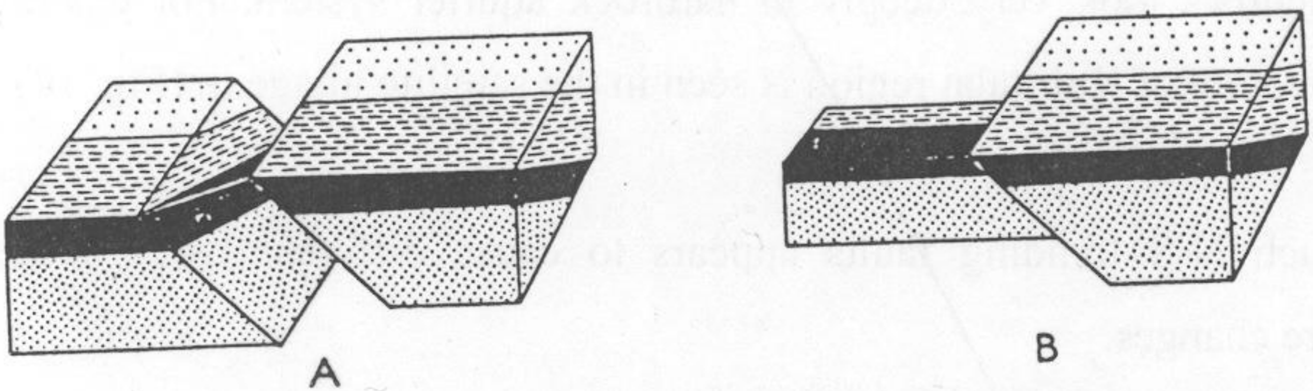
Fault is parallel to bedding, and hence there is no apparent movement. (A) *ab* is the net slip, which in thi: case equals the dip slip. (B) After removal of top of footwall block.



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.

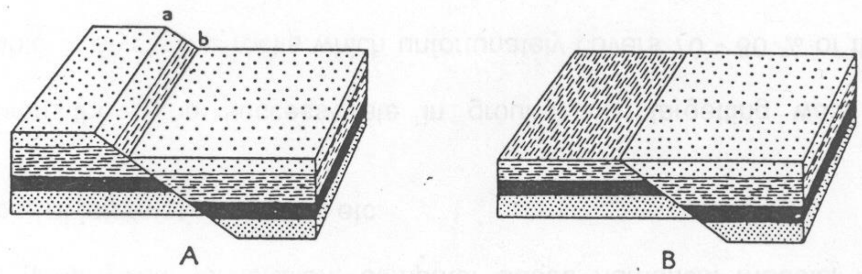


Apparent movement in a vertical section gives the erroneous impression that the hanging wall has gone up. (A) *ab* is the net slip, which in this case equals the strike slip. (B) After removal of front of footwall block. A left separation.

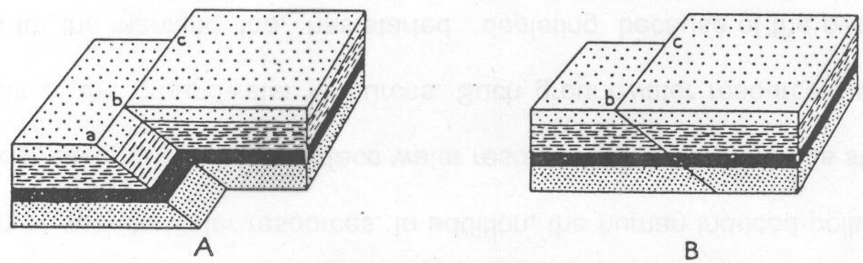


Apparent movement in vertical section is less than net slip. (A) *n* is the net slip. (B) After removal of top of footwall block.

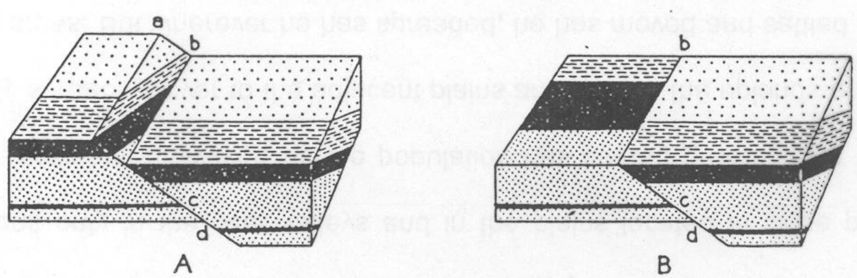
Effects on Disrupted Strata



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.



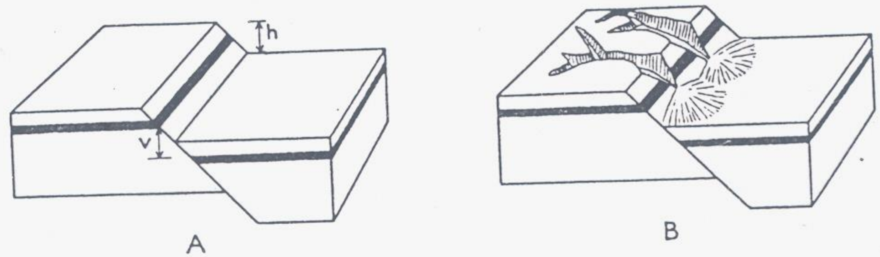
Apparent movement in a vertical section is zero. (A) *ab* is the net slip, which in this case equals the strike slip. (B) After removal of front of footwall block.



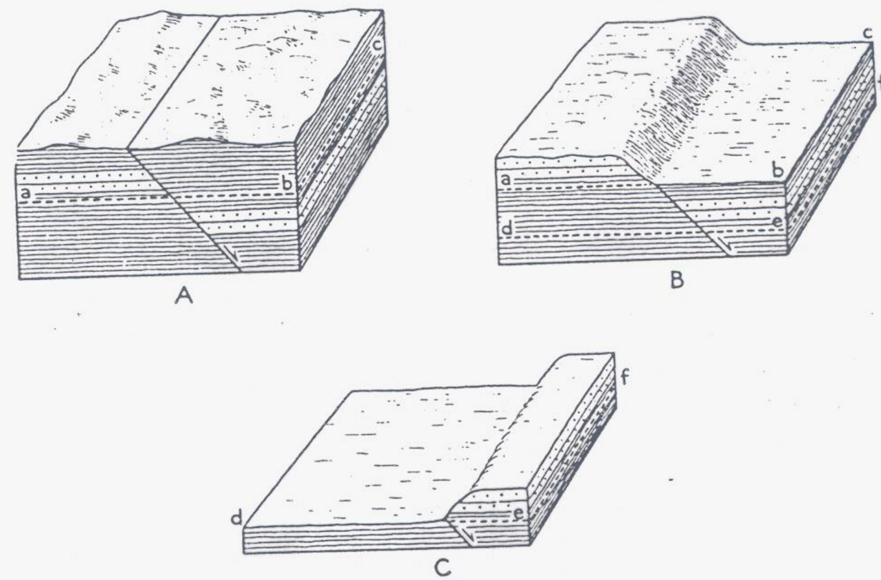
Apparent movement in vertical section equals the net slip. (A) *ab* is the net slip, which in this case equals the dip slip. (B) After erosion of top of footwall block. A right separation.

EVIDENCES OF FAULTS

Criteria for Faulting

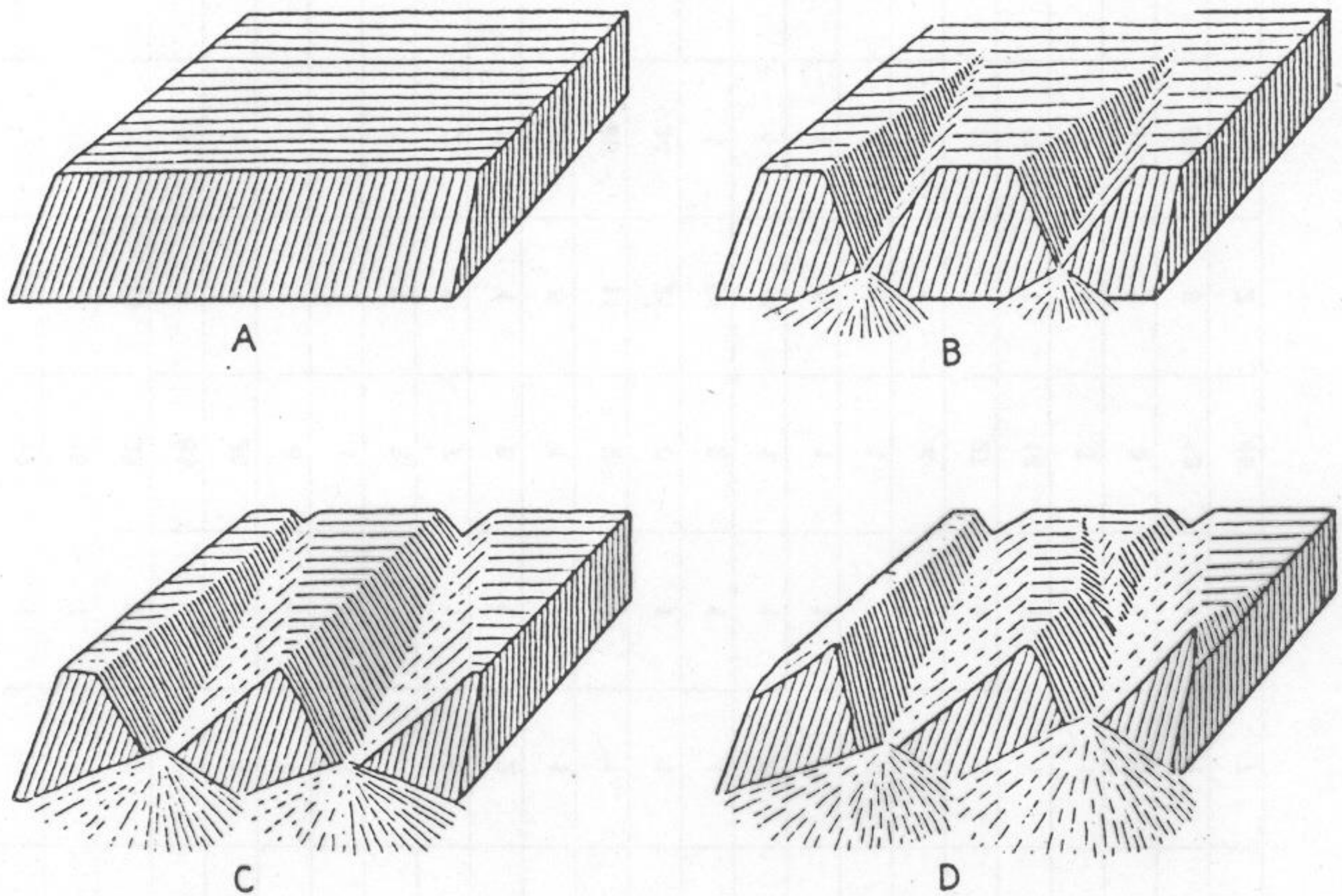


Fault scarp. (A) Before erosion; *h*, height of scarp, equals *v*, the vertical slip. (B) After some erosion the material removed from deep valleys on the footwall block has been deposited as alluvial fans on hanging-wall block.



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 down-dropped block.

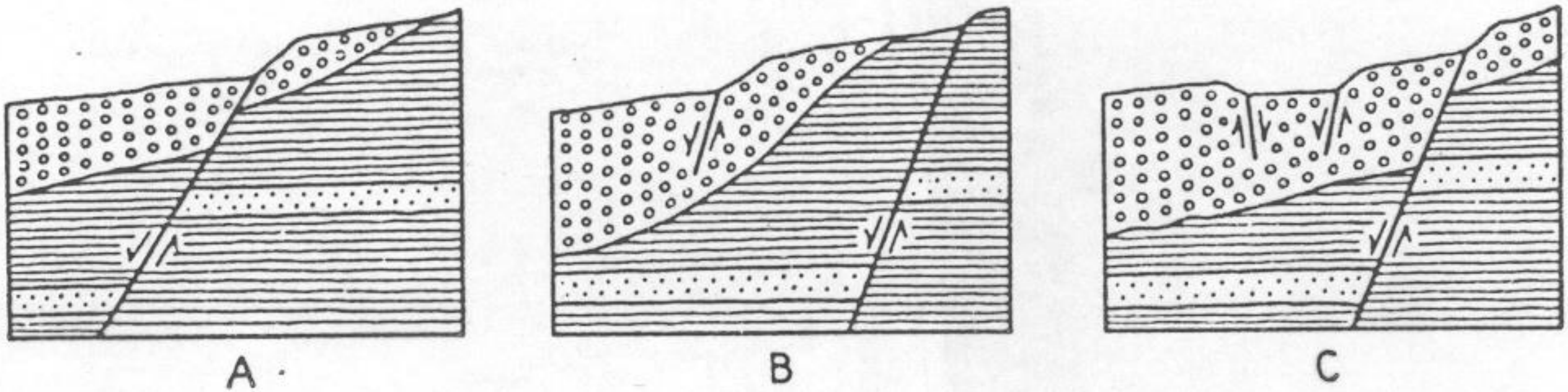
EVIDENCES OF FAULTS



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.

EVIDENCES OF FAULTS

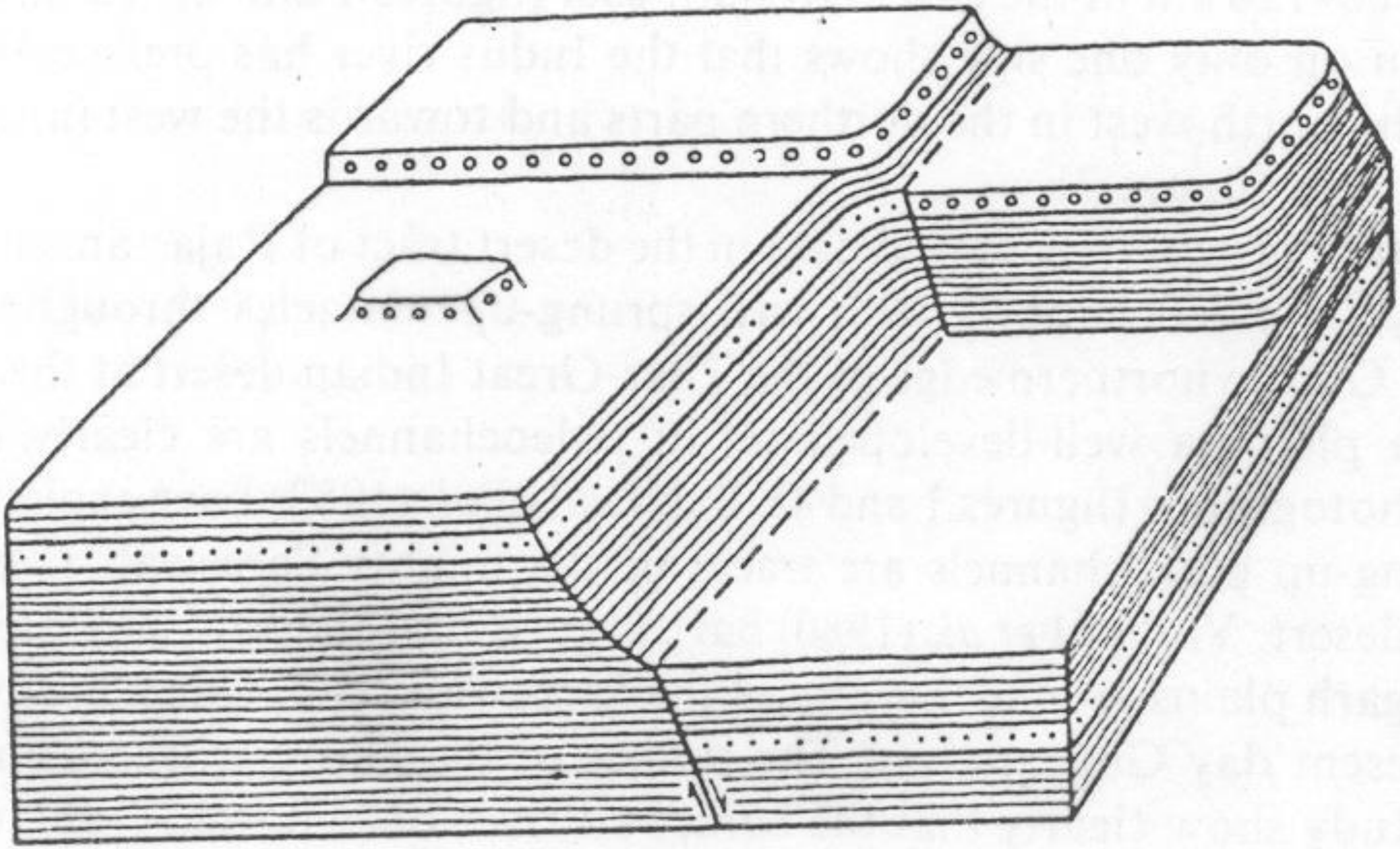
Physiographic Criteria



Scarplets or piedmont scarps. Dotted and lined patterns represent bedrock. Open circles represent unconsolidated material. (A) Scarplet that is a direct continuation of a fault in the bedrock. (B) Scarplet on right is direct continuation of fault in the bedrock, but scarplet on left is not. (C) Graben bounded by faults that do not extend into bedrock.

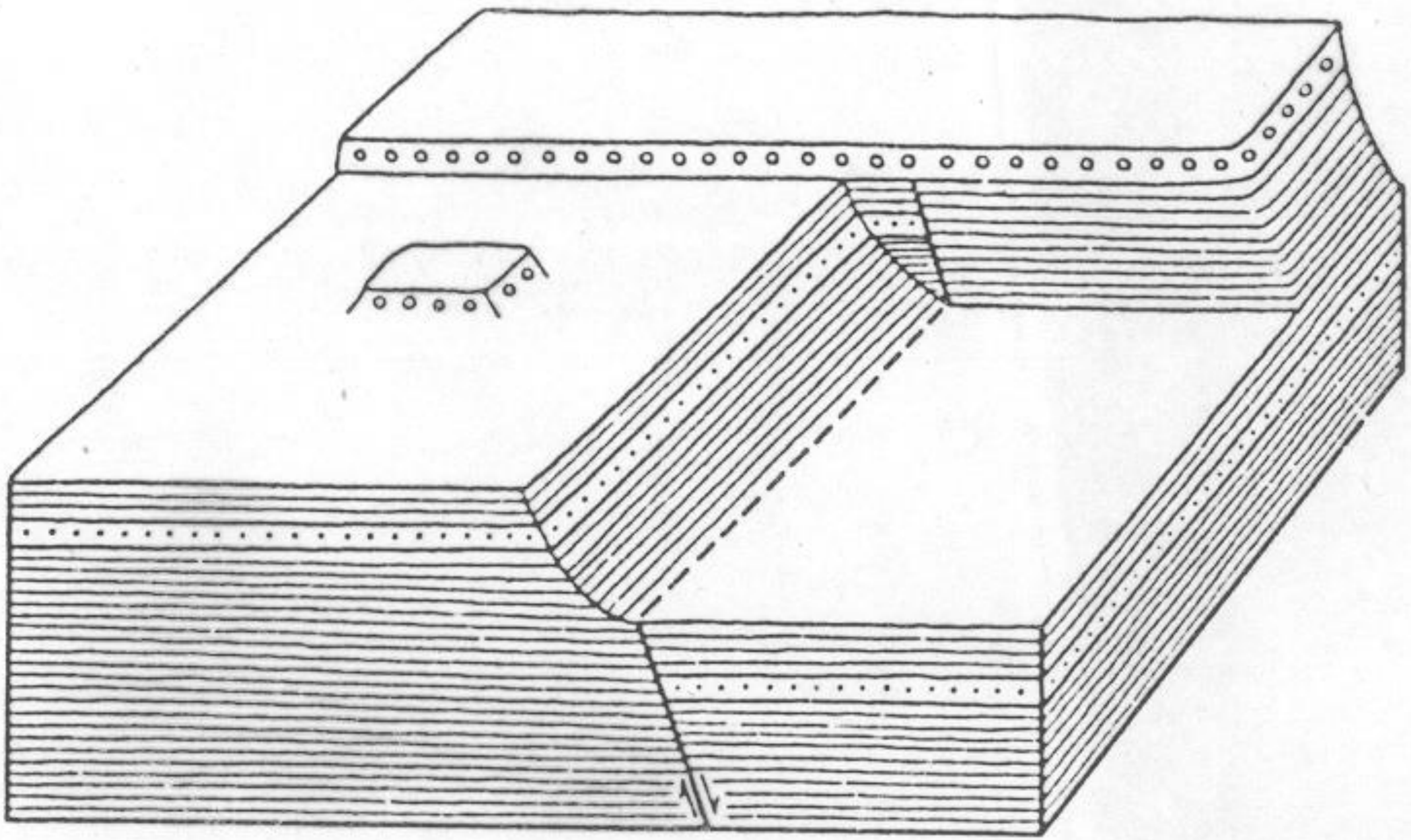
EVIDENCES OF FAULTS

Criteria for Faulting



Composite fault scarp. Dots represent sandstone; parallel lines, shale; circles, conglomerate. (See text.)

EVIDENCES OF FAULTS



Fault-line scarp. Dots represent sandstone; parallel lines, shale; circles, conglomerate. (See text.)

JOINTS

Most rocks are broken by Relatively smooth fractures known as joints.

They are very closely spaced with a spacing of inches or fractions of inches

In British coal field they thought that the rocks joining along the fracture just as the bricks are put together in the wall.

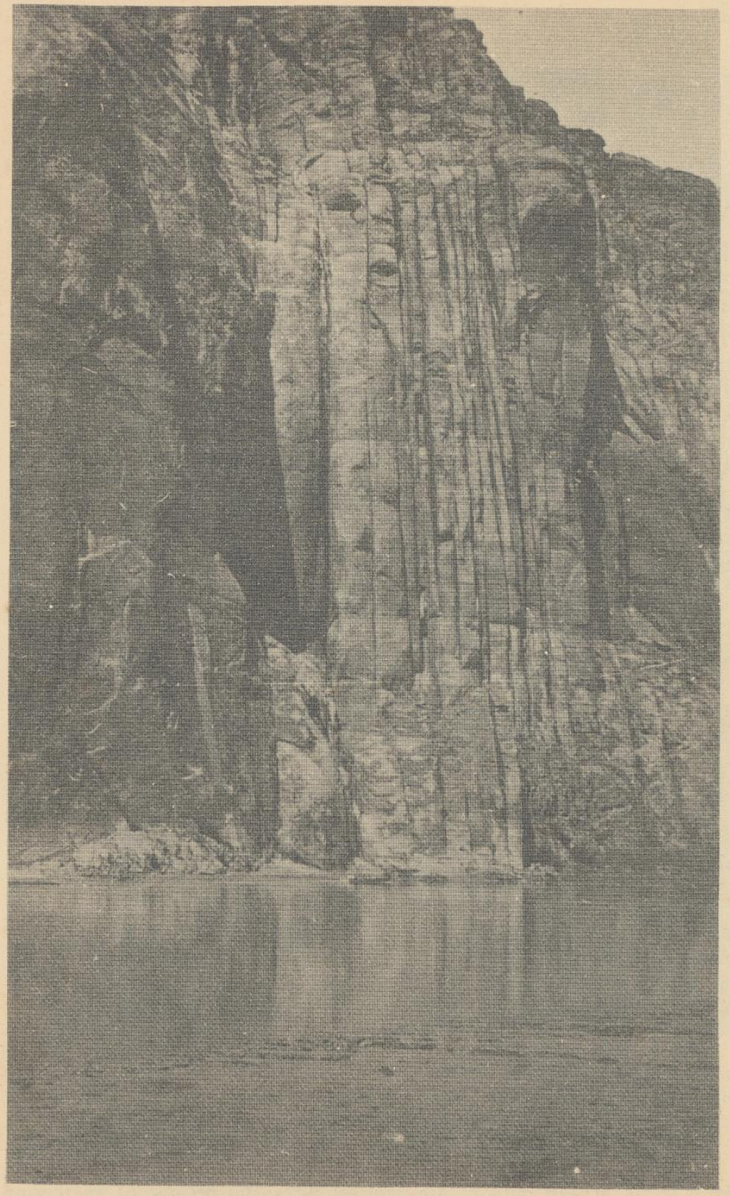


Plate 15. *Vertical joints.* At dam site at Lees Ferry, Coconimo County, Arizona. Photo: E. C. LaRue, U. S. Geological Survey.

Plate 16. *Joints.* Vertical joint planes in Portage Formation. Tompkins County, New York. Photo: E. M. Kindle, U. S. Geological Survey.

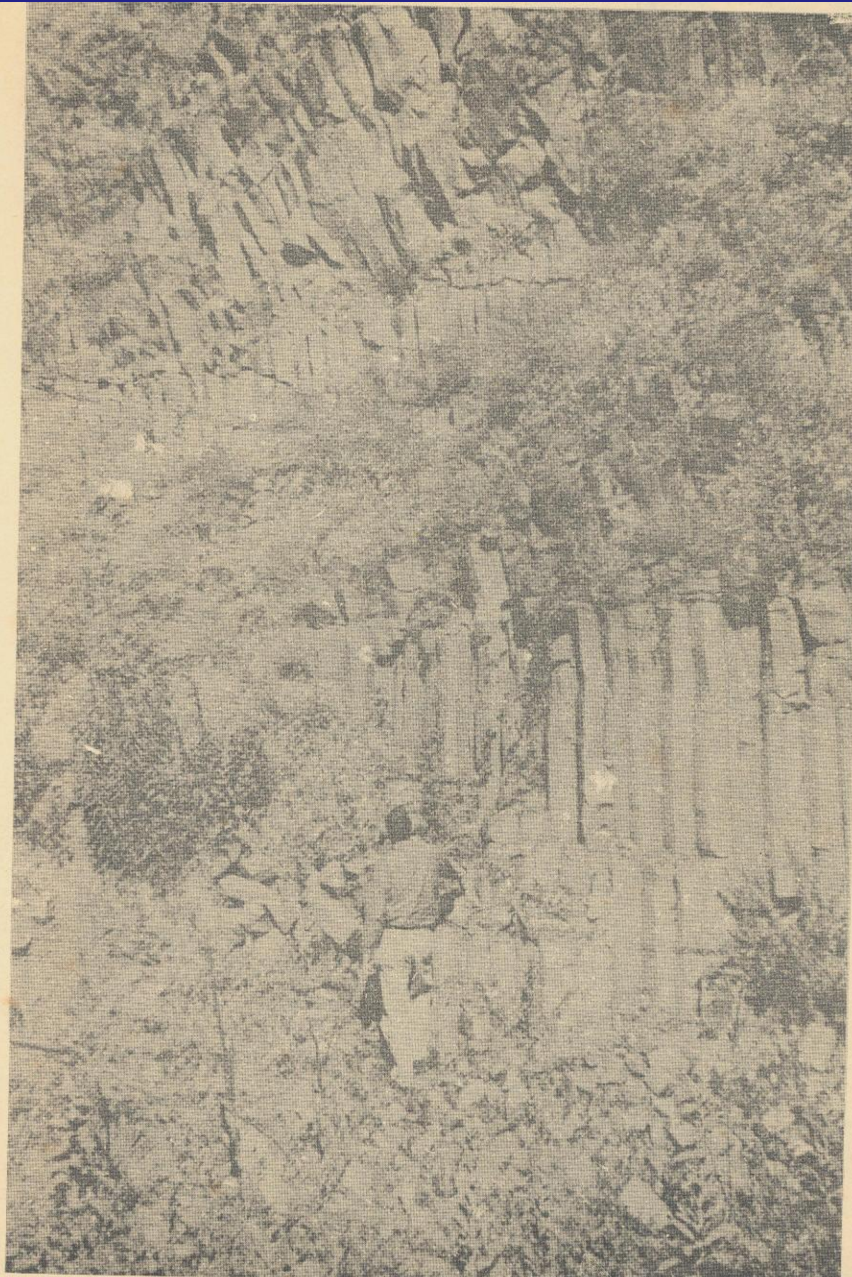


Plate 17. *A columnar jointing.* Columbia River Basalt near Race Creek, Riggins Quadrangle, Idaho. Photo: W. B. Hamilton, U. S. Geological Survey.

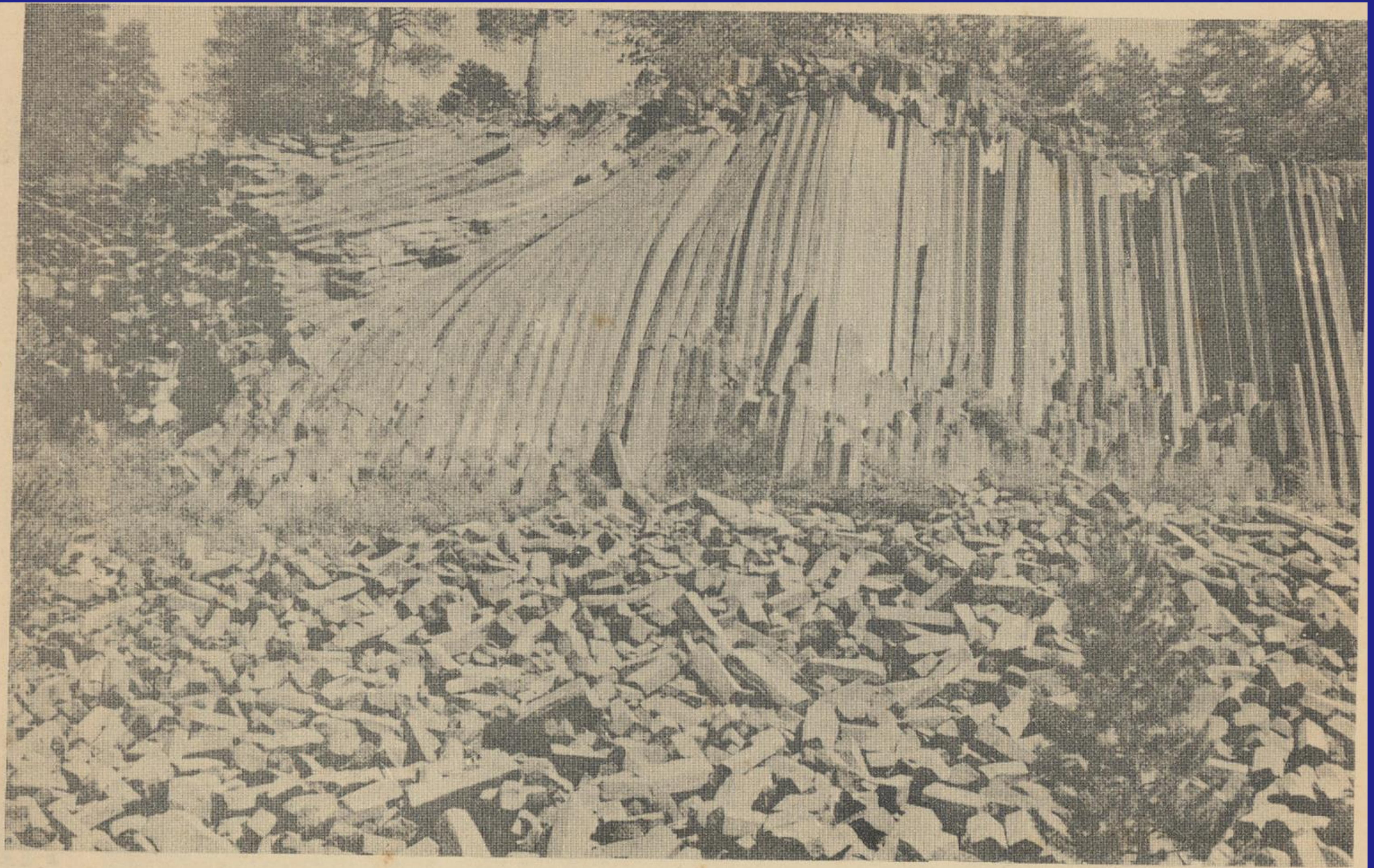


Plate 17B. *A columnar jointing.* Basalt flow. Devil Postpile National Monument. Madera County, California. Photo: H. R. Cornwall, U. S. Geological Survey.

DIMENTIONS/ CHARACTERS

Lengths: few feet to hundreds of feet
Intervals: feet to tens of feet.

- No relative movements
- If movement is perpendicular to the joint plane the joint is open fissure.
- Generally they are very tight but due to weathering it gets opened up.
- In general they are smooth planes.

USEFULLNESS:

- In quarry operations
- Engineering projects
- In High way project
- Ground water prospecting
- To determine the forces acted in the region.

ATTITUDE:

- Horizontal, vertical and inclined
- It has got the strike and dip.

CLASSIFICATION:

- Geometrical
- Genetic

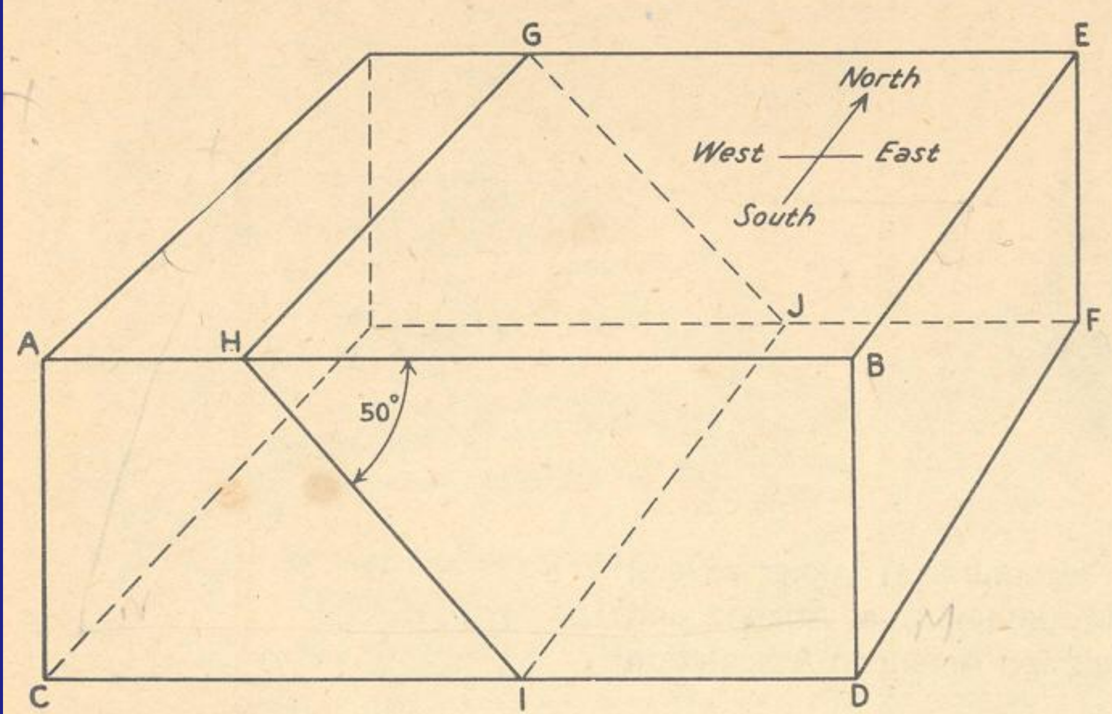


Fig. 7-2. Attitude of joints. Plane *ABCD* represents a vertical joint that strikes east-west; plane *BDEF* represents a vertical joint that strikes north-south; plane *GHIJ* represents a joint that strikes north-south and dips 50° east.

Geometrical classification

On the basis of their attitude to the bedding or similar structures.

- Strike joint
- Dip joint
- Oblique / diagonal joint
- Bedding joint

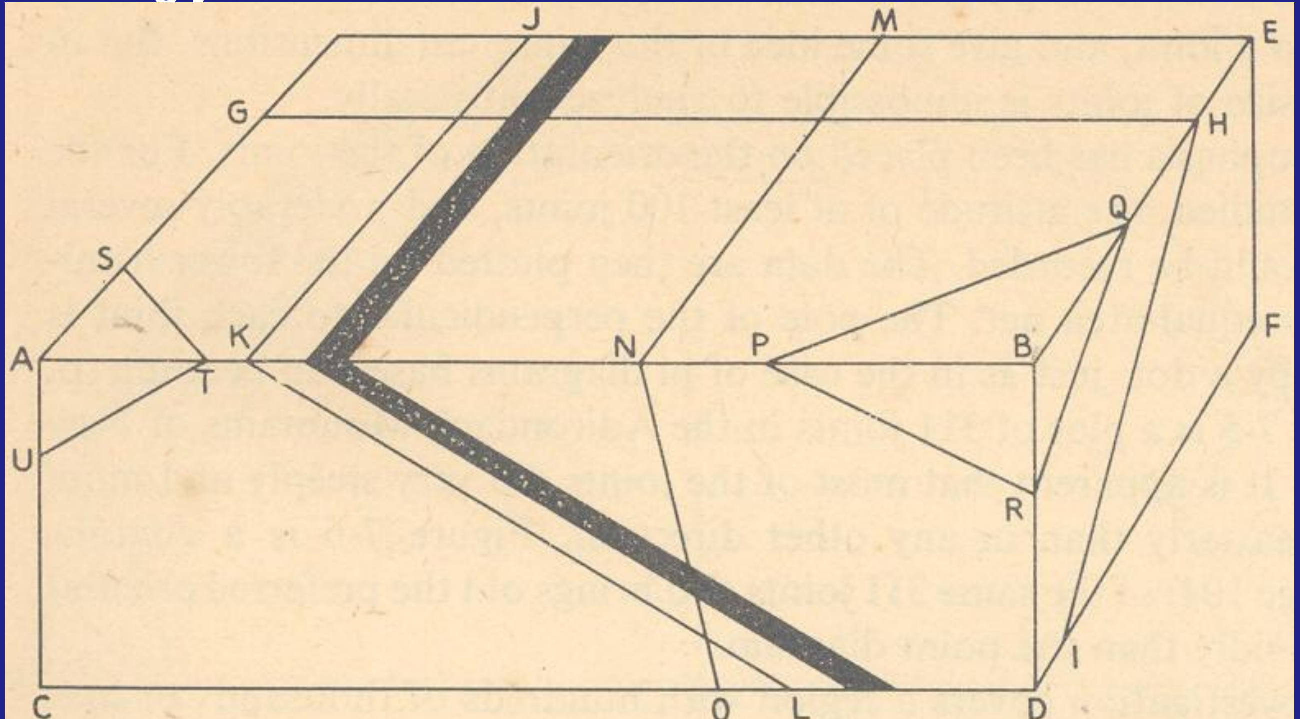


Fig. 7-4. Geometrical classification of joints. Heavy black layer is a bed. *ABCD* and *GHI* are dip joints; *BDEF* and *MNO* are strike joints. *JKL* is a bedding joint. *PQR* and *STU* are diagonal joints.

Geometrical classification Conti……….

On the basis of its numbers / quantities

- **Joint sets (Parallel joints)**
- **Joint system (two or more with different orientation)**

(in some cases with one orientation but varying dips eg. N-S/30,50,80 degree)

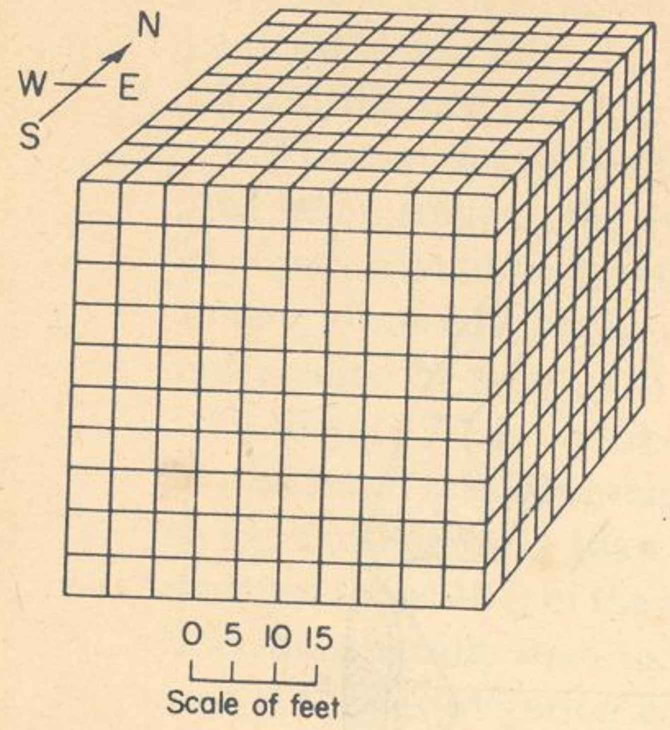


Fig. 7-7. Block with three sets of joints. Demonstrates importance of attitude of surface on which sets are seen.

GENESIS OF JOINTS:

The causes may be several

- **Tectonic stress** – Causing fracturing essentially contemporaneous with the tectonic activity
- **Residual stress** -- Due to events that happened long before the fracturing.
- **Contraction** -- due to shrinkage because of cooling or desiccation
- **Surfacial movements** – such as downhill movements of rocks or mountain glaciers.

TYPES OF JOINTS:

i) Tectonic

- Extension joints
- Release Joints
- Shear joints

ii) Residual stress:

- Sheeting joints
- Exfoliation joints

iii) Contraction:

- Columnar joints
- Mud cracks

iv) Surfacial movements :

- Landslide and related cracks

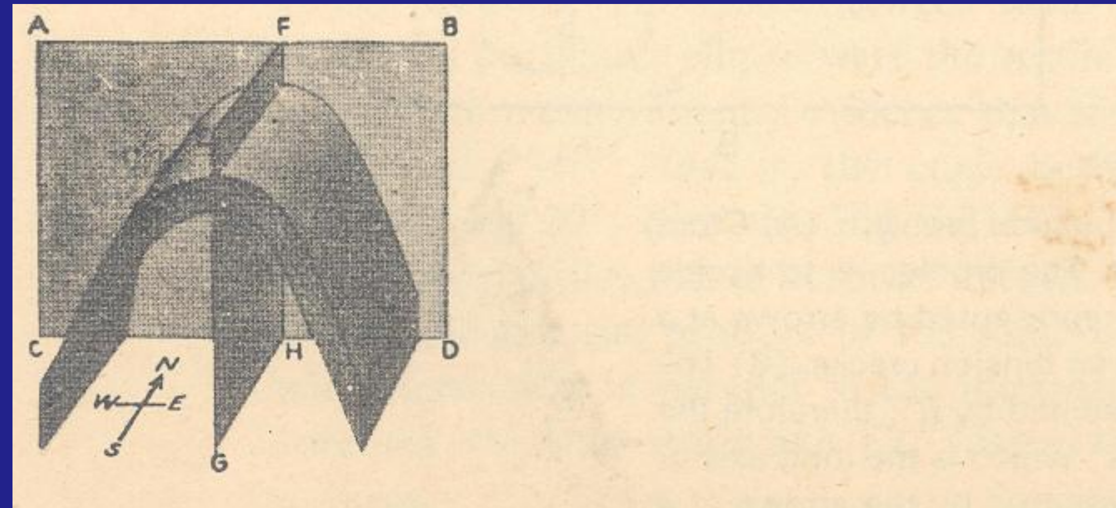


Fig. 7-25. Fold with vertical dip joint and vertical strike joint. *ABCD*, vertical dip joint. *EFGH*, vertical strike joint.

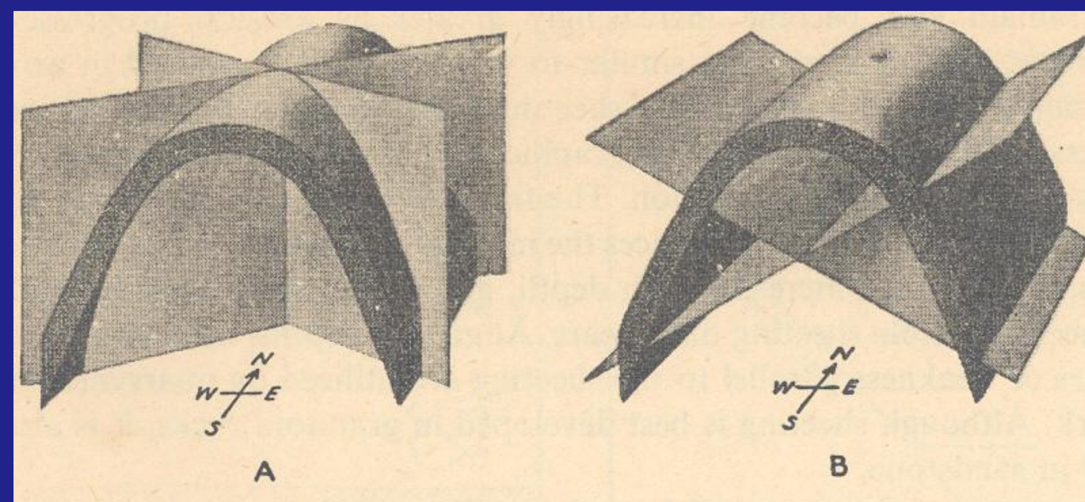


Fig. 7-26. Folds with conjugate joint systems. (A) Fold with vertical diagonal joints. (B) Fold with strike joints dipping about 30°.

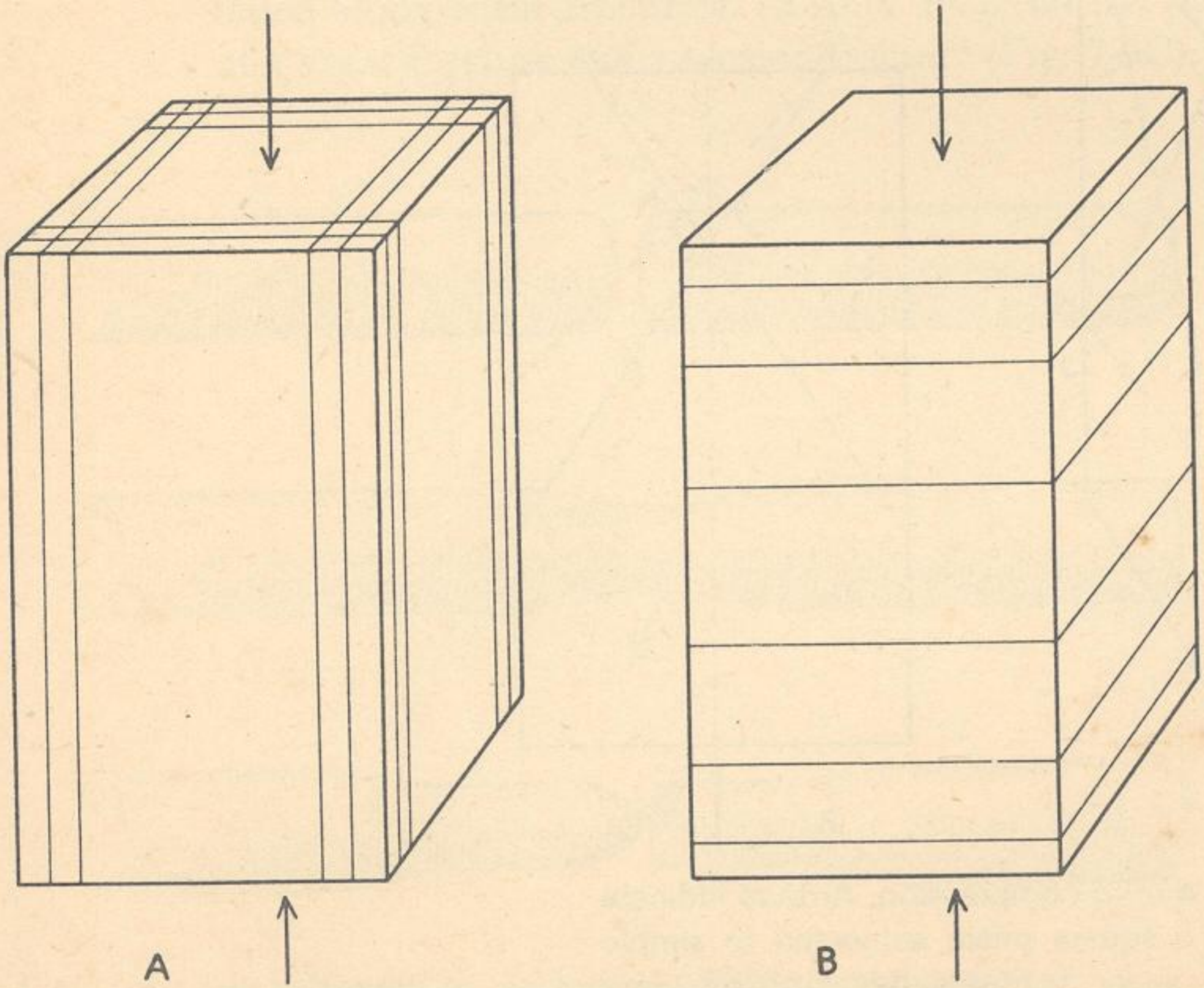


Fig. 7-11. Extension fractures and release fractures due to compression. Arrows indicate compressive force. (A) Extension fractures form parallel to sides of the prism. (B) Release fractures form parallel to top of prism.

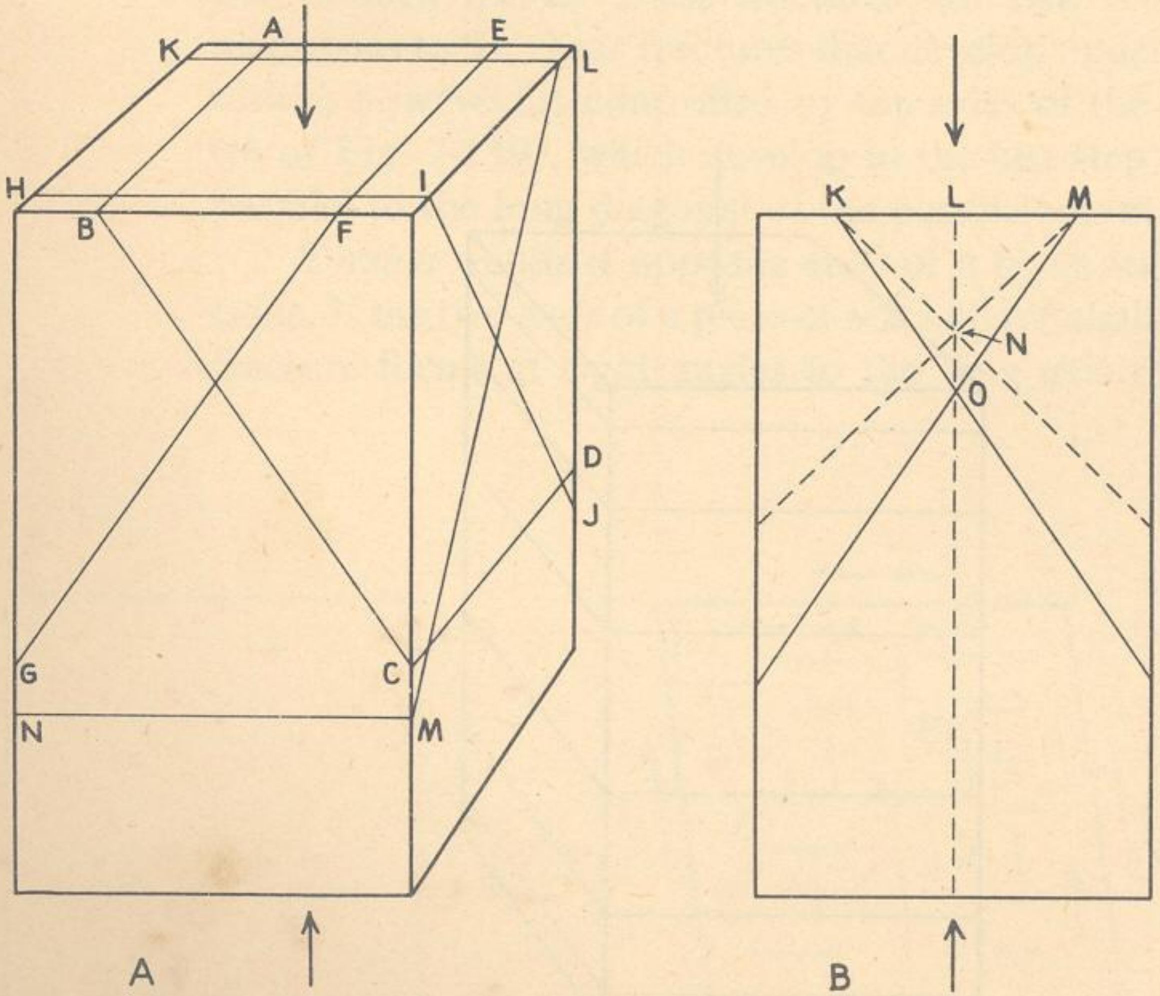


Fig. 7-10. Shear fractures due to compression. Arrows indicate compressive force. (A) In a square prism subjected to simple compression, four sets of shear fractures develop; they are parallel to the planes *ABCD, EFG, HIJ,* and *KLMN*. (B) *KN* and *MN* represent planes of maximum shearing stress deduced mathematically; *KO* and *MO* represent approximate position of shear fractures that form in experiments.

REMOTE SENSING FOR LINEAMENT ANALYSIS

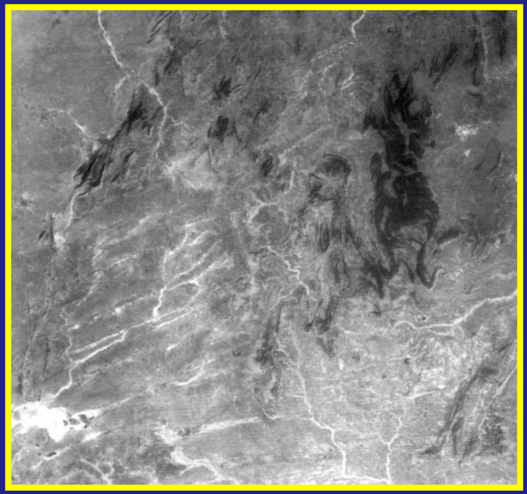
CREDIBILITY OF REMOTE SENSING

- SYNOPTIVITY
- MULTI SPECTRAL NATURE
- REPETIVITY

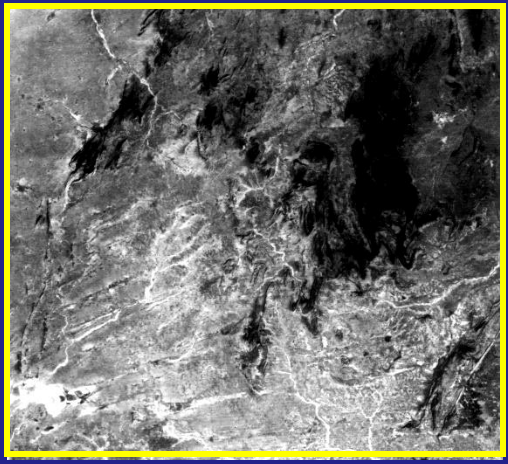
SOUTH INDIA MOSAIC

MULTISPECTRAL IMAGE

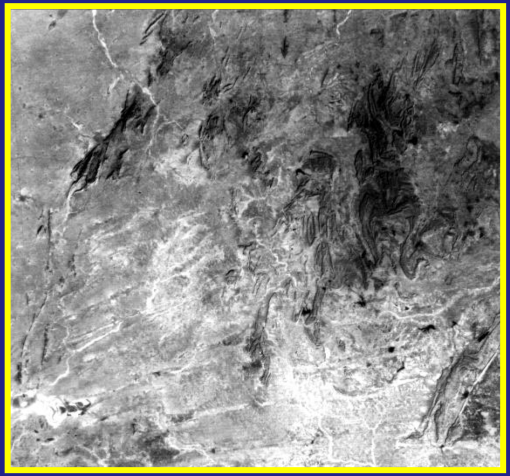
MSS 4



MSS 5



MSS 6



MSS 7

RECOGNITION OF FAULTS THROUGH REMOTE SENSING

- Linear feature in terrain
- Abrupt end of hills
- Juxta position of terrain of contrasting elevation
- Abrupt end of lithologies
- Abrupt end of folded structures
- Striking contrast in the intensity of weathering & degree of denudation
- Occurrences of older & younger tectonic land forms on either side of lineaments
- Contrast drainage density on either side.

Drainage anomalies like straightness

Sudden loss or emergence of drainage

Straightness in shore line

Occurrence of mass wasting phenomenon in desert

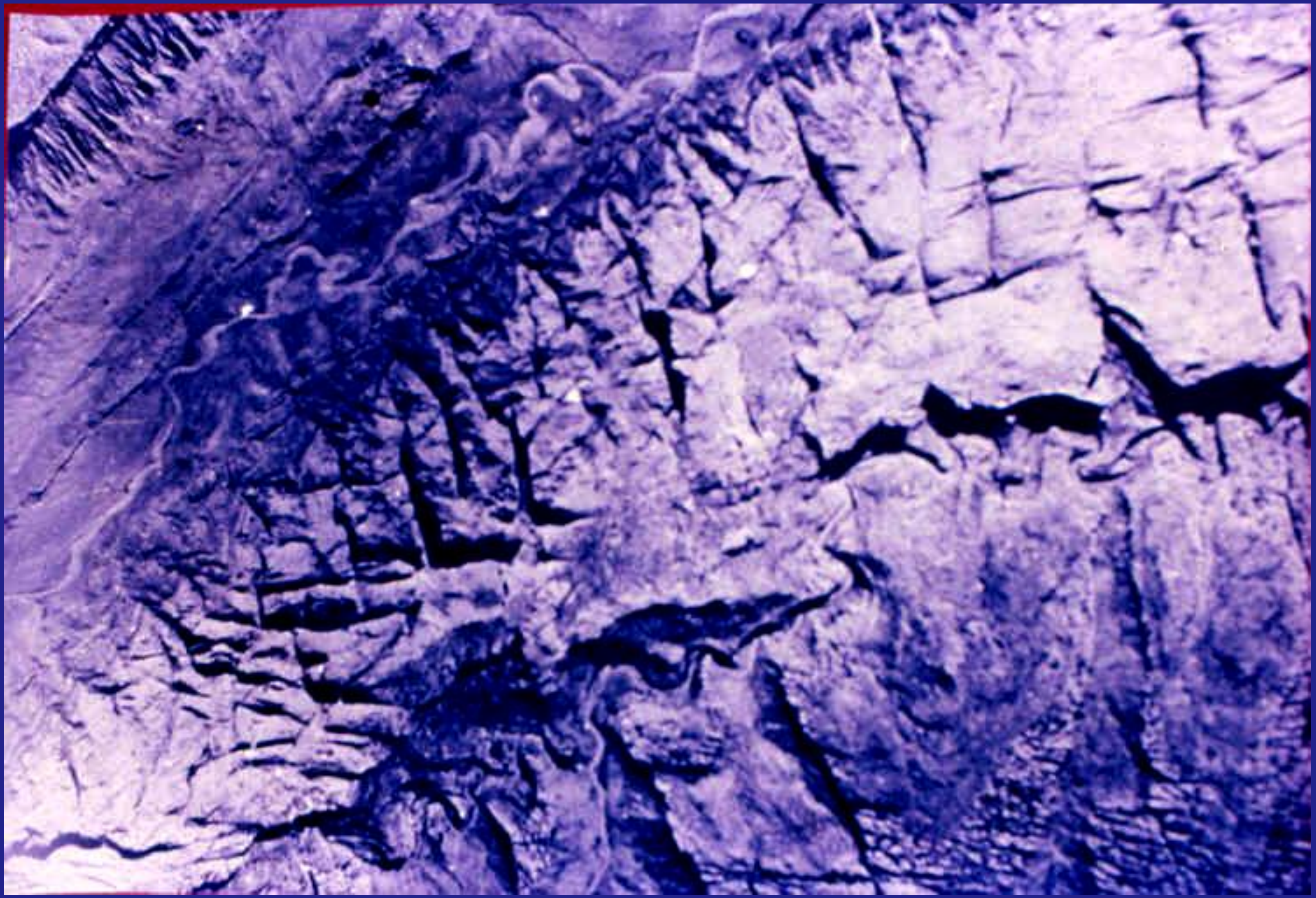
Occurrence of mineralisation along a lineament

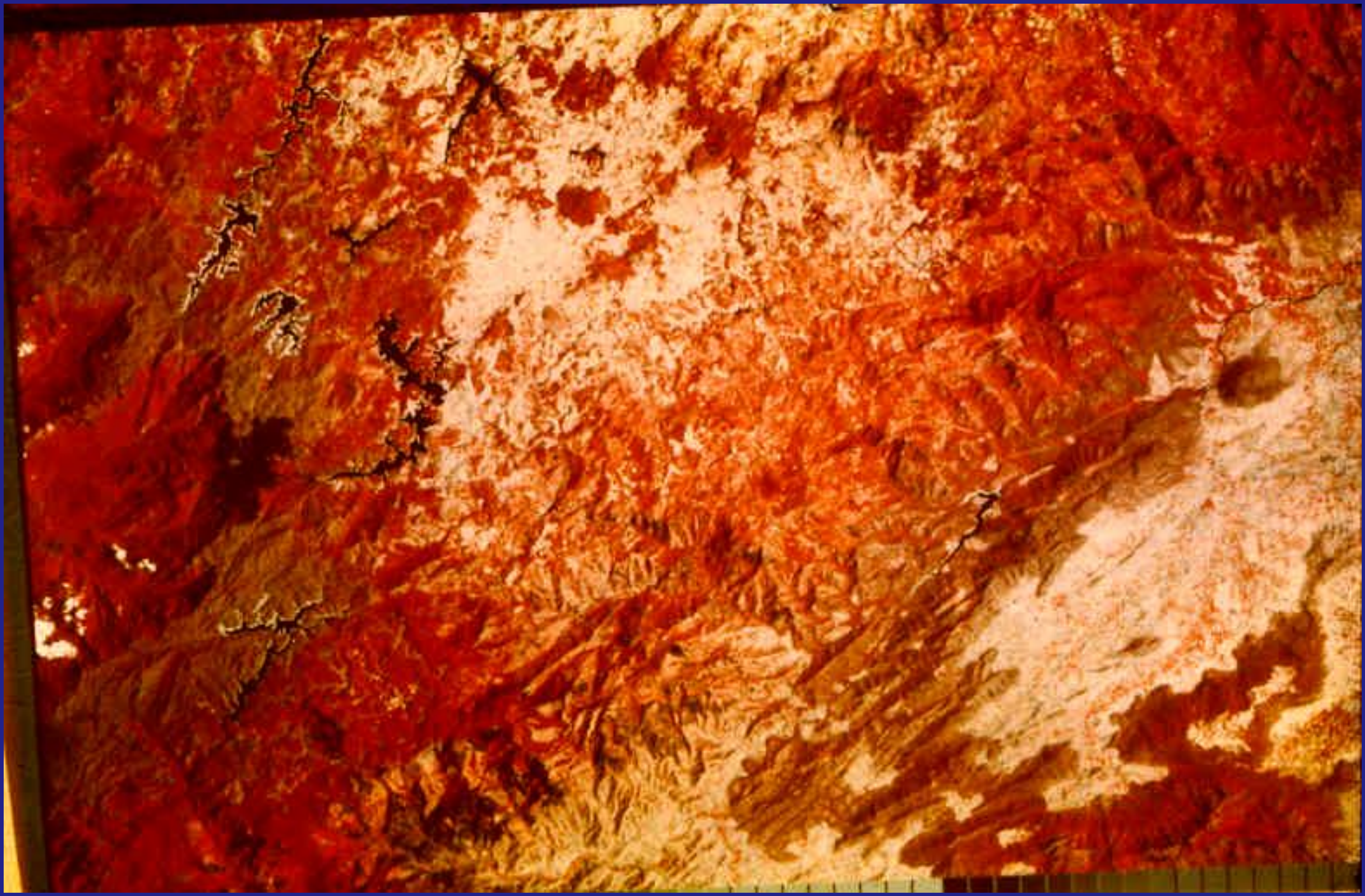
Occurrence of high yield wells along a lineament

Occurrence of hot springs along a lineament

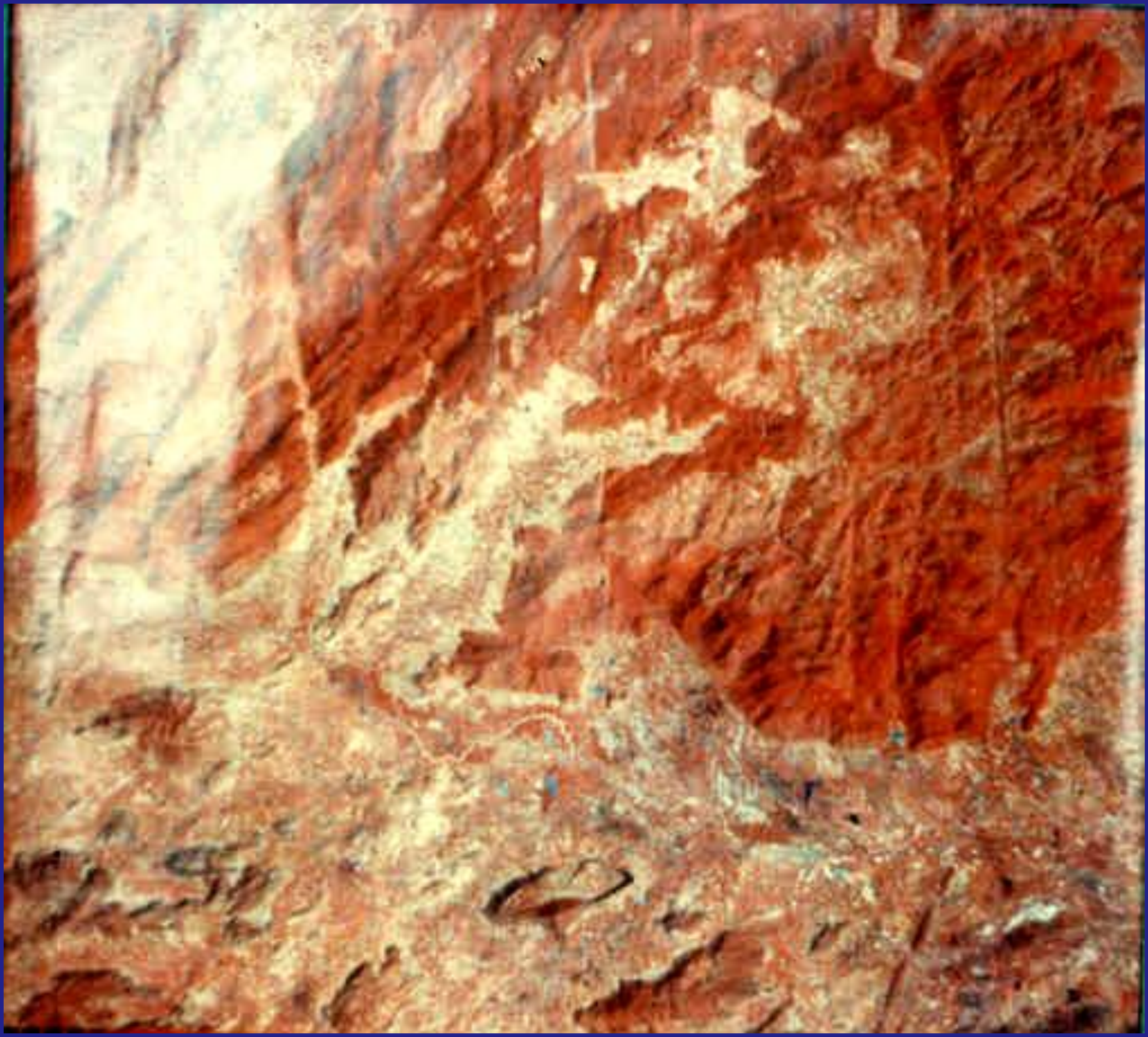
Occurrence of seismic epicenter along a lineament

Occurrence of plutonic bodies along a lineament.

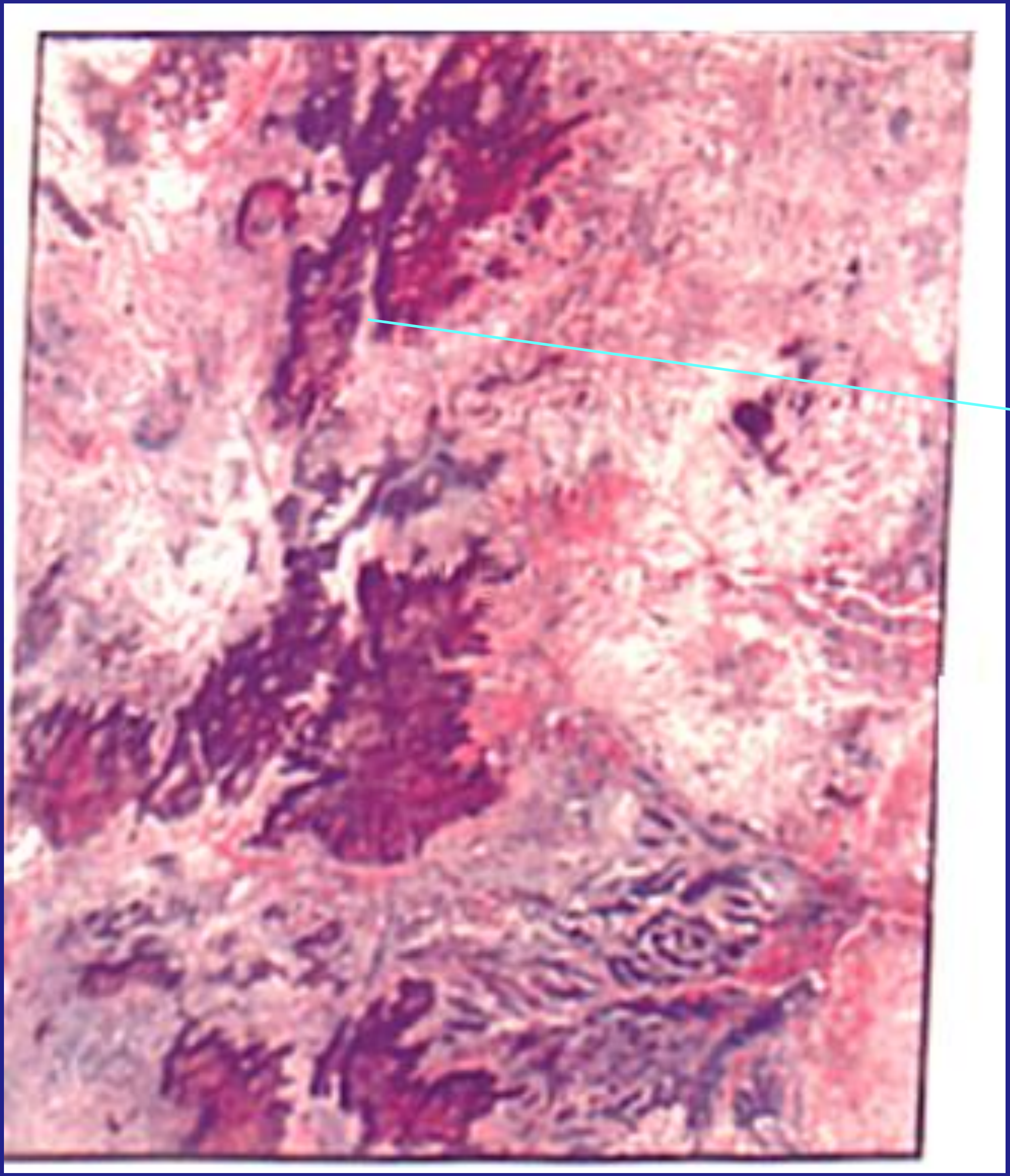




SPOT FCC –LINEAMENTS OF STANLEY RESERVOIR AREA

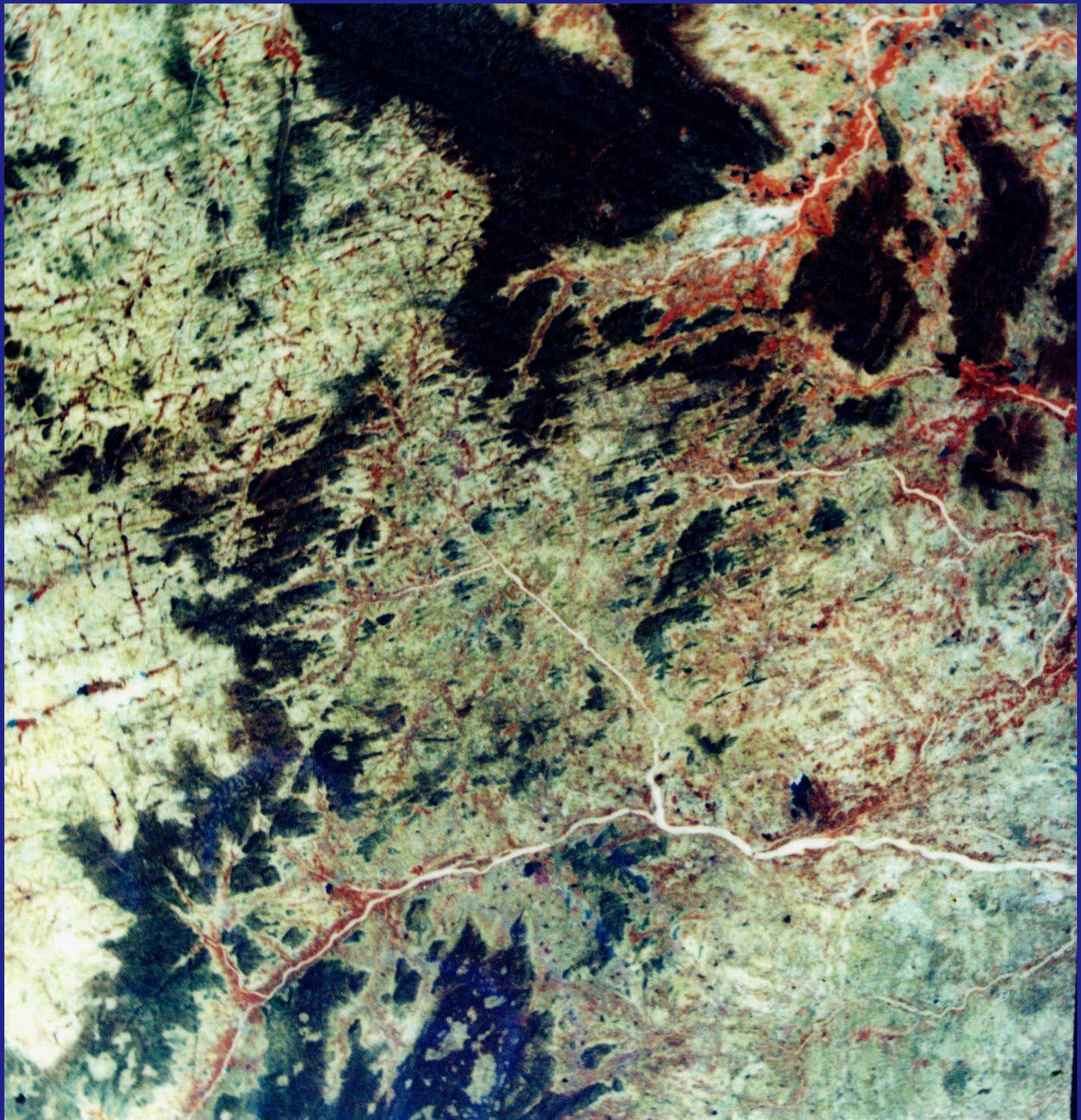


Salem Area



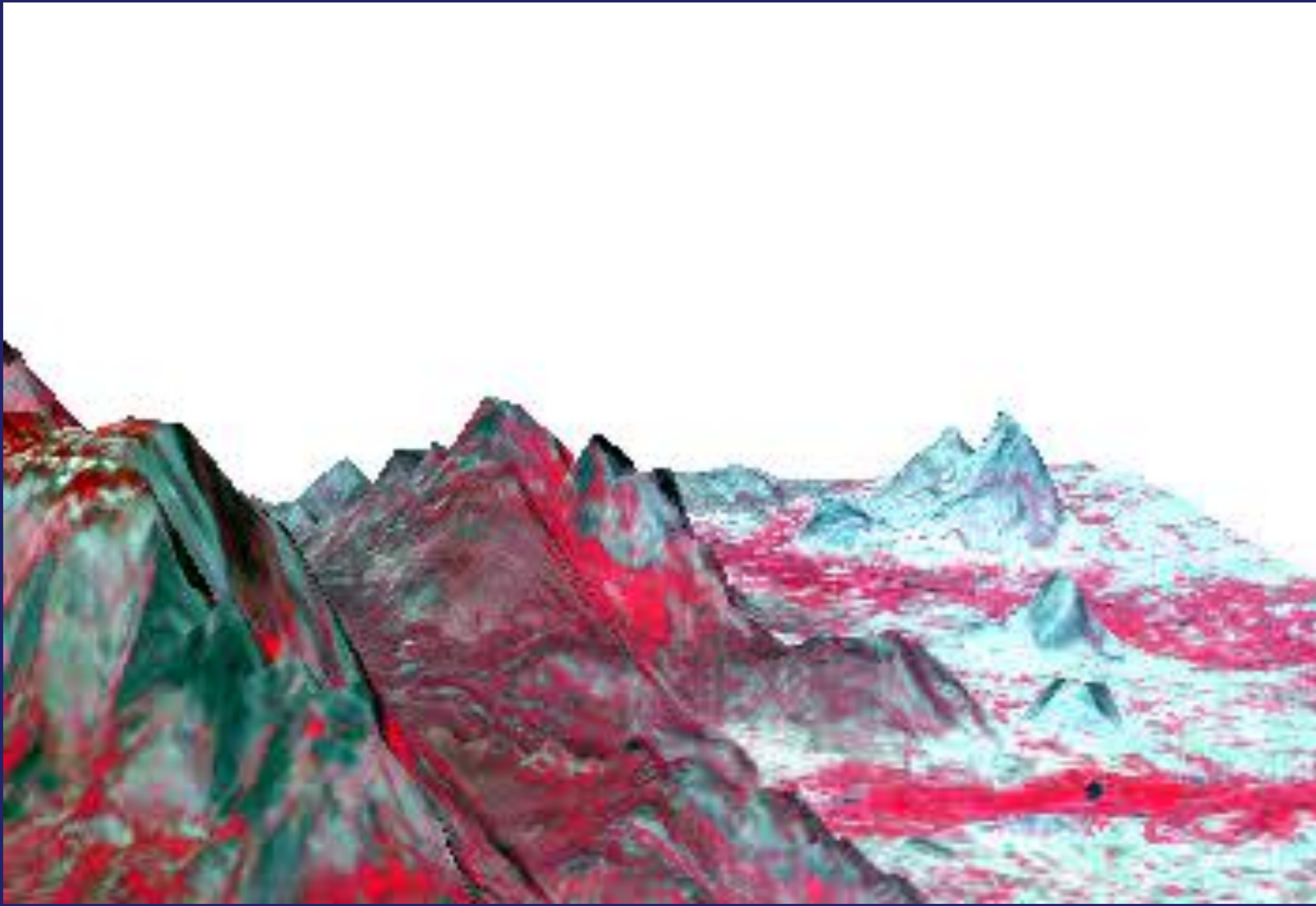
N-S Faults

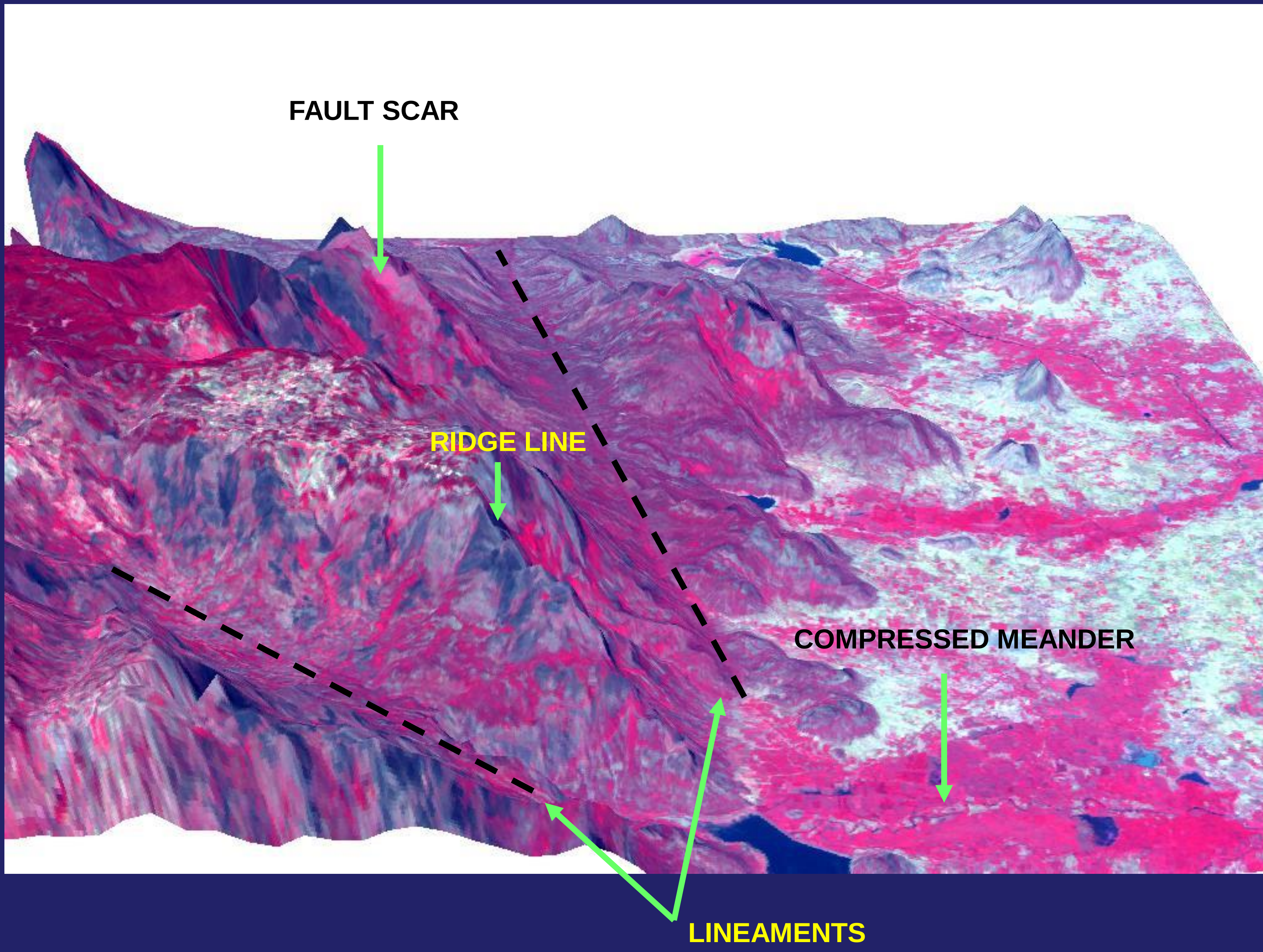
Tiruthani EW fractures

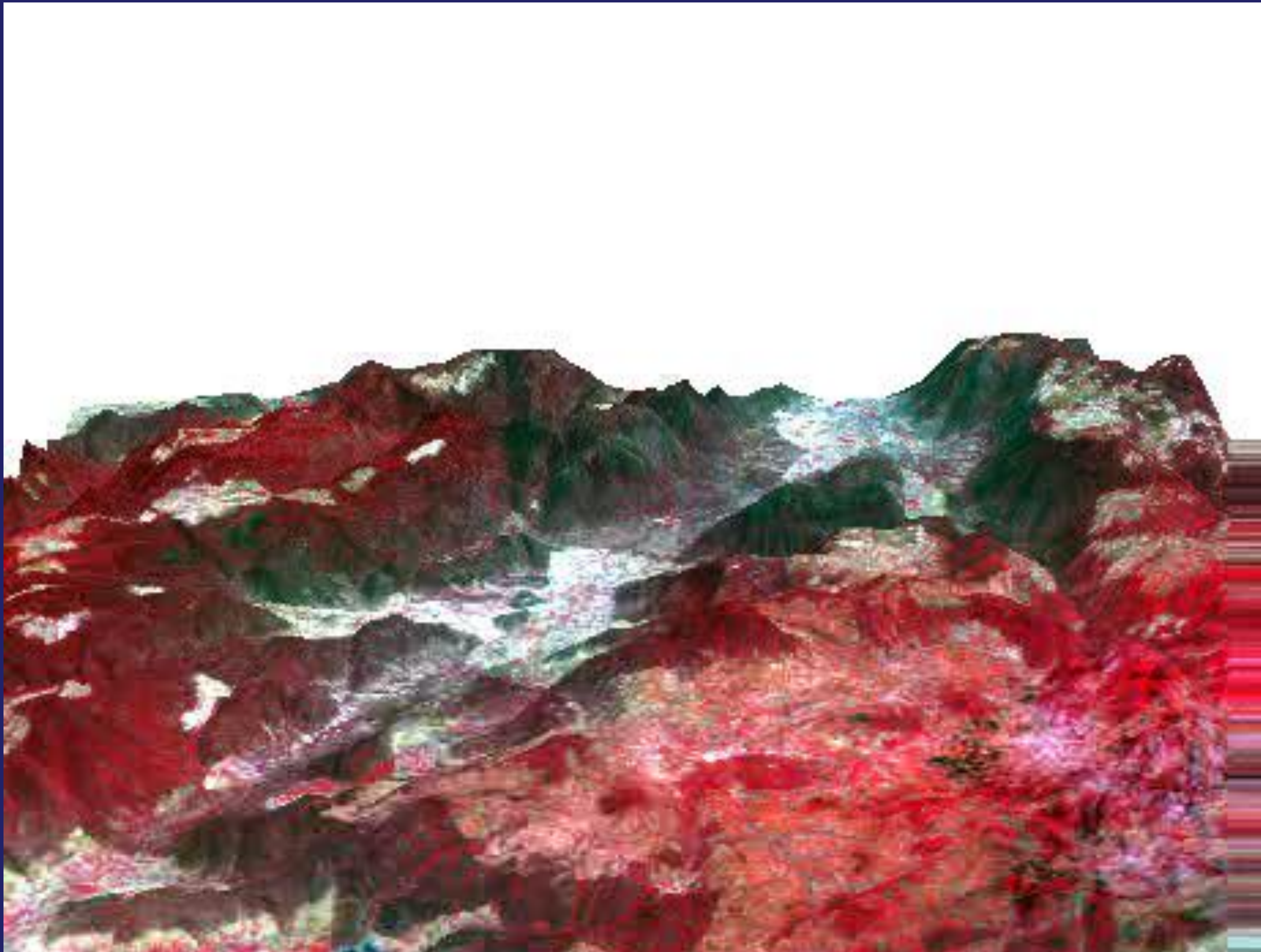


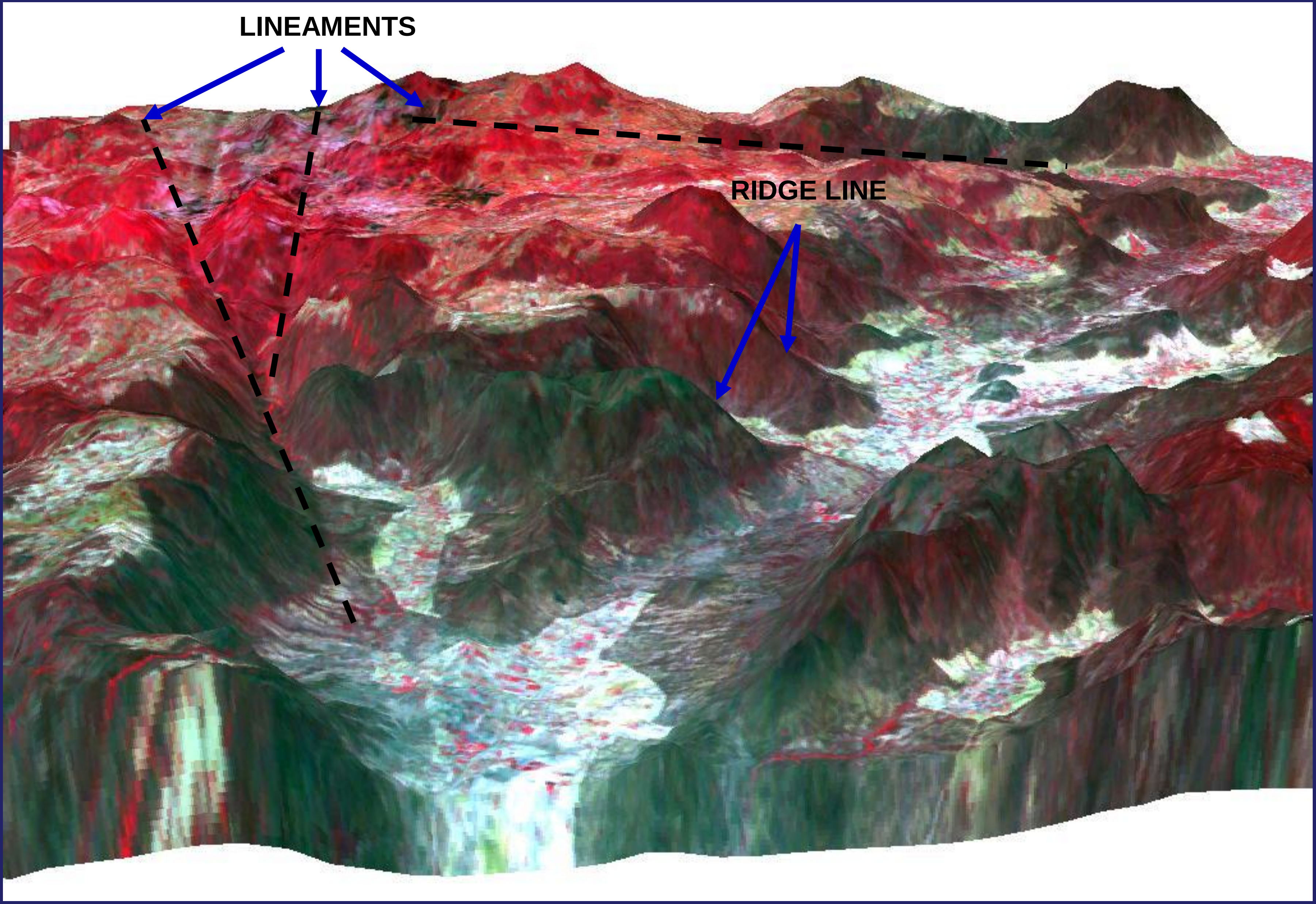
FAULT SCAR - SAN ANDREAS FAULT

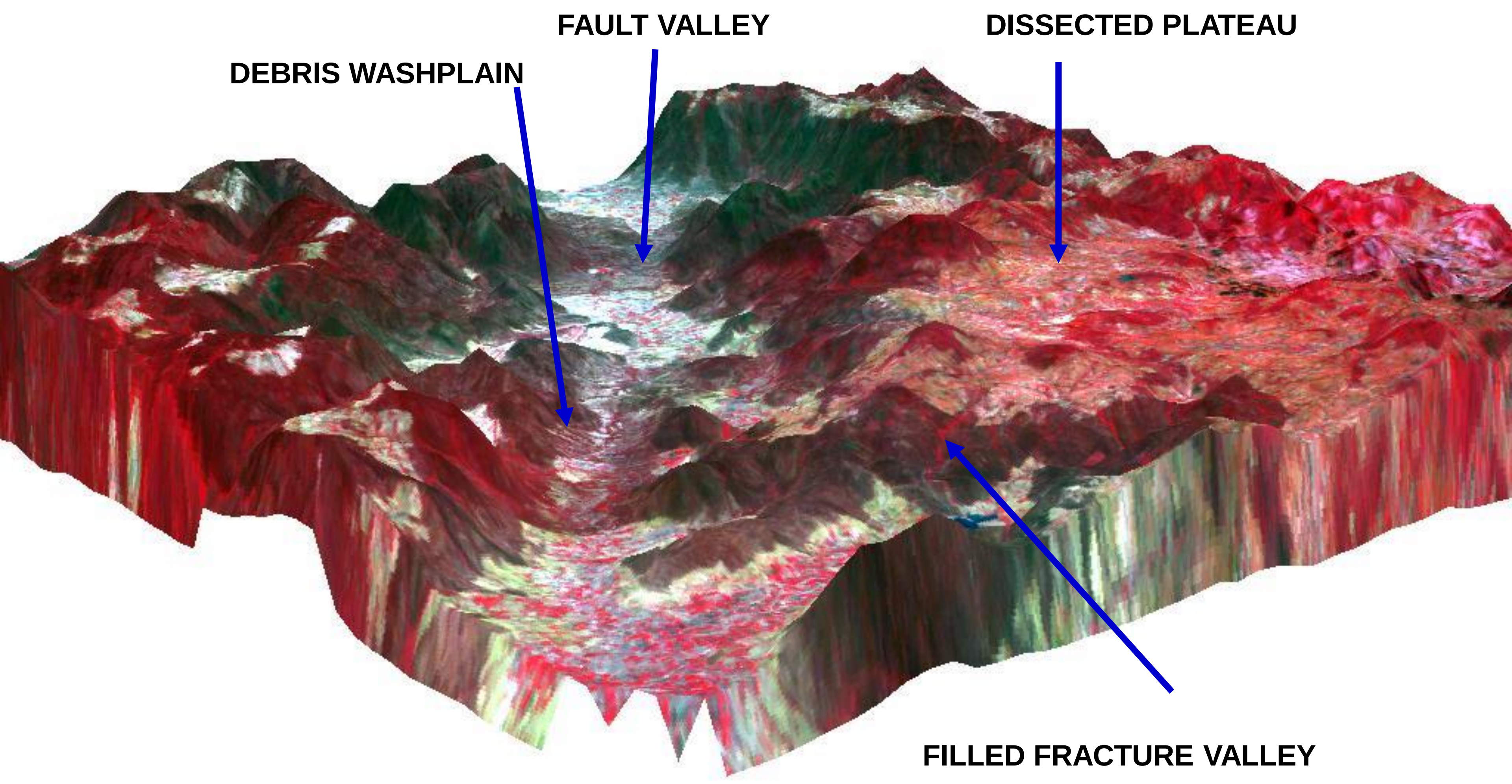
Regional Lineament Studies



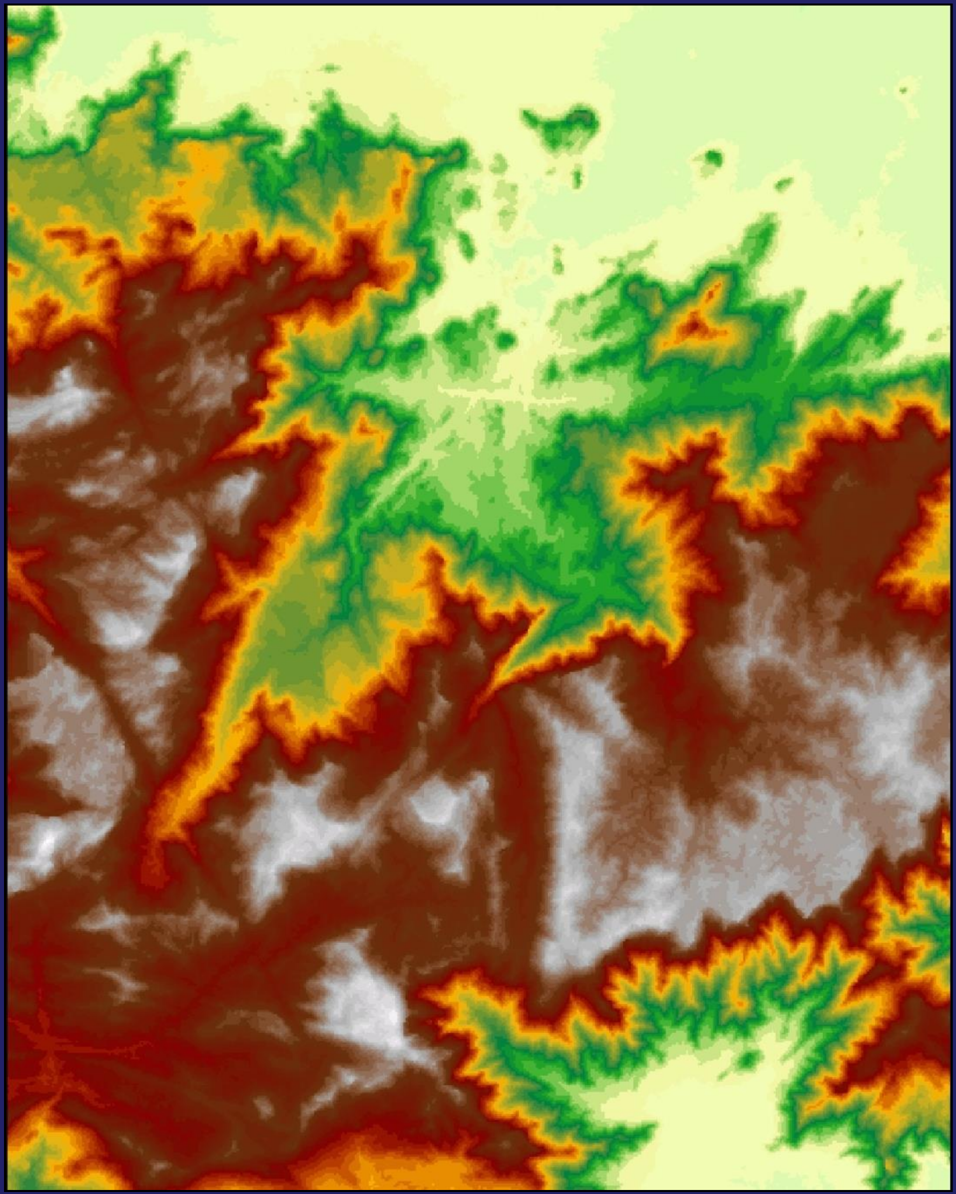

FAULT SCAR
RIDGE LINE
COMPRESSED MEANDER
LINEAMENTS

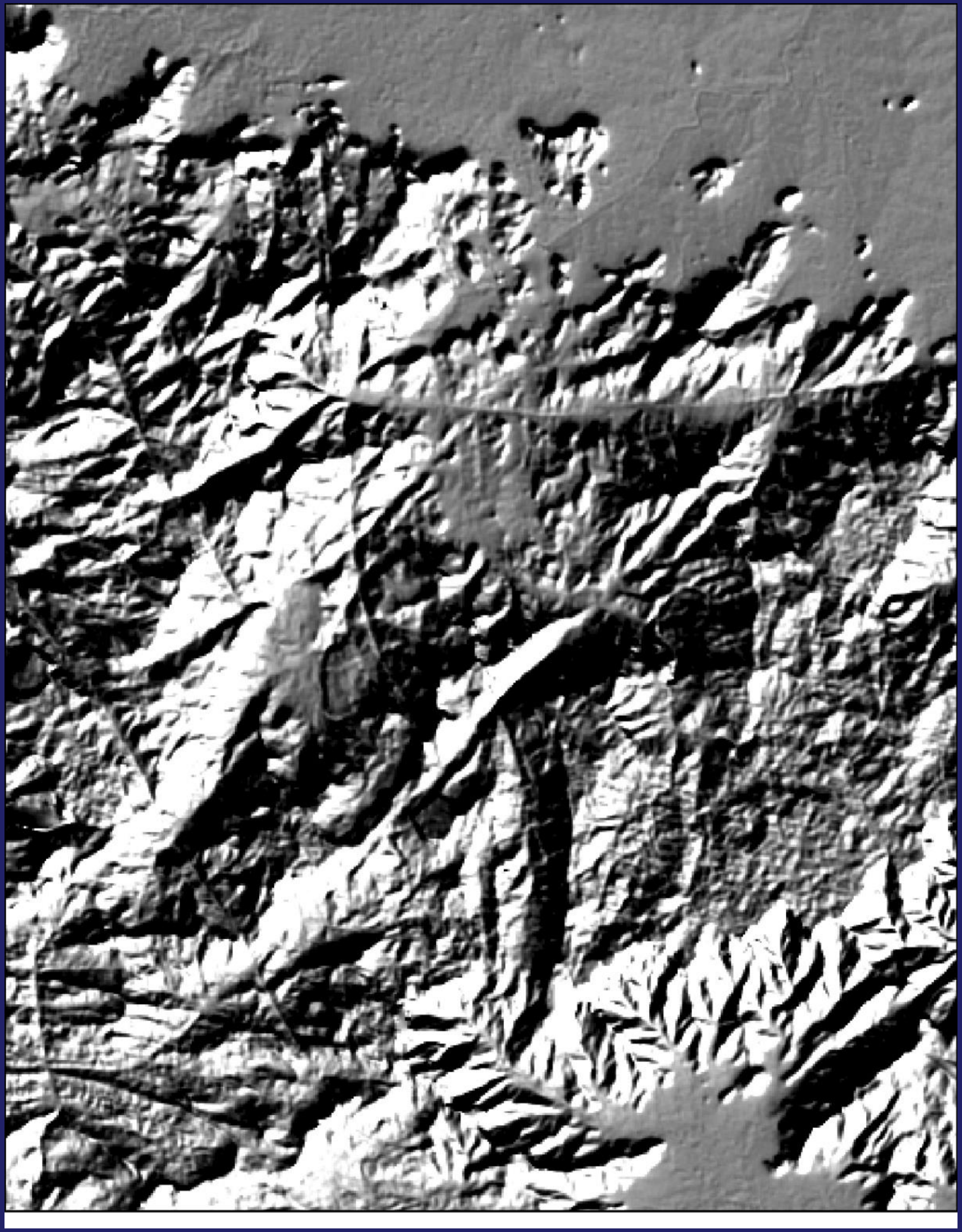



LINEAMENTS
RIDGE LINE


FAULT VALLEY
DISSECTED PLATEAU
DEBRIS WASHPLAIN
FILLED FRACTURE VALLEY

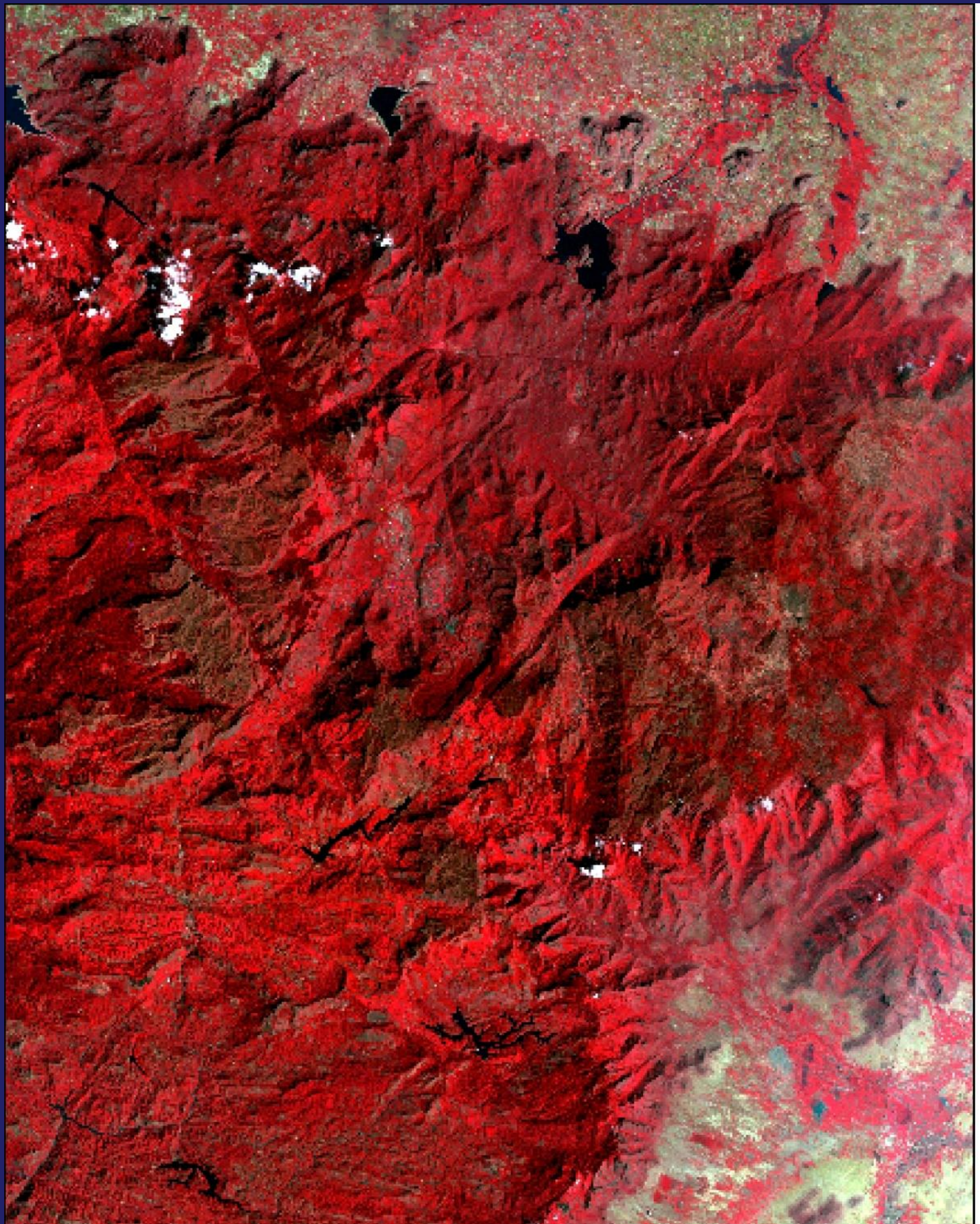
DENSITY SLICED SRTM DATA





SHADED RELIEF MAP

40 (ALTITUDE) -130 (AZIMUTH)



SATELLITE FCC IMAGE

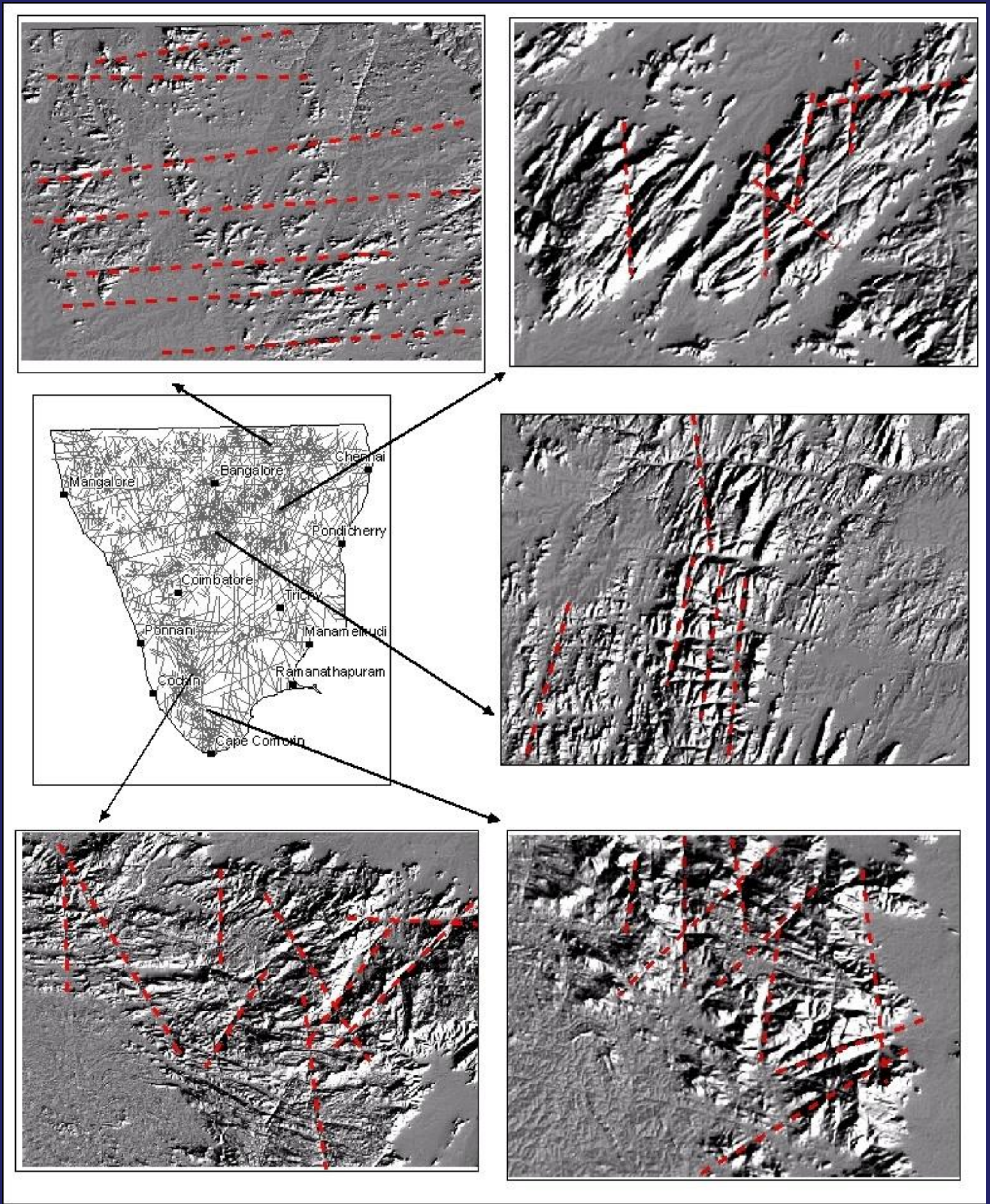


Fig.3 - Lineaments and faults derived from shaded relief map (SRTM)

Lineament Mapping from SRTM based Shaded Relief Map

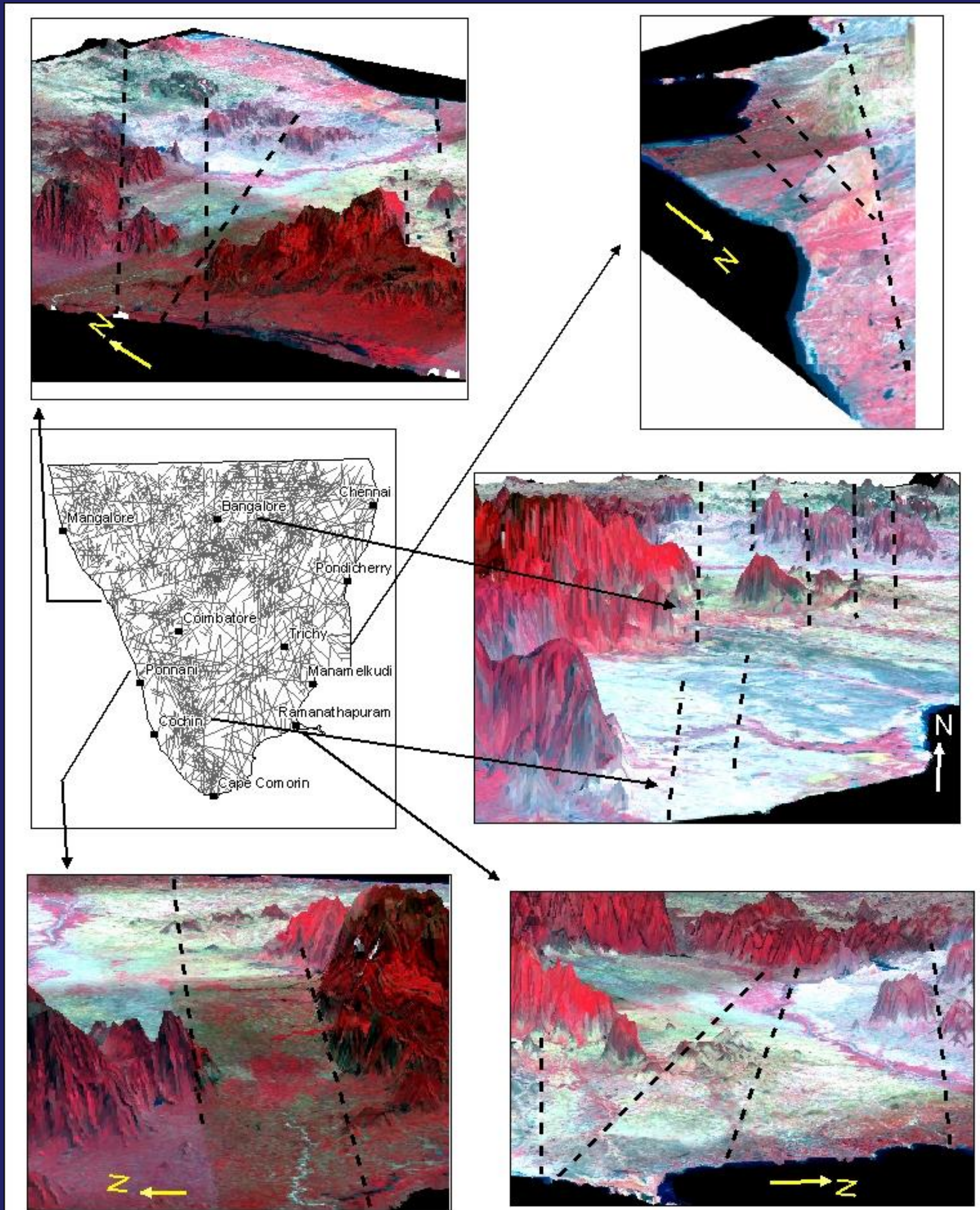


Fig.4 - Lineaments and faults derived from DEM wrapped FCC data

Lineament Mapping from SRTM based FCC Wrapped DEM