MICRO STRUCTURES

CLEVAGE, FOLIATION & LINEATION

Foliation:

"It is the property of rocks whereby they break along approximately parallel surface"

Primary: **inherited from the time of their formation.**

- Bedding fissility – Parallel to stratification caused by the platy & elongated grains in sedimentary rocks
- Primary foliation --- Caused due to rock flowage in igneous rocks.

Secondary: **Due to metamorphism in metamorphic rocks.**

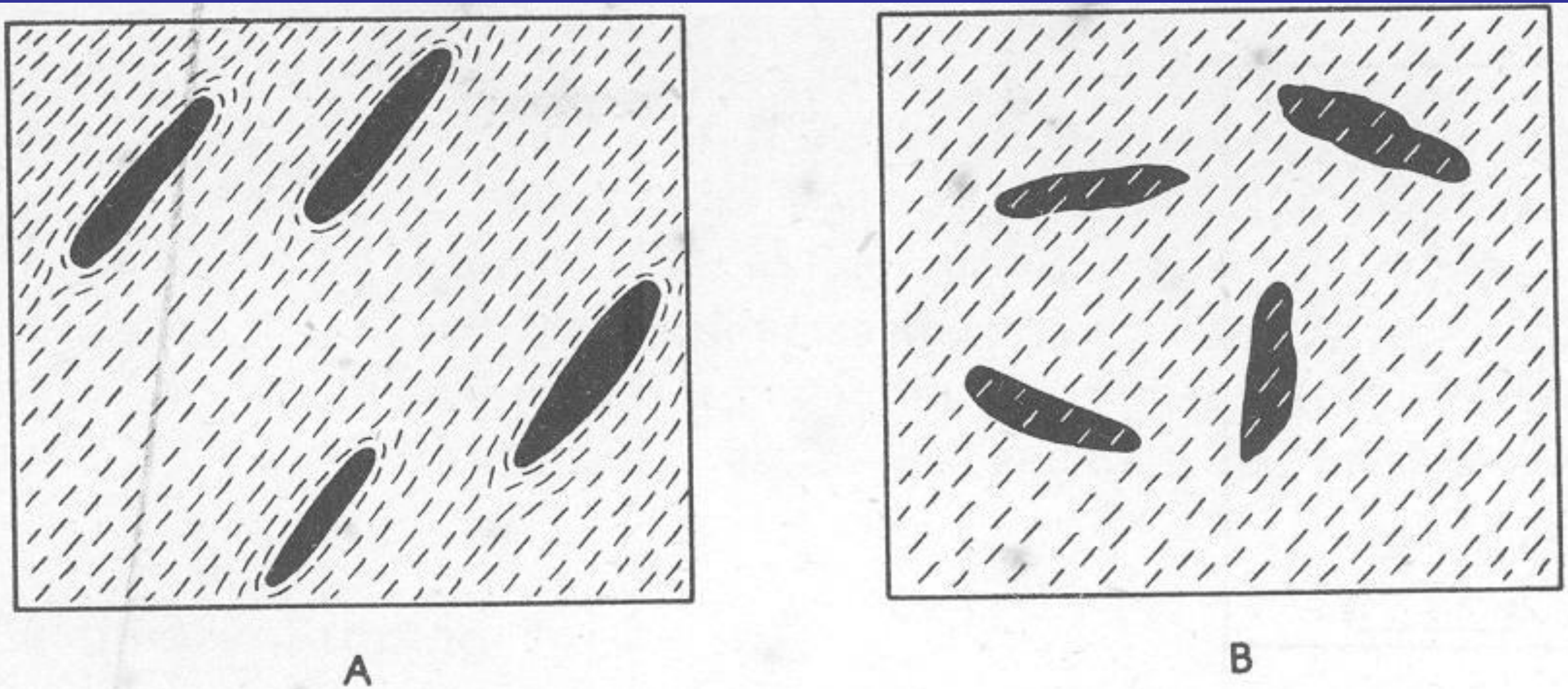


Fig. 17-9. Relation of inclusions to foliation. Solid black represents platy inclusions; black and white short dashes represent foliation due to platy minerals. (A) Platy inclusions parallel to primary foliation. (B) Platy inclusions, diversely oriented, cut by a secondary foliation.

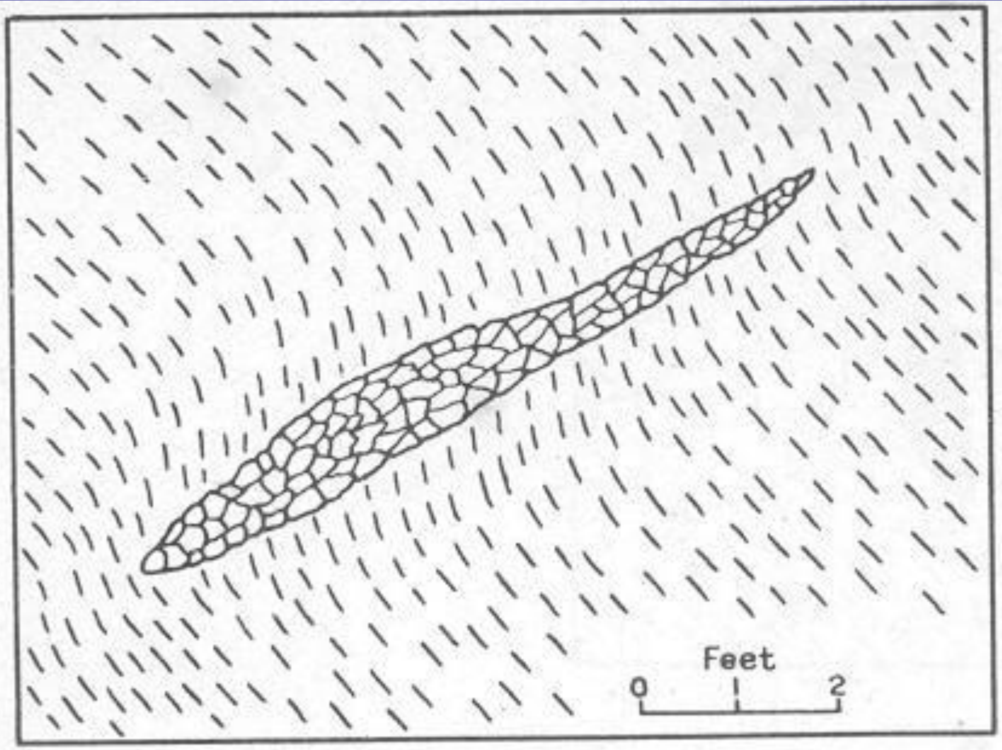


Fig. 17-10. Shear filled with pegmatite. Short dashes represent primary platy flow structure that is a primary foliation. Granular pattern is pegmatite or coarse granite.

Cleavage:

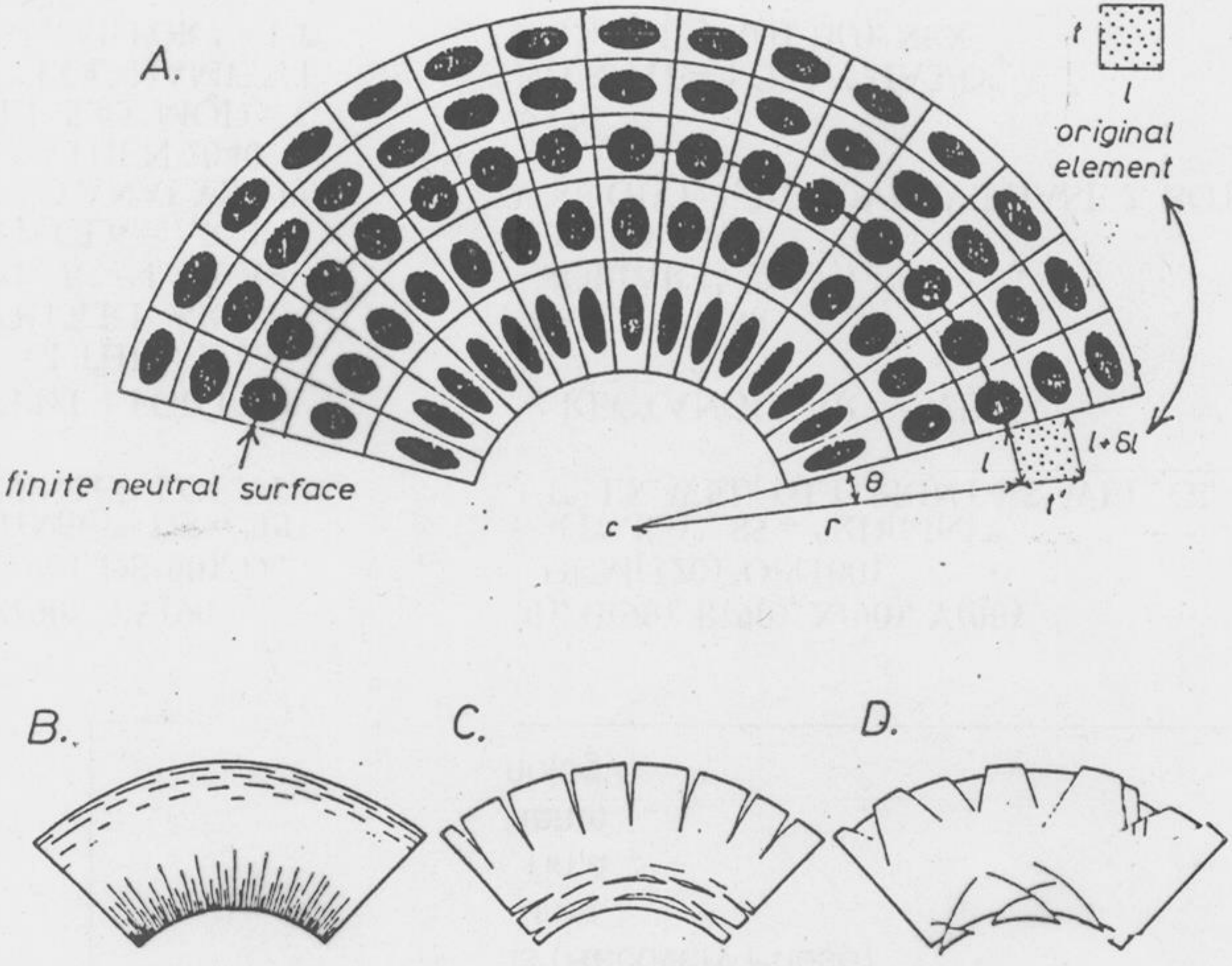
- Also called as rock cleavage – it is the property of the rocks where by they break along parallel surfaces (eg. Slate)

- In general they are oblique / inclined to primary bedding, some time they are parallel to bedding as well.

Schistosity:

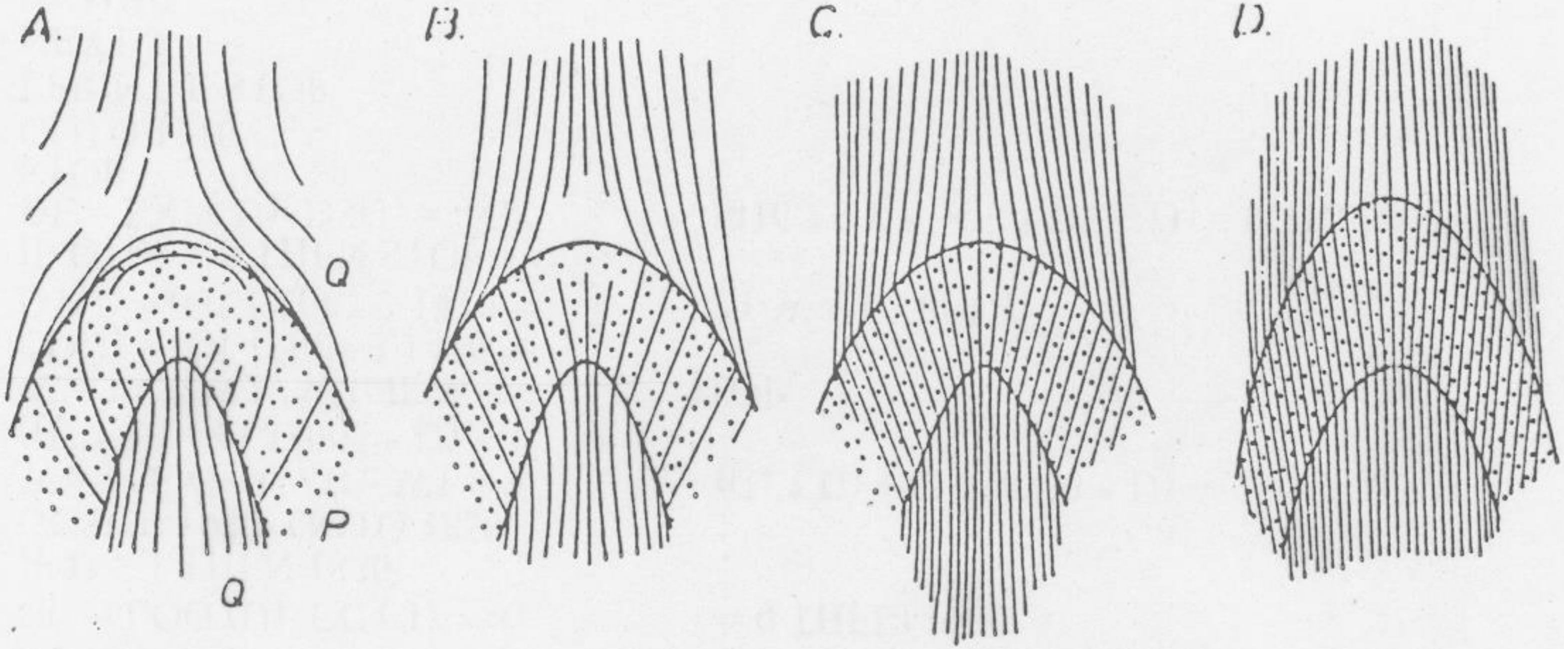
Variety of rock cleavage found in sufficiently recrystallised rocks (eg. Schists)

Structural development of rock strain



A: The geometrical features of a fold formed under conditions of pure tangential longitudinal strain. Structural development of rock strain: B, cleavage; C, extension fissures; D, conjugate shear faults.

Cleavage formation



Cleavage patterns in folds with no (A), some (B) and strong (C) initial layer parallel shortening. D shows the modified fold and cleavage geometry arising from a homogeneous strain with shortening normal to the fold axial surface. Rock P is more competent than rock Q.

TYPES OF CLEVAGES / SCHISTOSITIES:

- **Slaty cleavage or schistosity**
- **Fracture cleavage**
- **Shear cleavage**
- **Slip cleavage**
- **Bedding cleavage**
- **Axial plane cleavage.**

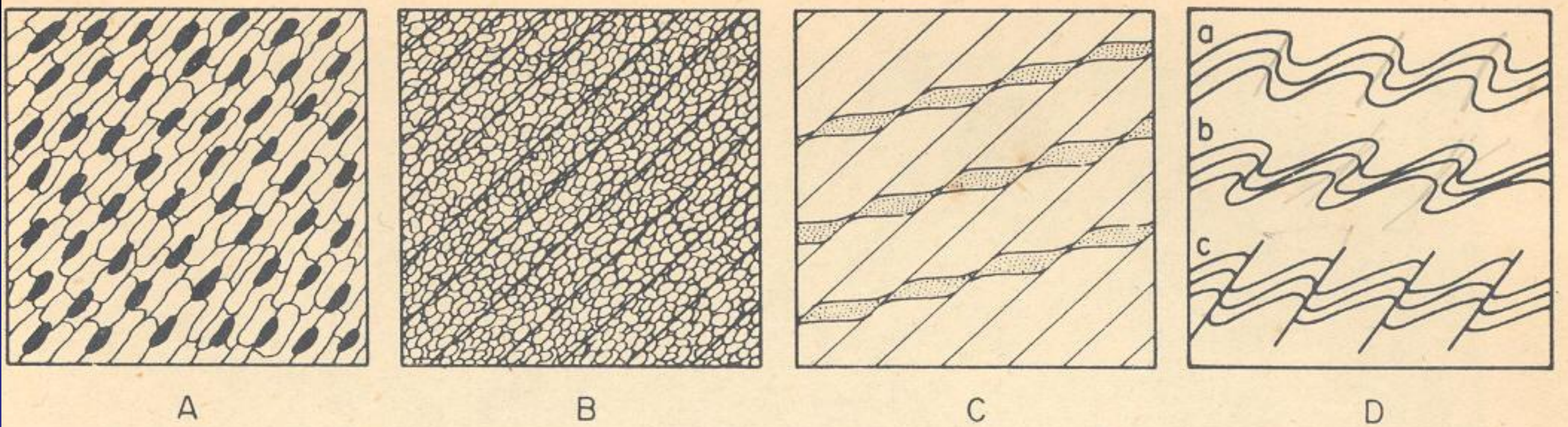


Fig. 18-2. Kinds of cleavage. (A) Slaty cleavage or schistosity. (B) Fracture cleavage. (C) Shear cleavage. (D) Slip cleavage.

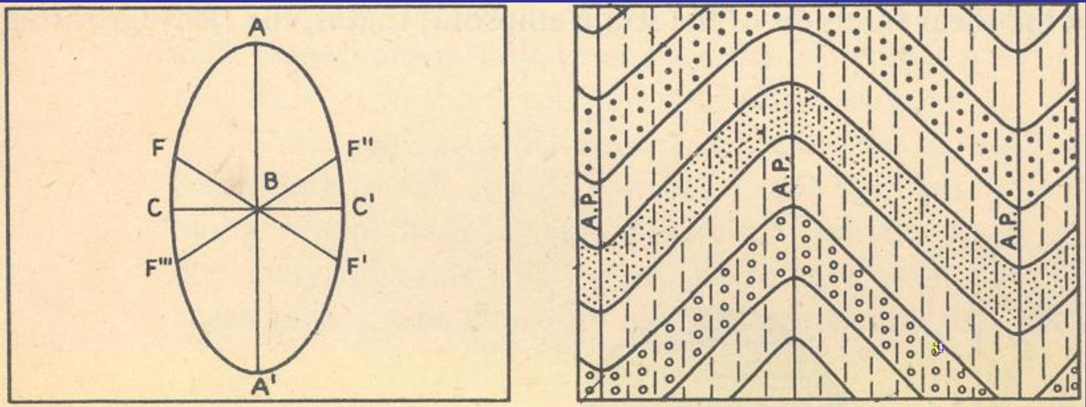


Fig. 18-5. Relation of cleavage to strain ellipsoid. Flow cleavage forms at right angles to the least strain axis (CC') of the strain ellipsoid; it includes the greatest strain axis (AA') and the intermediate strain axis (B), which is perpendicular to the plane of the paper. Fracture cleavage develops essentially parallel to the planes represented by FF' and $F''F'''$.

Plate 39. *Axial plane cleavage in syncline.* Old quarry No. 2, Slatington, Lehigh County, Pennsylvania. Photo: E. B. Hardin, U. S. Geological Survey.

Slaty cleavage or schistosity:

Slaty cleavage

Parallel arrangement of

- **Platy minerals of mica and chlorite**
- **Ellipsoidal minerals such as quartz and feldspar**
- **Elongate minerals like hornblende, actinolite, tremolite**

Their long axis lie in perpendicular direction to the force.

Rock can be split into an indefinite number of thin sheets.

- **Slaty cleavage in less metamorphosed rocks**
- **Schistosity in more metamorphosed rocks**

Schistosity is called as “**Continuous cleavage”**

- **Cleavage is the result of rock flowage**
- **Rock is shortened perpendicular ti cleavage and lengthened parallel to the cleavage**
- **Rotation of flaky and needle minerals parallel to the cleavage surface**
- **Greater the deformation more is the rotation**
- **Flatening and as well as crystalisation alon the cleavage.**

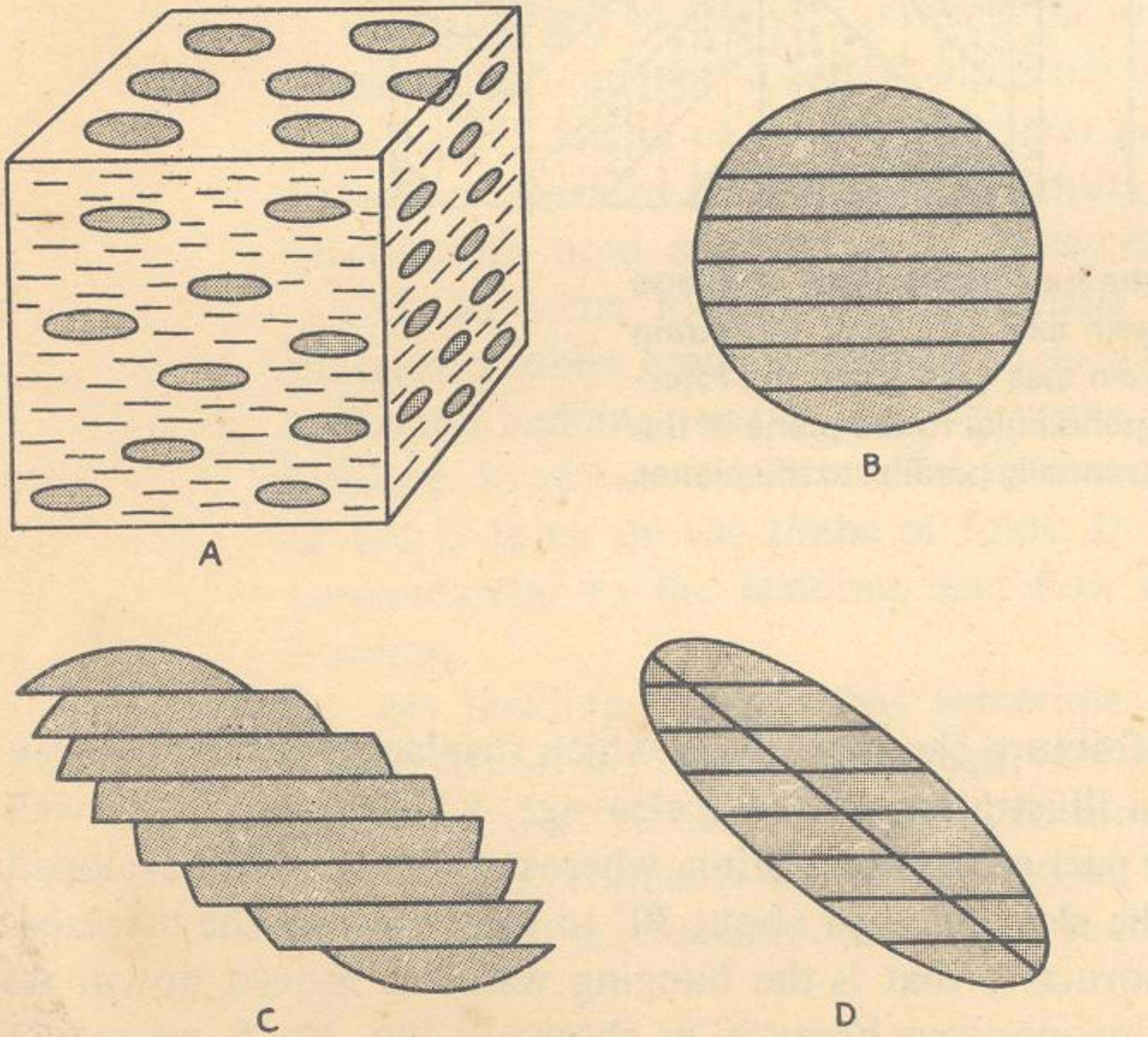


Fig. 18-4. Evidence against shear theory for origin of cleavage. (A) Characteristics of slaty cleavage; short dashes are platy minerals, stippled areas are ellipsoidal grains. (B) Circle cut by shear planes. (C) Circle sheared to jagged ellipse. (D) Same as (C), but with shear planes so close that ellipse is smooth.

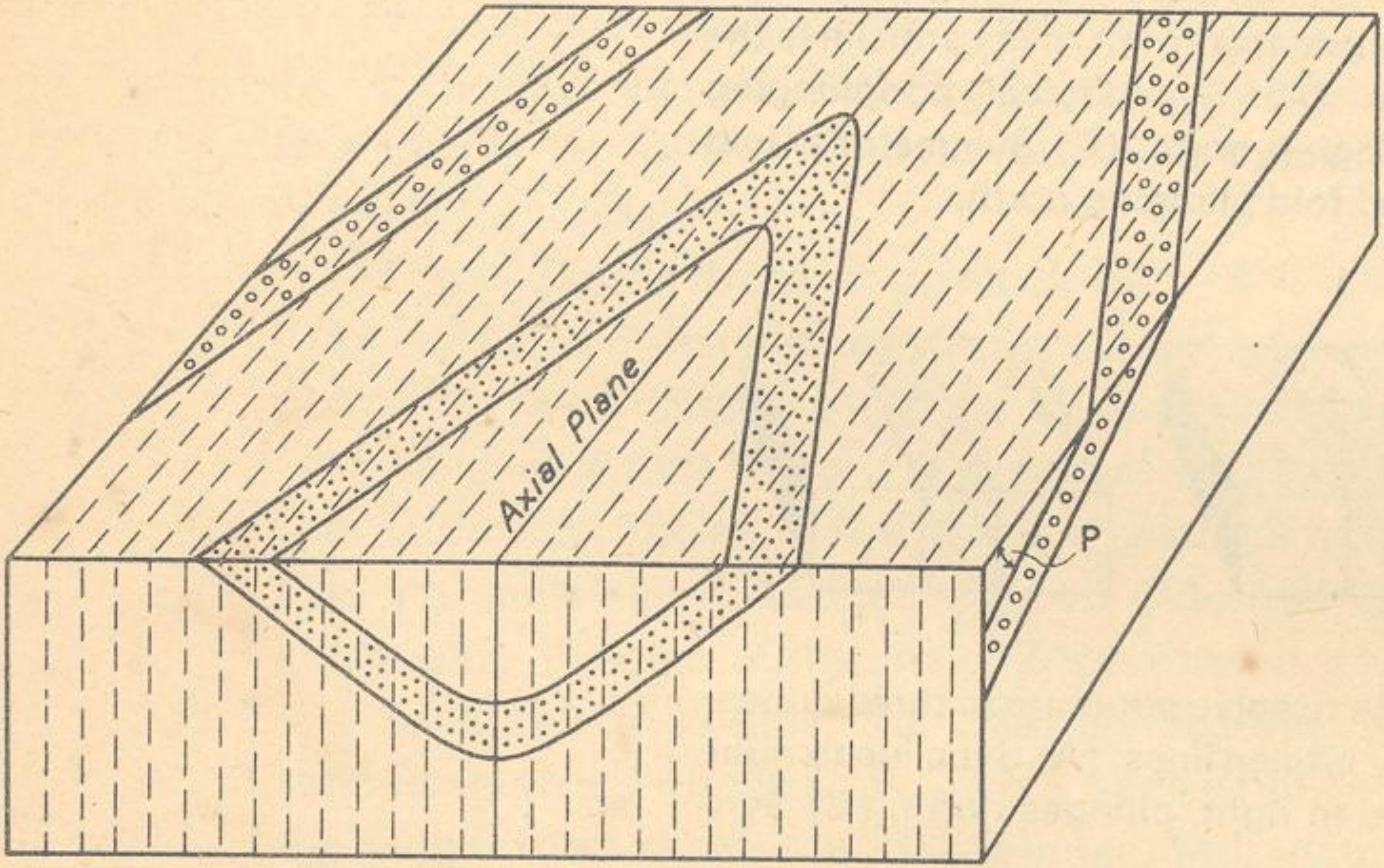


Fig. 18-10. Three-dimensional representation of slaty cleavage. Cleavage represented by broken lines. Value of plunge of fold is equal to *P*, which is measured on the cleavage; it is the angle between the trace of the bedding and a horizontal line.

Fracture cleavage:

- Closely spaced cleavage
- Minerals in the rocks are not parallel to the cleavage
- Spacing is few millimeter to centimeter
- If spacing exceeds few centimeters , it is called Joint
- It is also called as "Spaced Cleavage"
- It is the Phenomenon of shearing
- Cleavage is inclined to the greatest principle stress axis with 30 degree.

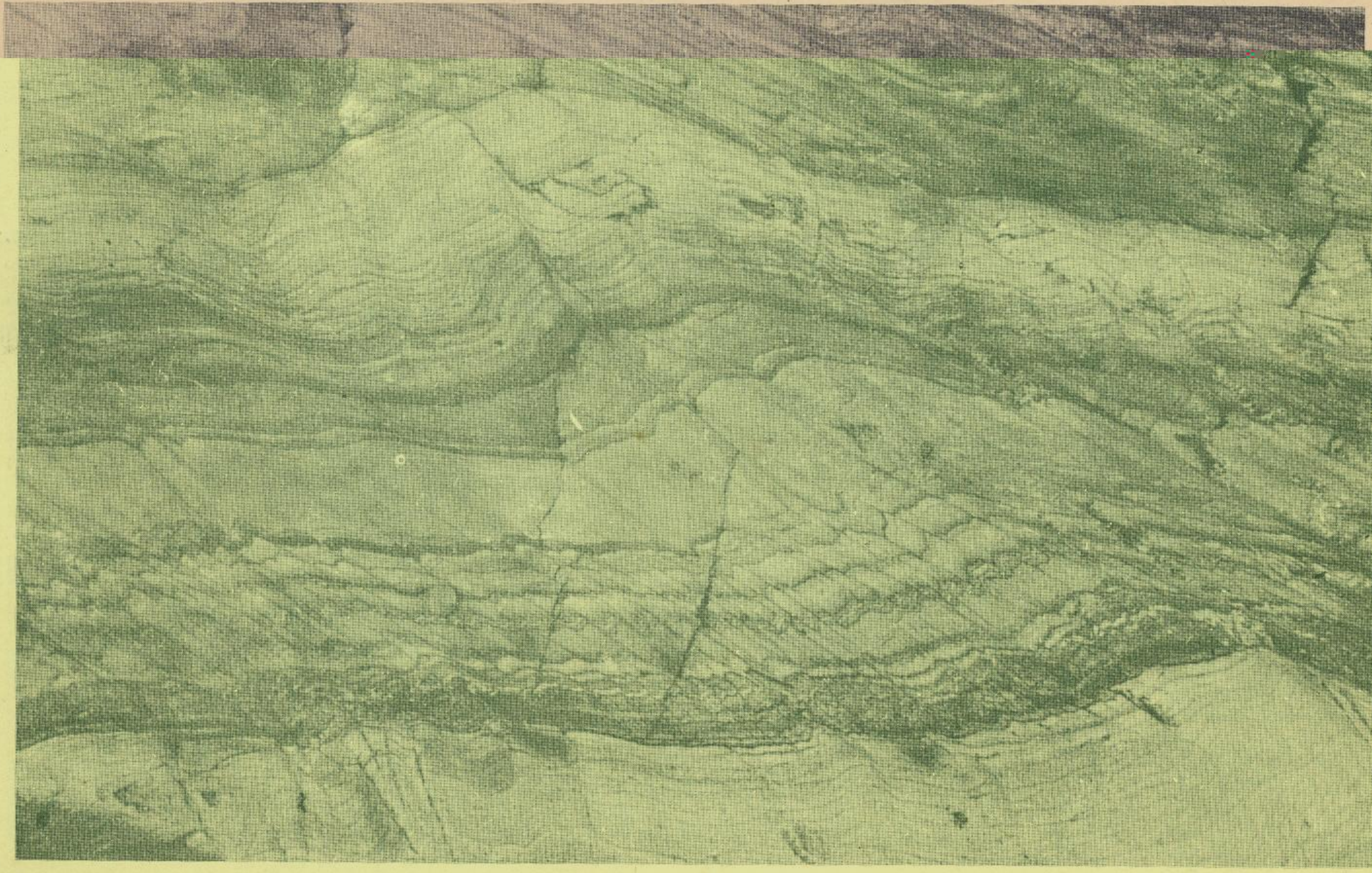


Plate 36. *Fracture cleavage.* Locally is a shear cleavage. Blue Canyon Formation, south bank of South Yuba River, 3½ miles east of Washington. Nevada County, California. Photo: L. D. Clark, U. S. Geological Survey.

Shear cleavage:

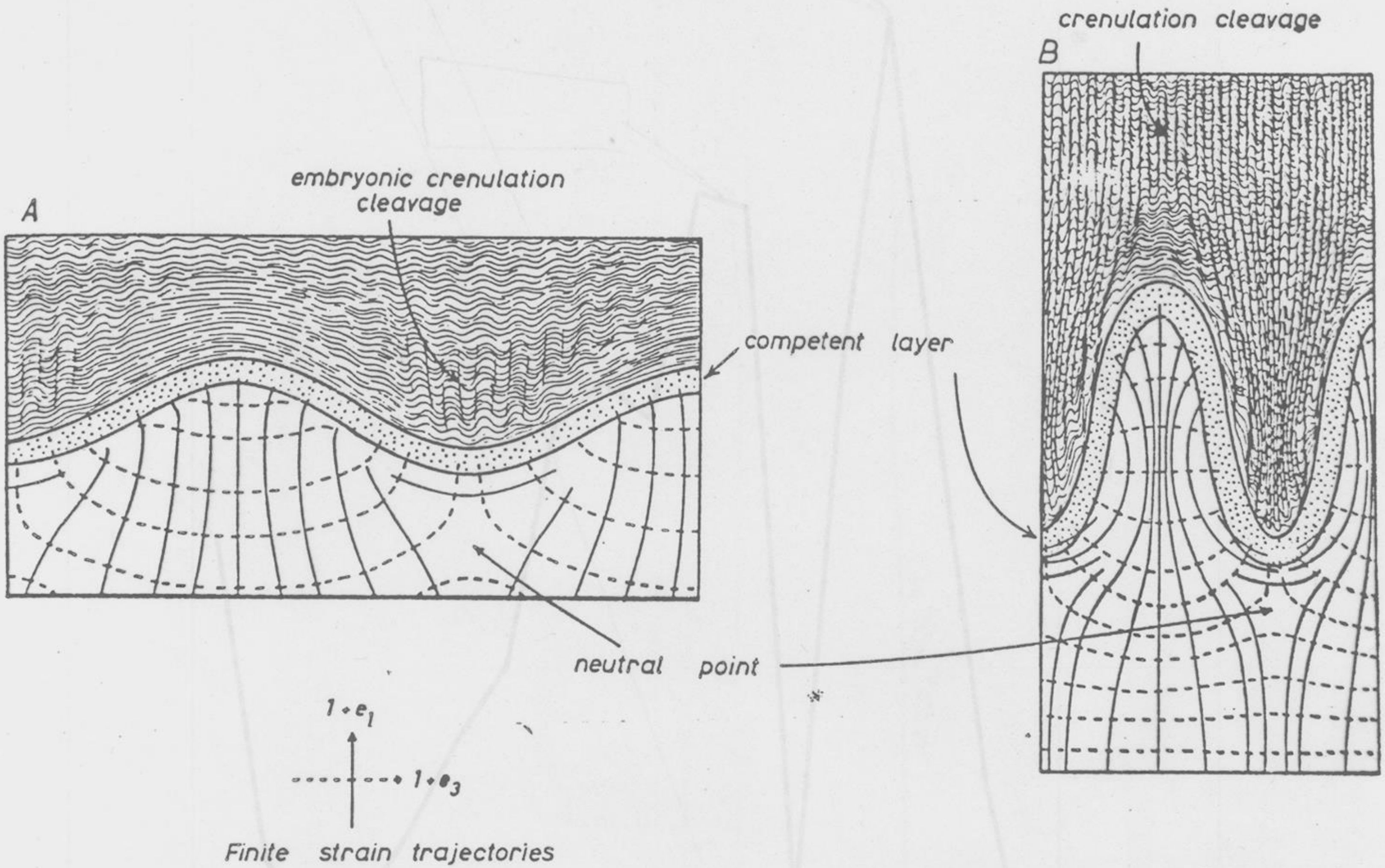
It is a fracture cleavage as well along which there has been displacement.

Minor drag develop near to cleavage.

Slip cleavage:

- Also called as strain-slip cleavage or crenulation cleavage
- Cleavage associated with small crinkles
- Shorter limb having maximum thinning and it is the plane of weakness.
- Earlier formed schistosity only thrown into crinckles.
- Crinckles developed due the force perpendicular to the plane normal to the schistosity.
- Assymetrical crinckle due to couple force acting parallel to schistosity.
- Mica flakes are rotated to this weak plane pof the axial plane of crinkles.
- Displacement takes place along this cleavage.

Cleavage formation



Scheme of development of symmetric and asymmetric crenulation cleavage in a material with a strong initial fabric as a result of buckling of a competent layer.

Bedding cleavage:

- Cleavage or schistosity is parallel to the bedding may be due to
- In Isoclinal folding – Cleavage parallel to the bedding in the limbs
- Mimetic recrystalisation – schistosity parallel to the hinge of the fold
- Rock flowage parallel to the bedding – Pebble flattening due to layer stretching, shortening takes place perpendicular to bedding and flow cleavage develop parallel to bedding – **bedding cleavage**

CLEAVAGE BANDING:

In a Sand stone and Shale intercalate layer – due to high degree of deformation squeezing of plastic shale into the inclined planes of cleavage that give rise to once again an intercalation appearance but along the cleavage orientation

Some time during the deformation and metamorphism the metamorphic fluids come and occupy the cleavage which finally look like banding.

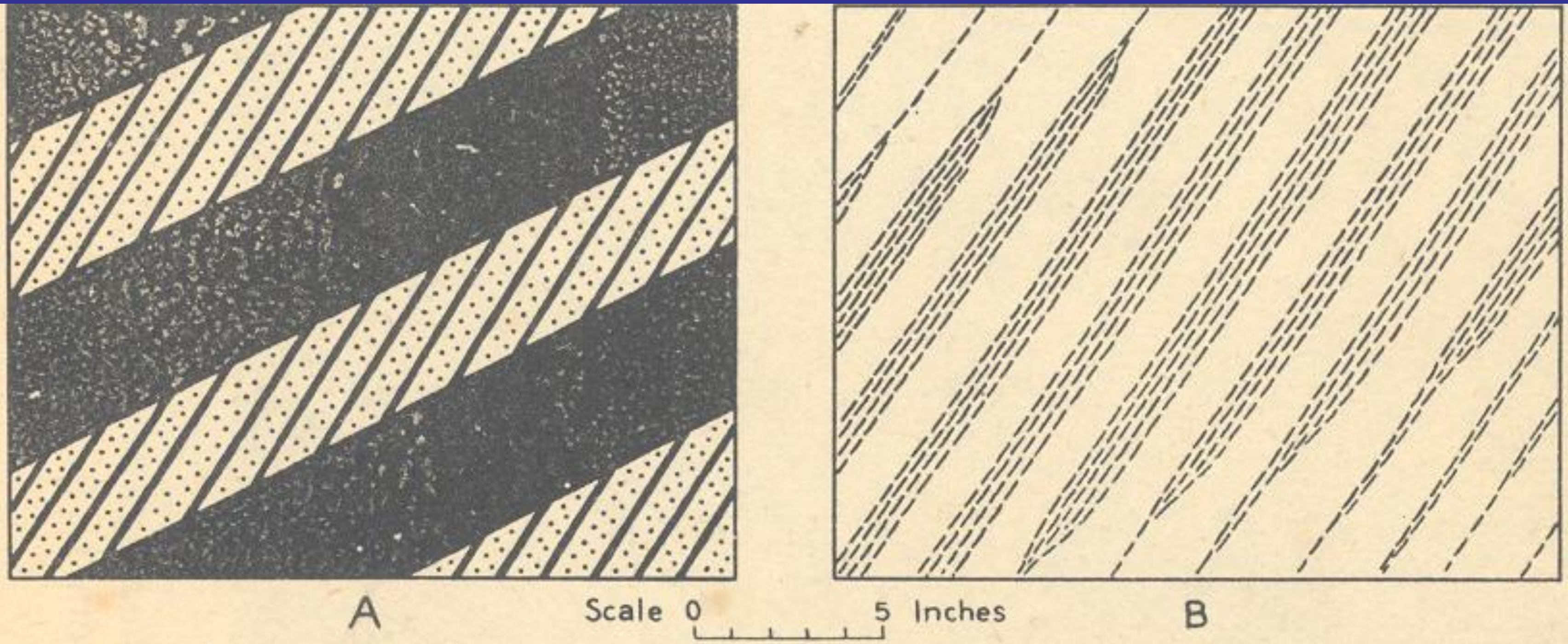


Fig. 18-3. Cleavage banding and segregation banding. (A) Cleavage banding. Solid black represents shale; dots represent sandstone. Bedding dips 25 degrees to left; cleavage dips 60 degrees to left. The more plastic shale has been injected along cleavage in the sandstone to produce a rhythmic alternation of shale and sandstone that simulates bedding. (B). Segregation banding. Short dashes represent bands rich in dark minerals. White areas are rich in light mineral. Bedding dips 25 degrees to the left.

METAMORPHIC BANDING

Due to very high grade metamorphism the dark and light colour minerals segregate together and give rise banding appearance which is called metamorphic or segregation banding.

RELATION OF CLEVAGE AND SCHISTOSITY TO MAJOR STRUCTURES:

Cleavage and schistosity bear a cosnsistant relationship to the major structures

Because folds and cleavage developed under the same forces (compressive force)

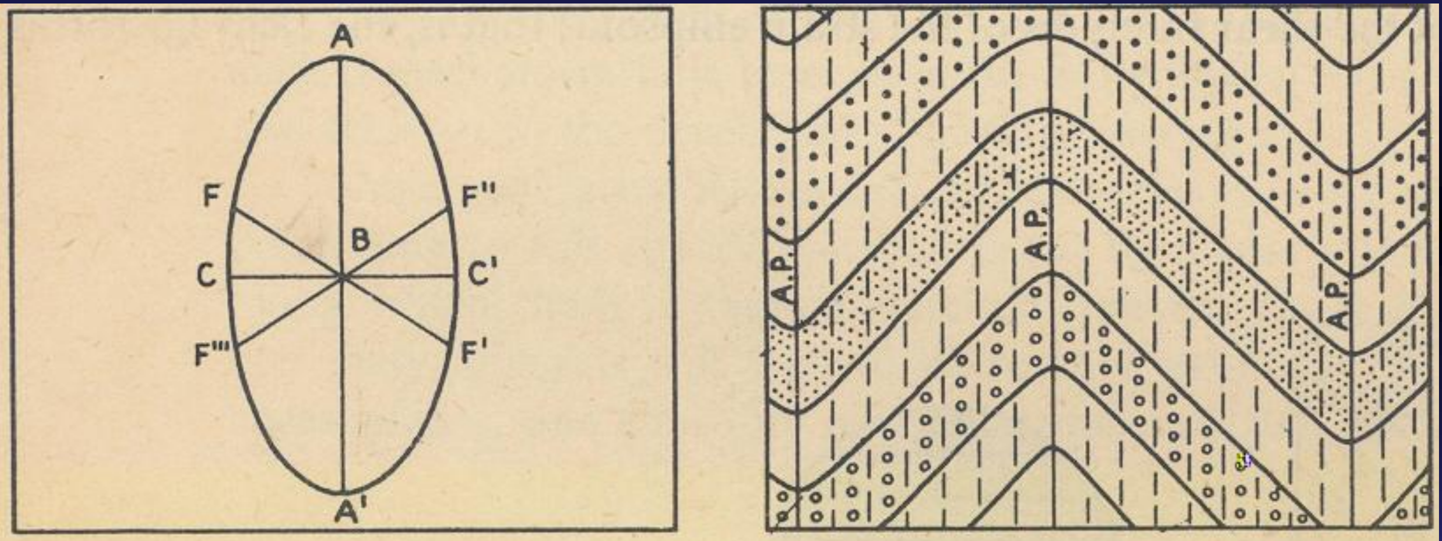


Fig. 18-5. Relation of cleavage to strain ellipsoid. Flow cleavage forms at right angles to the least strain axis (*CC'*) of the strain ellipsoid; it includes the greatest strain axis (*AA'*) and the intermediate strain axis (*B*), which is perpendicular to the plane of the paper. Fracture cleavage develops essentially parallel to the planes represented by *FF'* and *F''F'''*.

Stratigraphy establishment:

- **Clevage vertical – right side up - axial plane vertical and parallel**
- **Cleavage dips in the same direction of bedding dip – right side up – synclinal axis is in the same direction of bed dip**
- **If the bedding is vertical - right side up – synclinal axis is in the opposite direction to that of cleavage dip**
- **If the cleavage is gentler than the bedding dip – upside down – over turned limb – synclinal axis is in the opposite direction to that of cleavage**

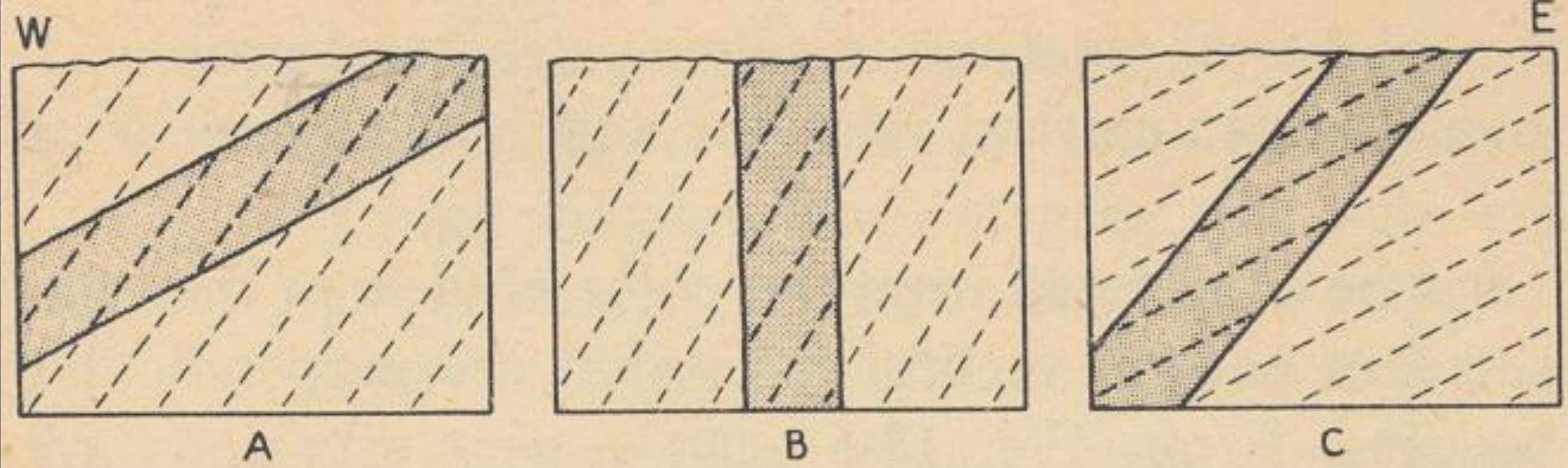


Fig. 18-7. Use of slaty cleavage to solve structure in two dimensions. Cleavage represented by broken lines. (A) Syncline is to left. (B) Syncline is to right. (C) Syncline is to right.

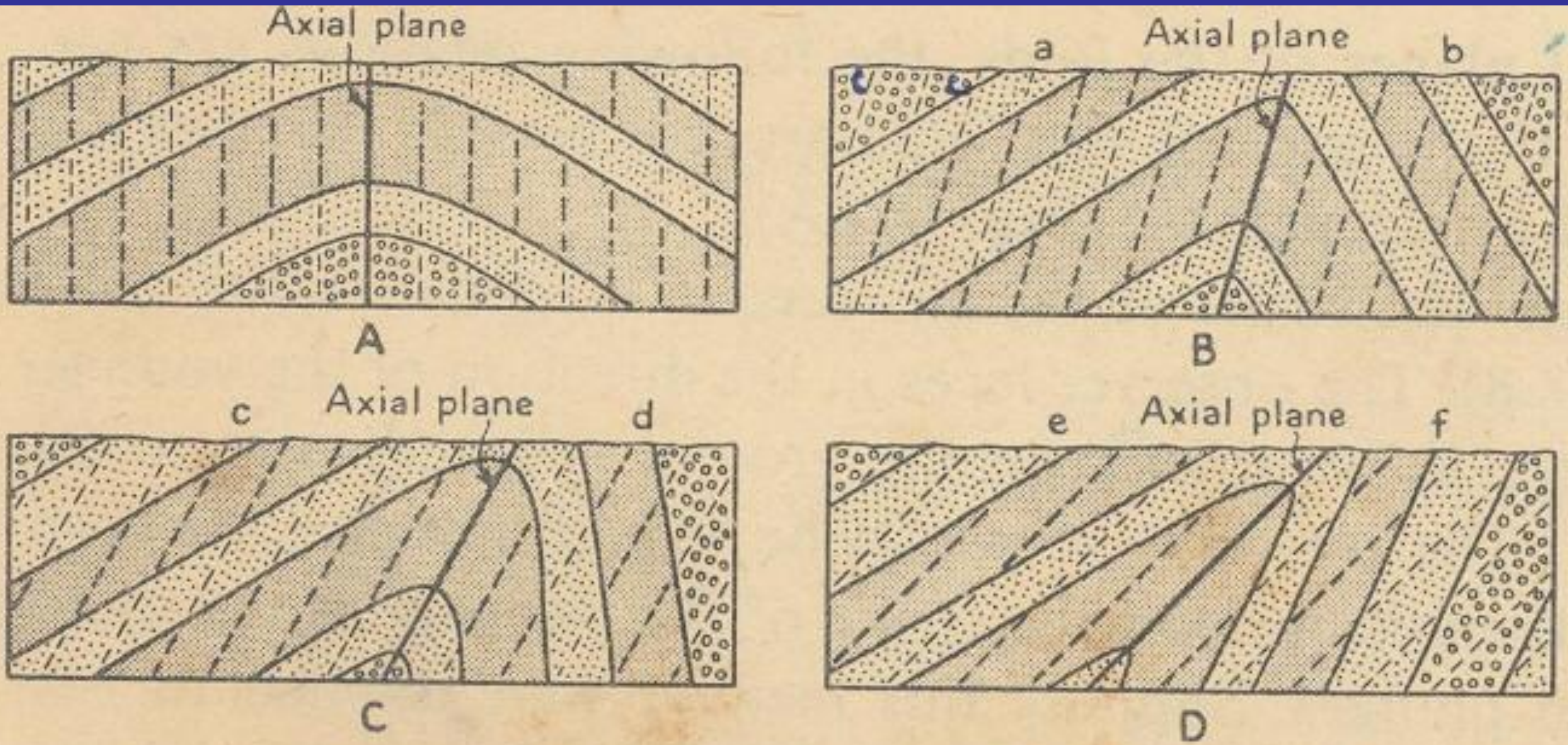


Fig. 18-6. Relation of slaty cleavage to folds in two dimensions. Cleavage represented by broken lines. Smaller letters are referred to in text. Rigorous parallelism of cleavage to axial plane is diagrammatic. (A) Symmetrical fold. (B) Asymmetrical fold. (C) Asymmetrical fold with one steep limb. (D). Overturned fold.

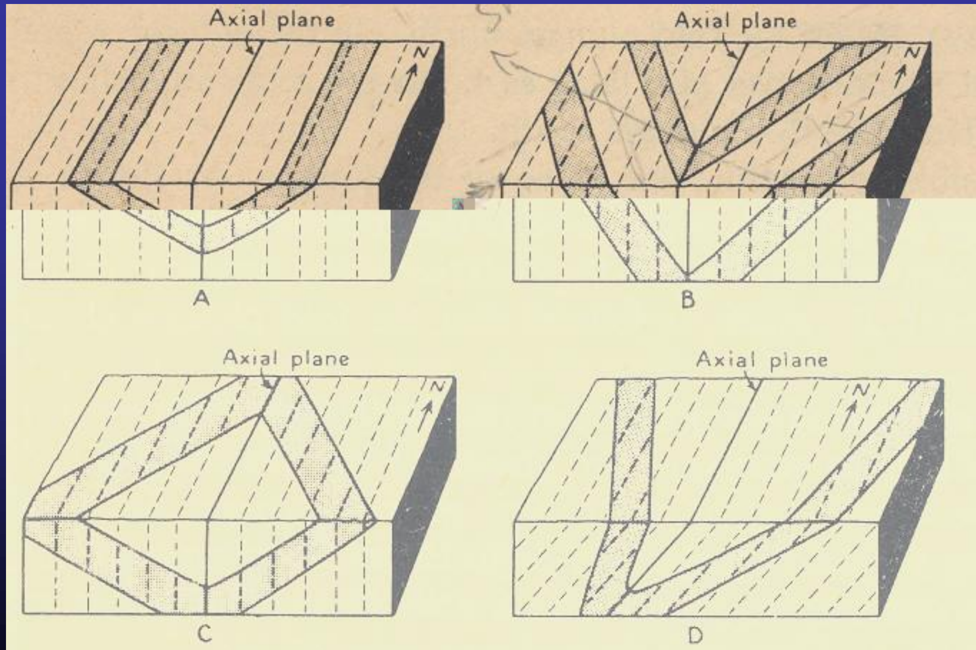


Fig. 18-8. Relation of slaty cleavage to folds in three dimensions. Cleavage represented by broken lines. Rigorous parallelism of cleavage to axial plane is diagrammatic; in many anticlines the cleavage diverges downward. (A) Symmetrical nonplunging fold. (B) Symmetrical fold plunging north. (C) Symmetrical fold plunging south. (D) Overturned fold plunging north.

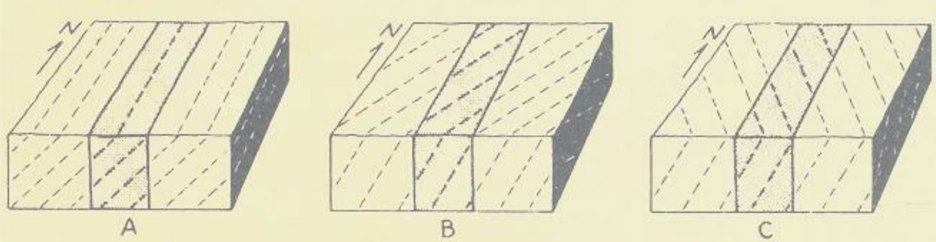


Fig. 18-9. Use of slaty cleavage to solve structure in three dimensions. Cleavage represented by broken lines. (A) Syncline to right, does not plunge. (B) Syncline to right, plunges north. (C) Syncline to right, plunges south.

LINEATION

Lineation:

Is the result of the parallelism of some directorial property in the rock such as the long axis of Hornblende crystals. Platy minerals or spherical grains may be strung out in lines to produce lineation.

Lineation Types:

Primary
- Igneous Rock
- Sedimentary Rocks

Secondary - Metamorphic Rocks

➔It may occur with or without foliation

➔A rock without cleavage or schistosity may possess lineation

➔Commonly this secondary lineation is associated with foliation and lies in the plane of foliation

Kinds of Lineation

- Pebble lineation
- Intersection lineation
- Slickenside
- Bundinage or sausage
- Mullion structures

Fold axes are commonly considered to be the lineation

The attitude of the fold axis is often the reference to which other lineations are Compared

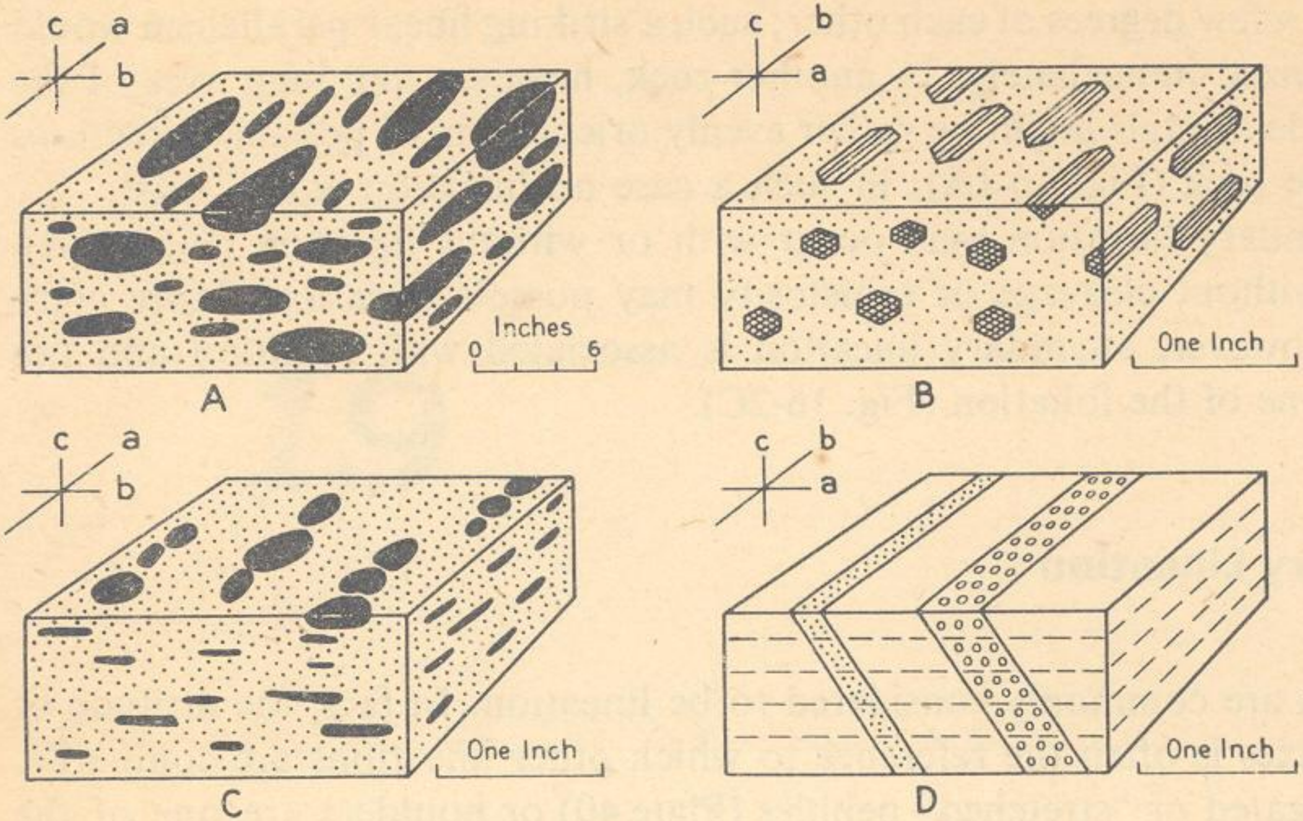


Fig. 19-1. Lineation. (A) Elongated pebbles are shown in solid black. Each pebble is an irregular ellipsoid, the longest axis of which is parallel to *a*, the shortest axis is parallel to *c*, and the intermediate axis is parallel to *b*. (B) Elongate crystals of hornblende, the long axes of which are parallel to *b* in the diagram. (C) Lineation caused by circular plates of mica, shown in solid black, strung out like beads on a string. (D) Cleavage is represented by top of block and by planes shown by broken lines. Bedding is shown by dots and open circles. Trace of bedding on cleavage gives a lineation.

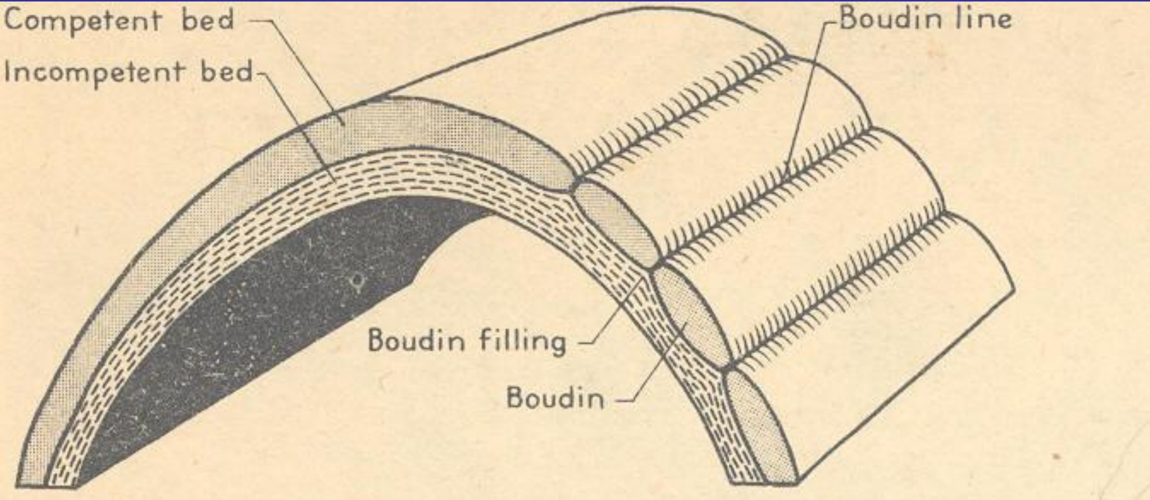


Fig. 19-2. Boudinage. In this case the boudin line is parallel to fold axis, but this is not necessarily true.

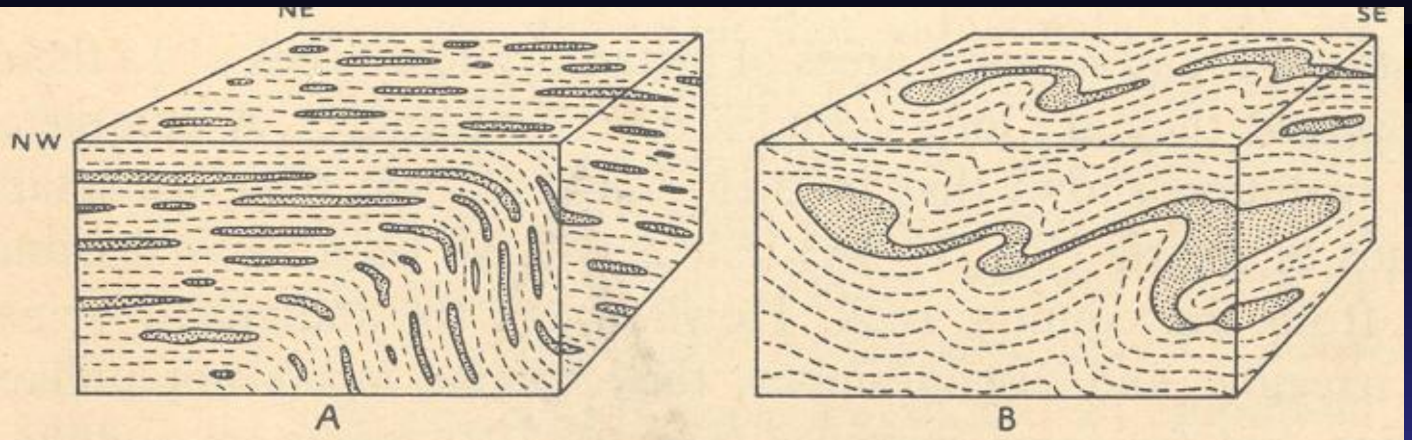


Fig. 19-3. Quartz rods. Quartz shown by dots, bedding by broken lines. (A) Quartz lenses parallel to bedding. (B) More irregular quartz lenses parallel to bedding. (Based on diagrams by G. Wilson.[7])

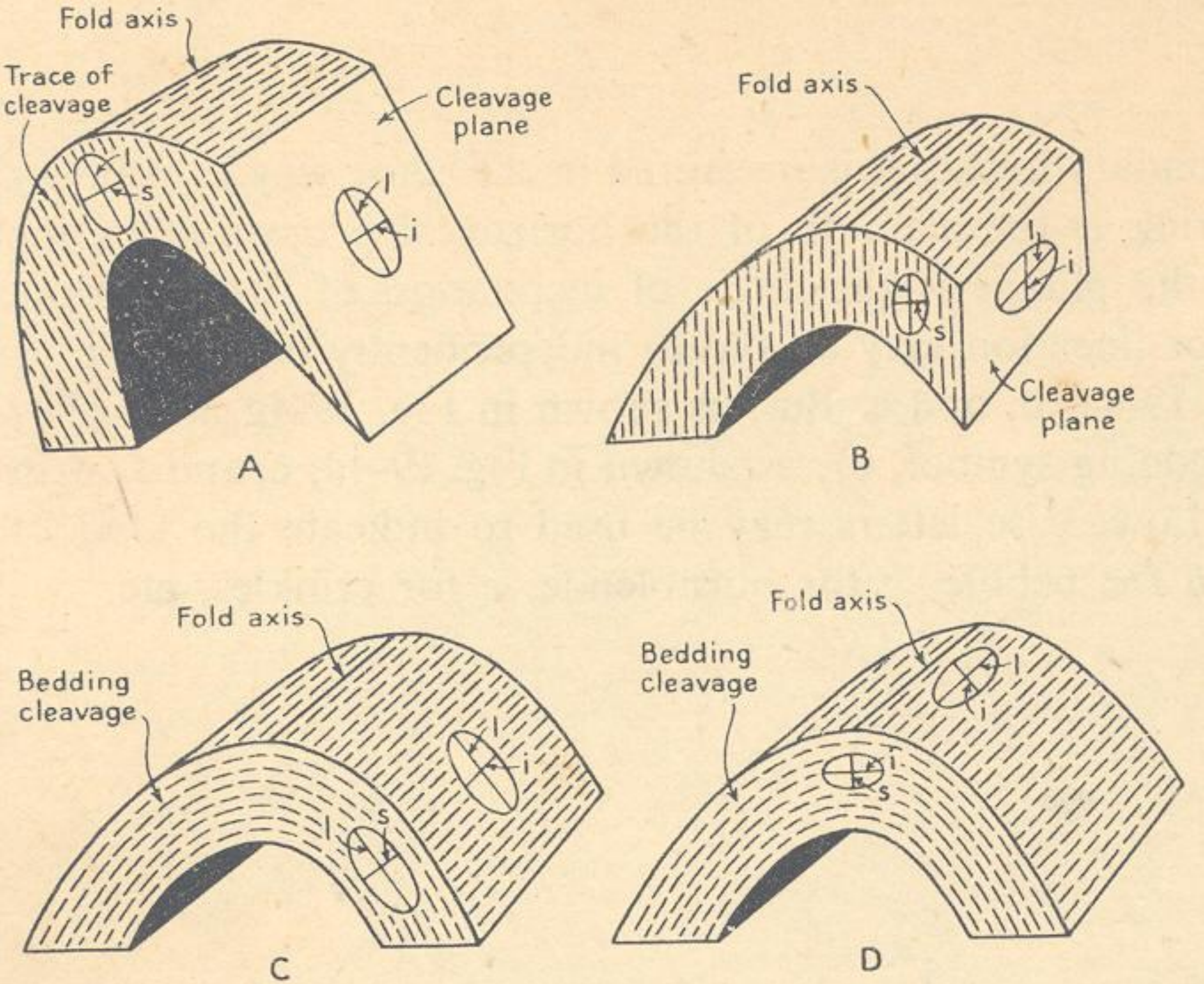


Fig. 19-5. Various orientations of long axes of deformed spheres. (A) In axial plane cleavage and perpendicular to fold axis. (B). In axial plane cleavage and parallel to fold axis. (C) In bedding plane cleavage and perpendicular to fold axis. (D) In bedding plane cleavage and parallel to fold axes.

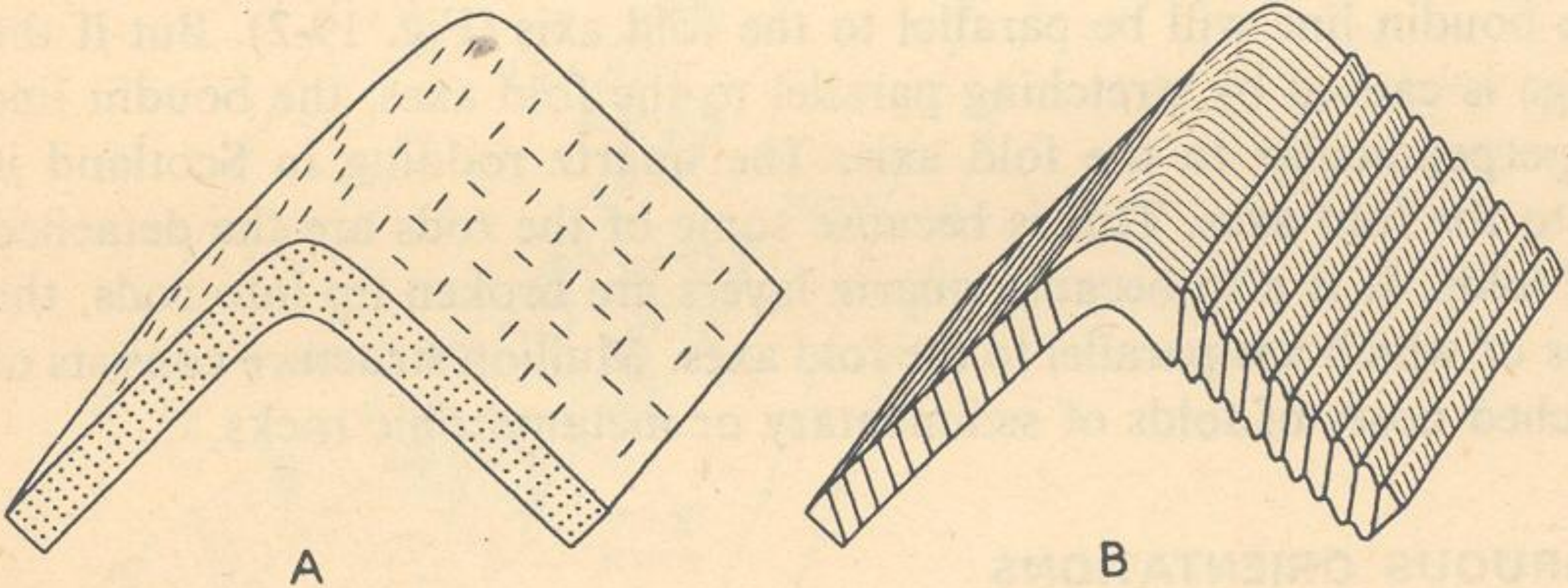


Fig. 19-6. Different kinds of lineation on folds. (A) Two lineations, one parallel to axis of fold and other at right angles. (B) Left-hand limb shows lineation due to intersection of fracture cleavage with bedding. Right-hand limb shows lineation due to intersection of shear cleavage with bedding; displacement on the cleavage causes either tiny faults or small crinkles.

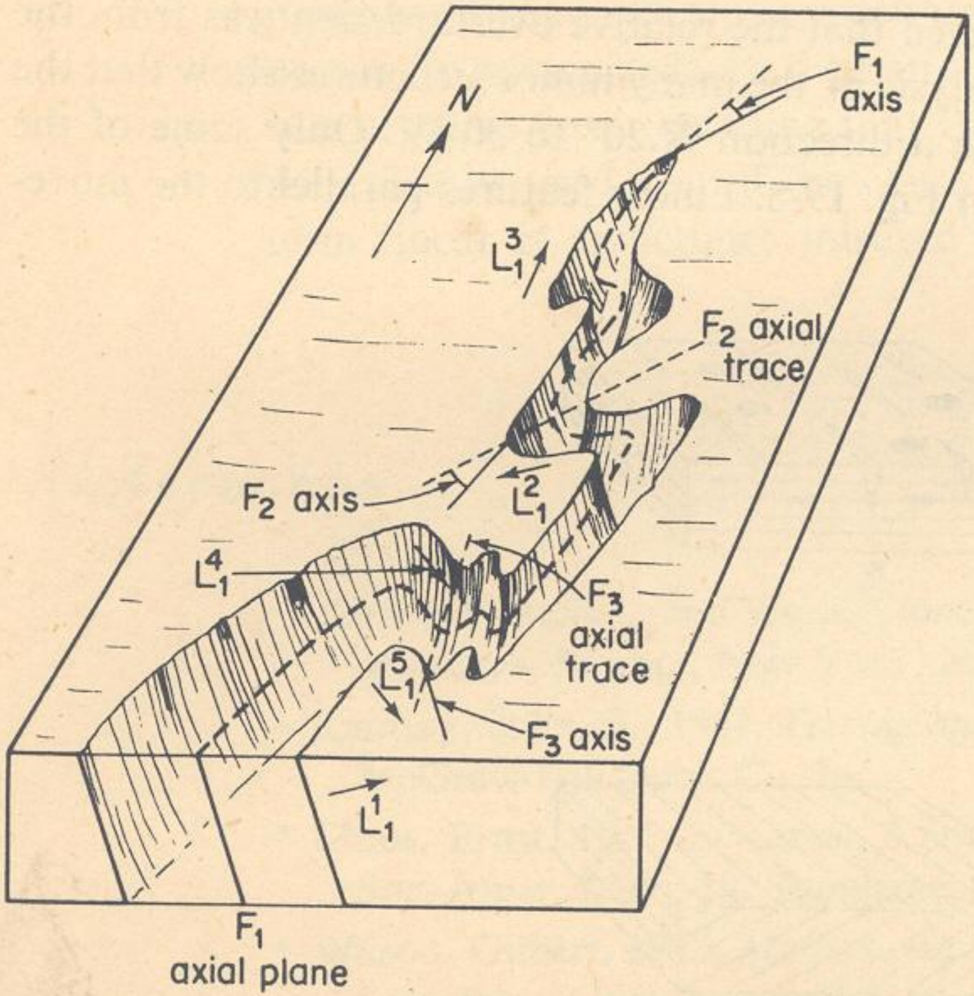


Fig. 19-7. Orientation of original lineation changed by succeeding stages of folding. Three stages of folding, F_1, F_2, F_3. In first stage of folding the axial plane of an isoclinal anticline dips steeply east and plunges 15° north. Lineation, L_1^1, forms parallel to fold axes at this time. But this lineation is reoriented to positions such as L_1^2 and L_1^3 by a second folding, and to such positions as L_1^4 and L_1^5 by a third stage of folding.

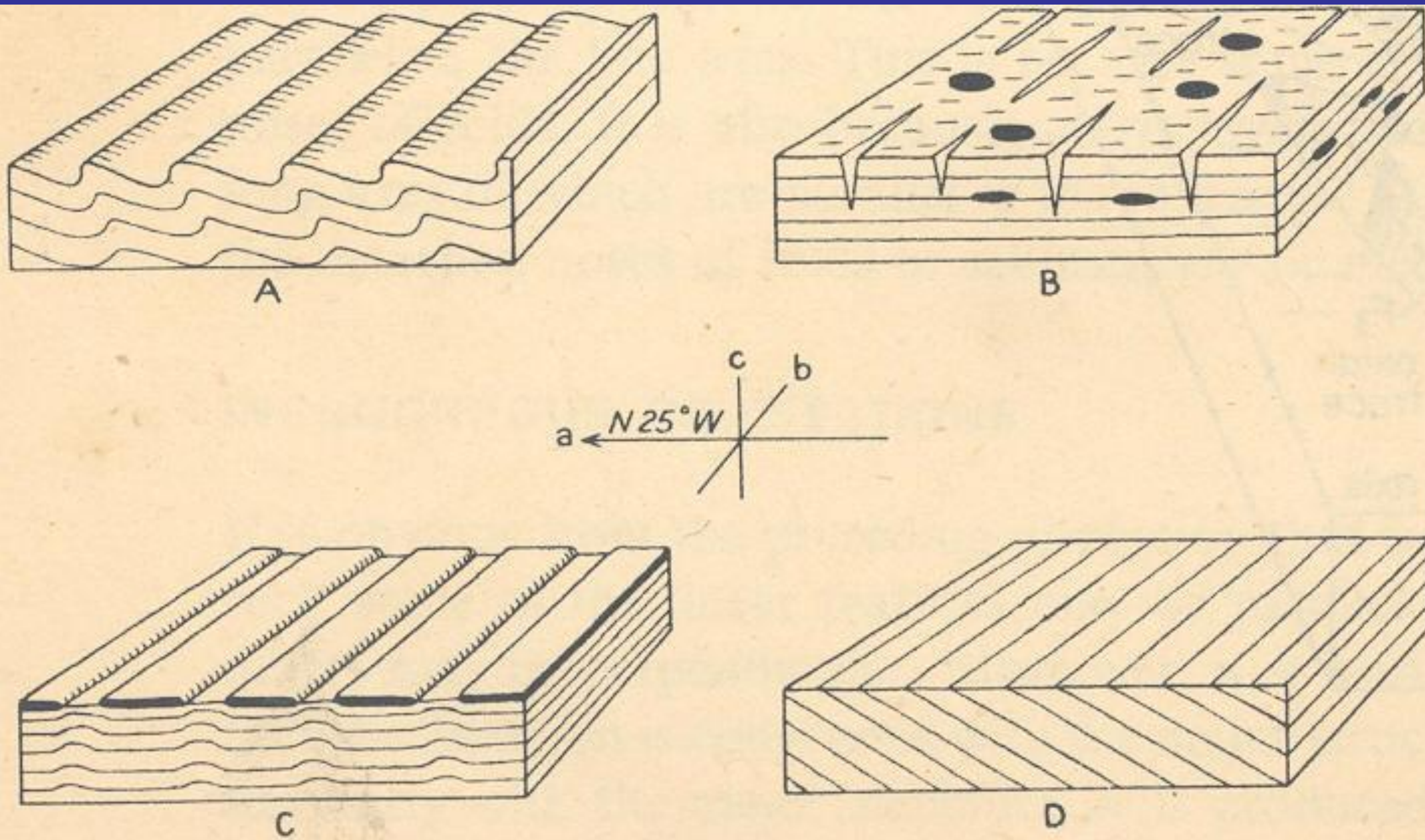


Fig. 19-8. Relation of minor structures to overthrusting in Tintagel area, North Cornwall, England. (A) Drag folds. (B) slickensides shown by short lines on top of block; deformed pillows and amygdules shown in solid black; tension cracks shown by open gashes. (C) Boudinage. (D) Fracture cleavage. (After Gilbert Wilson.[7])

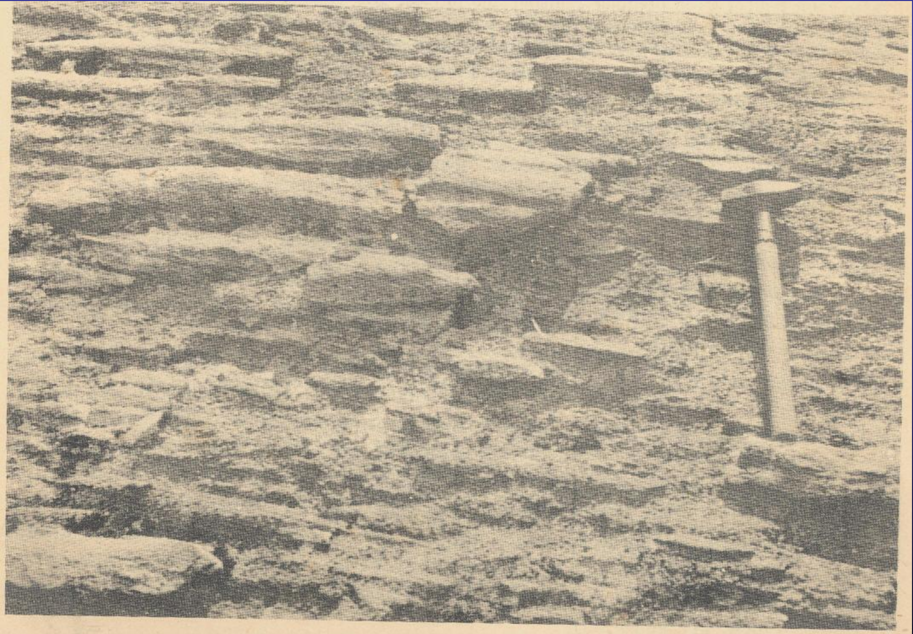


Plate 40. *Stretched conglomerate.* Actually a garnet amphibolite derived from an agglomerate, a clastic rock of volcanic origin, Lower Paleozoic. Överuman (lake), Swedish Lapland. Photo: J. Haller.

Plate 41. *Boudinage.* Light-colored dolomite interstratified with dark shaly limestone. Boudin in center is about 400 feet across. Limestone-dolomite series of Precambrian Eleanore Bay Group. Kejser Franz Joseph Fjord, East Greenland. Photo: Lauge Koch Expedition.

Conformity structures related to Igneous Intrusion

Igneous intrusion due to mobility and forcible injection into the higher level due to squeezing.

Intrusion

- **Batholiths**
- **Stocks**
- **Tongues and apophyses**

Surface Character

- Doming up of the surrounding rock
- Encircling nature of foliation
- Mostly discordant relation to the surrounding rock
- Local Conformity
- Fragments of surrounding rocks into the intruded bodies as softs and Xenoliths
- Tongues and Apophyses of intrusive body with surround country rock
- Radial & Concentric fractures / faults.
- Drag effect (anticline and syncline)

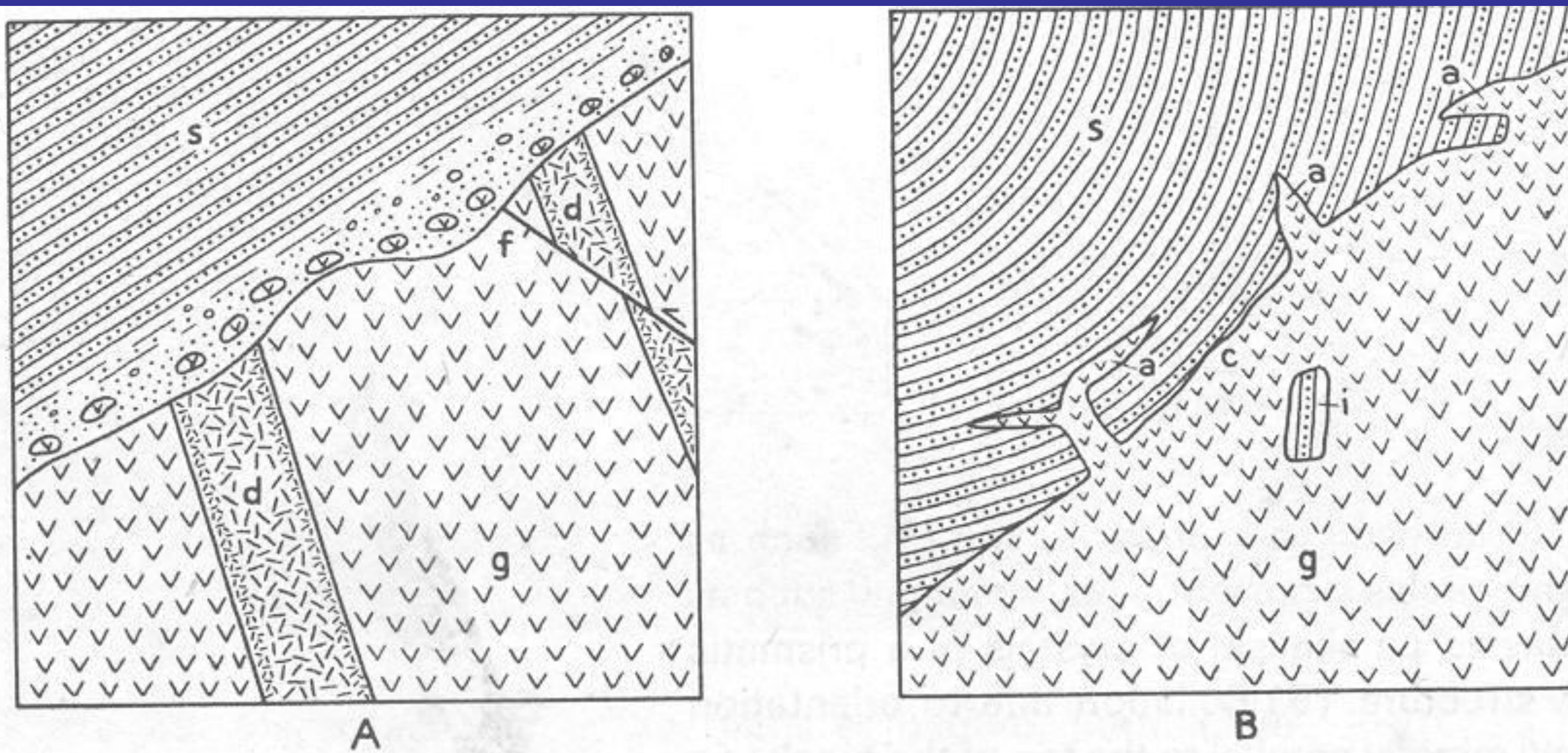


Fig. 16-3. Relative age of pluton and adjacent rocks. *s*, sandstone and shale ; *g*, granite ; *d*, dike of diorite ; *f*, fault ; *i*, inclusion ; *a*, apophyses ; *c*, chilled contact of granite. (A) Unconformity. (B) Intrusive contact.

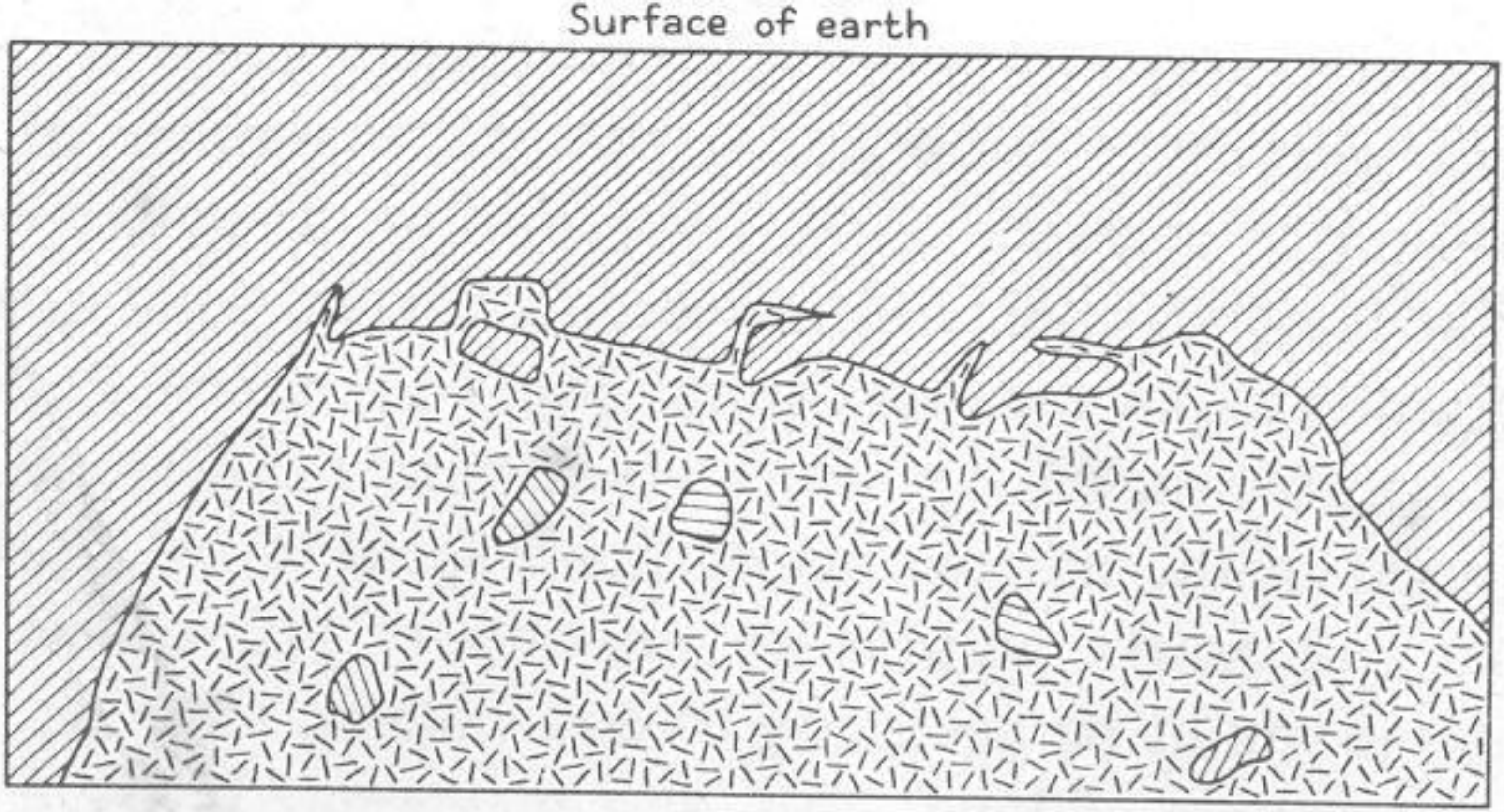


Fig. 17-12. Magmatic stoping. Diagonal lines are older rocks. Diversely oriented dashes are plutonic rock.

Sills - Parallel structures
Dyke - Discordant
Laccoliths - Doming up of the upper layer
Bysmoliths - roof was uplifted along a arcuate / circular fault.
Lopoliths - Intruded into structural bearing
Phacoliths - Intruded into structural Domes.

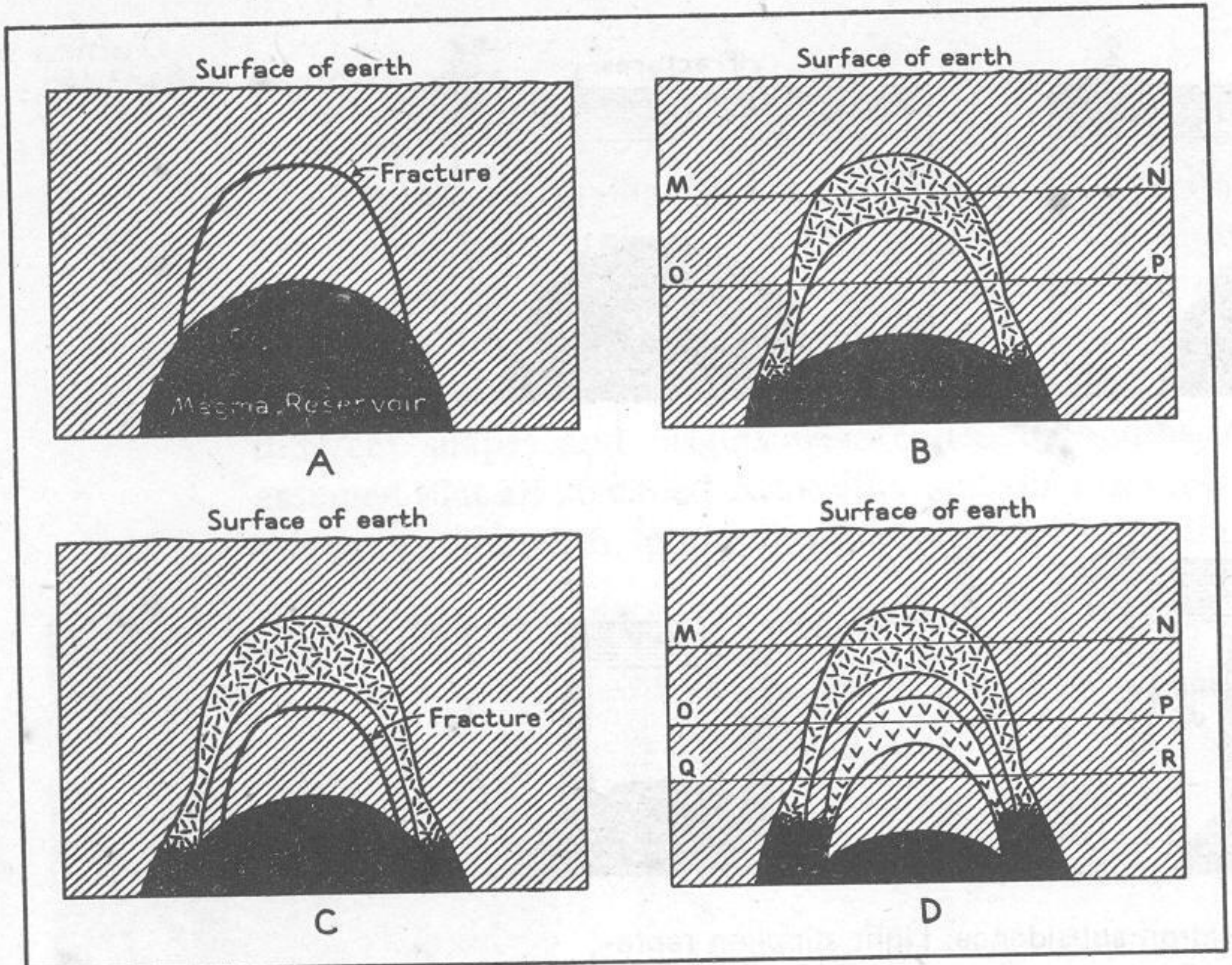


Fig. 16-33. Underground cauldron subsidence. Diagonal lining represents older country rock; diversely oriented short dashes represent one intrusion; checks represent a second intrusion. (A), (B), (C), and (D) represent successive stages of intrusion. *MN*, *OP*, and *QR* are a few of the many levels to which erosion may cut.

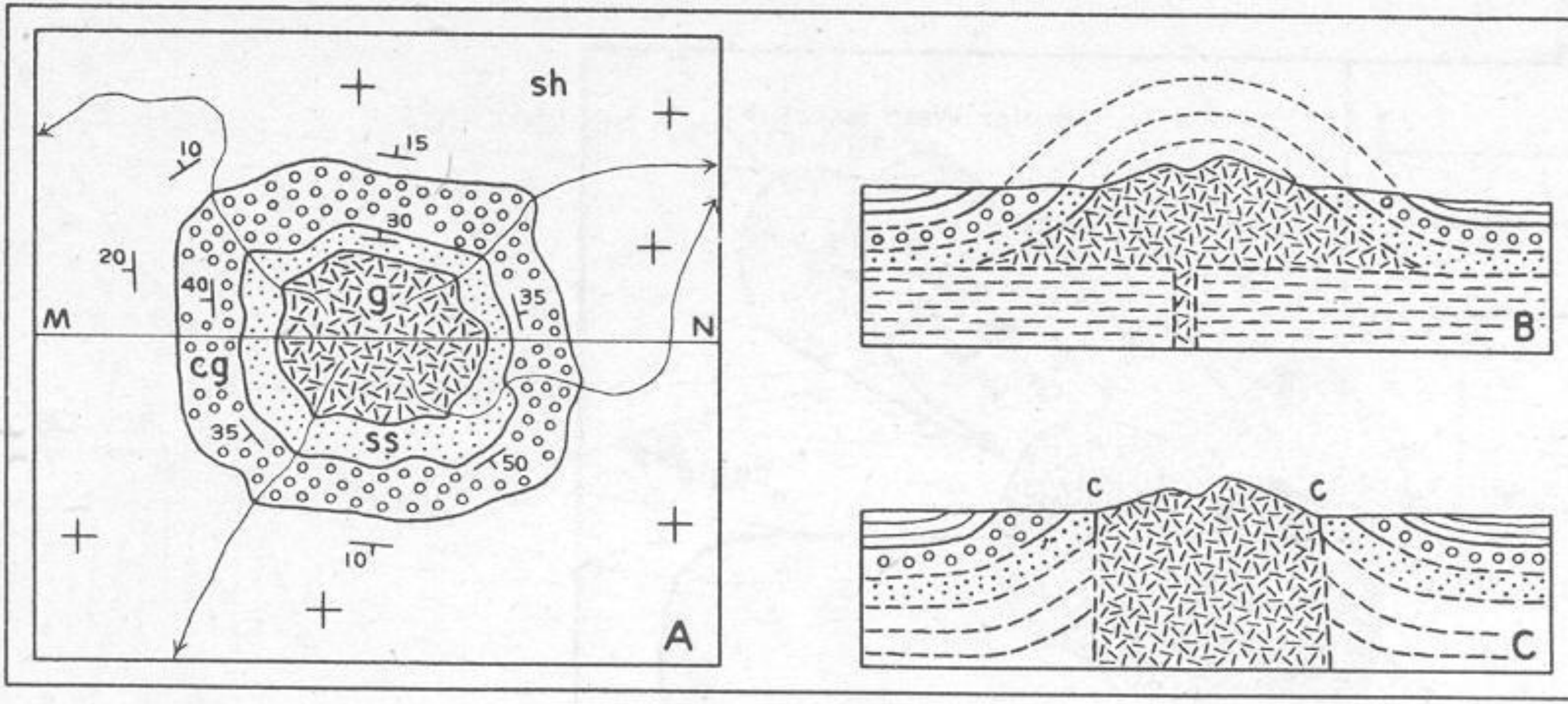


Fig. 16-14. Intrusive rock in the center of domed-up sediments: *g*, granite porphyry; *ss*, sandstone; *cg*, conglomerate; *sh*, shale; *c*, contact of intrusive. The granite porphyry intrudes the sandstone. (A) Geological map. (B) Interpreted as a laccolith. (C) Interpreted as a "bottomless" stock.

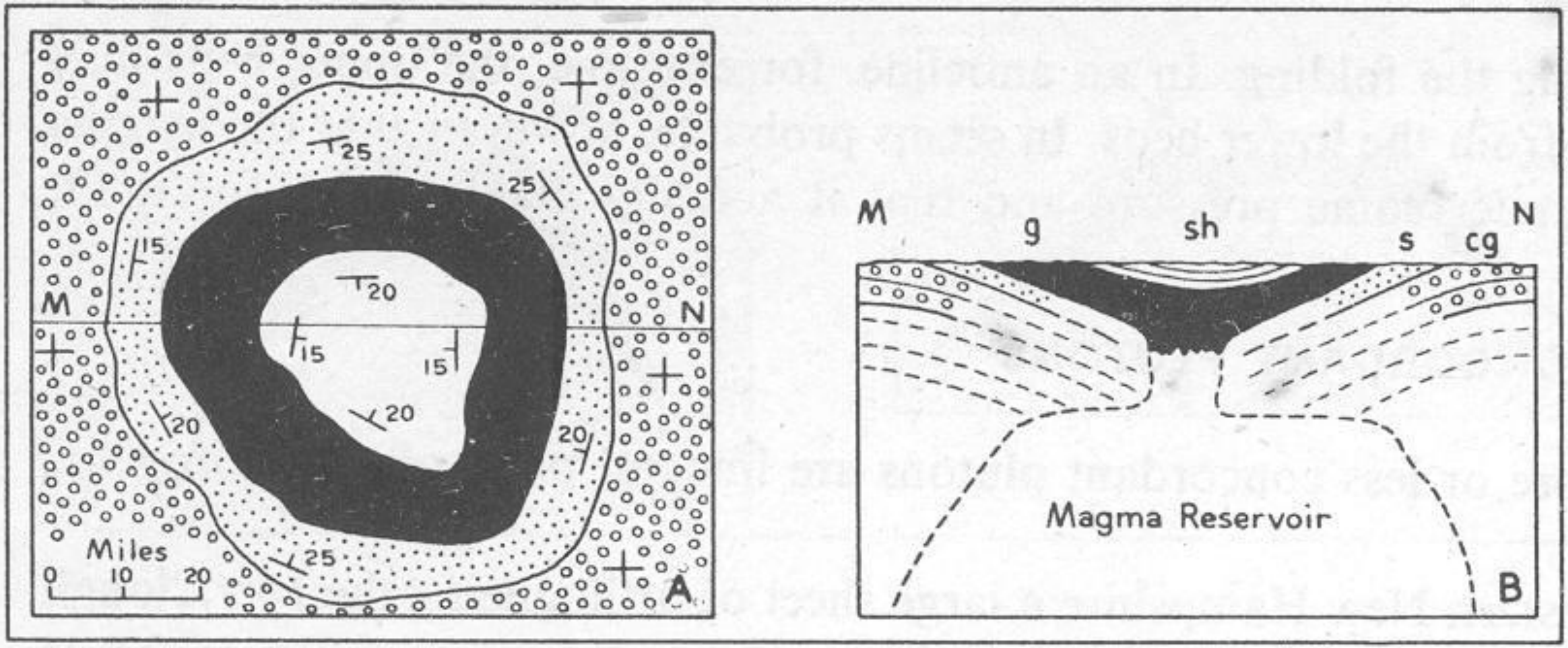


Fig. 16-18. Lopolith : *cg*, conglomerate ; *s*, sandstone ; *sh*, shale ; *g*, gabbro of lopolith. Usual dip-strike symbols ; +, flat strata. (A) Geological map. (B) Structure section.

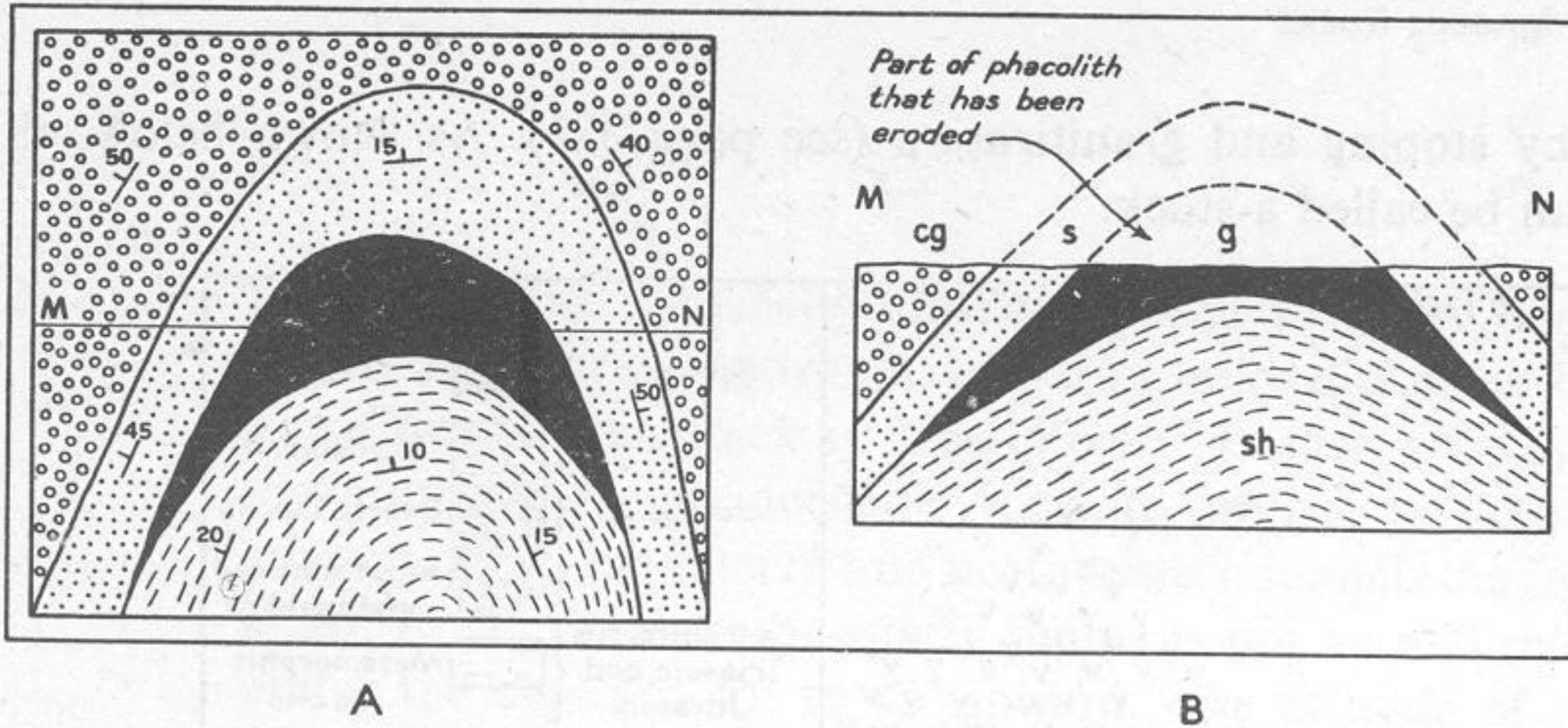


Fig. 16-21. Phacolith : *sh*, shale ; *s*, sandstone ; *cg*, conglomerate ; *g*, granite. (A) Map of granite phacolith in a northerly-plunging anticline. (B) Cross section of the same phacolith.

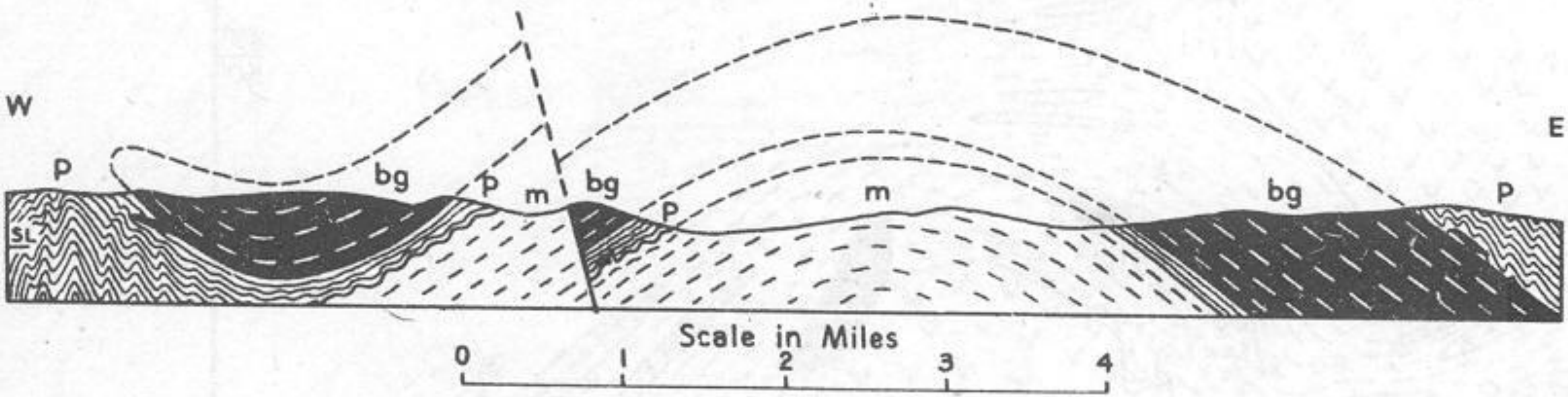


Fig. 16-22. Large concordant pluton, Mascoma quadrangle, New Hampshire. *P*, Paleozoic schists; *m*, granitic rocks of Mascoma group; *bg*, Bethlehem gneiss, which forms a large concordant pluton. (After C. A. Chapman.[14])

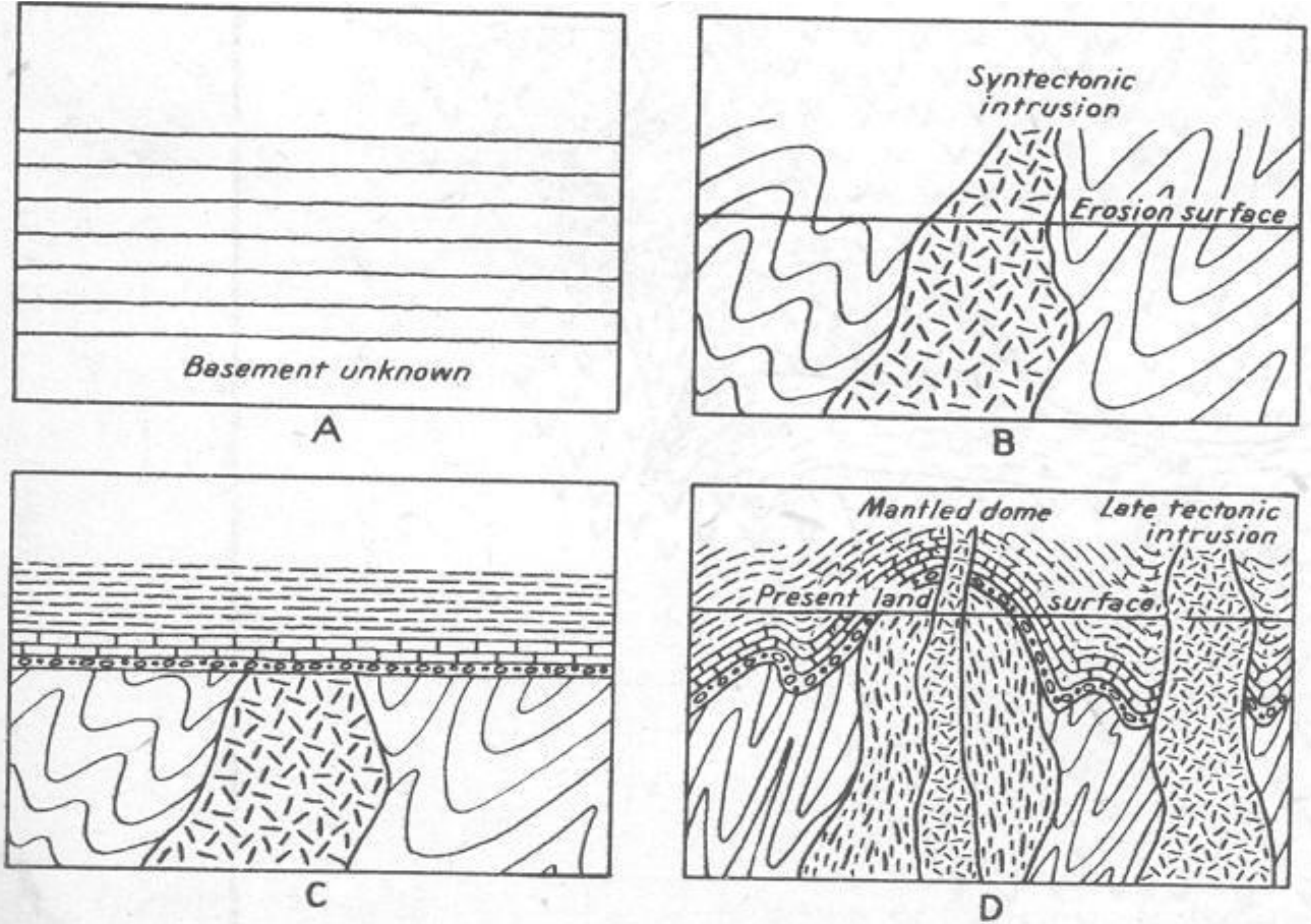


Fig. 16-23. Origin of mantled gneiss domes. (A) First sedimentation. (B) First orogeny. (C) Second sedimentation. (D) Second orogeny. (After P. Eskola.[15])

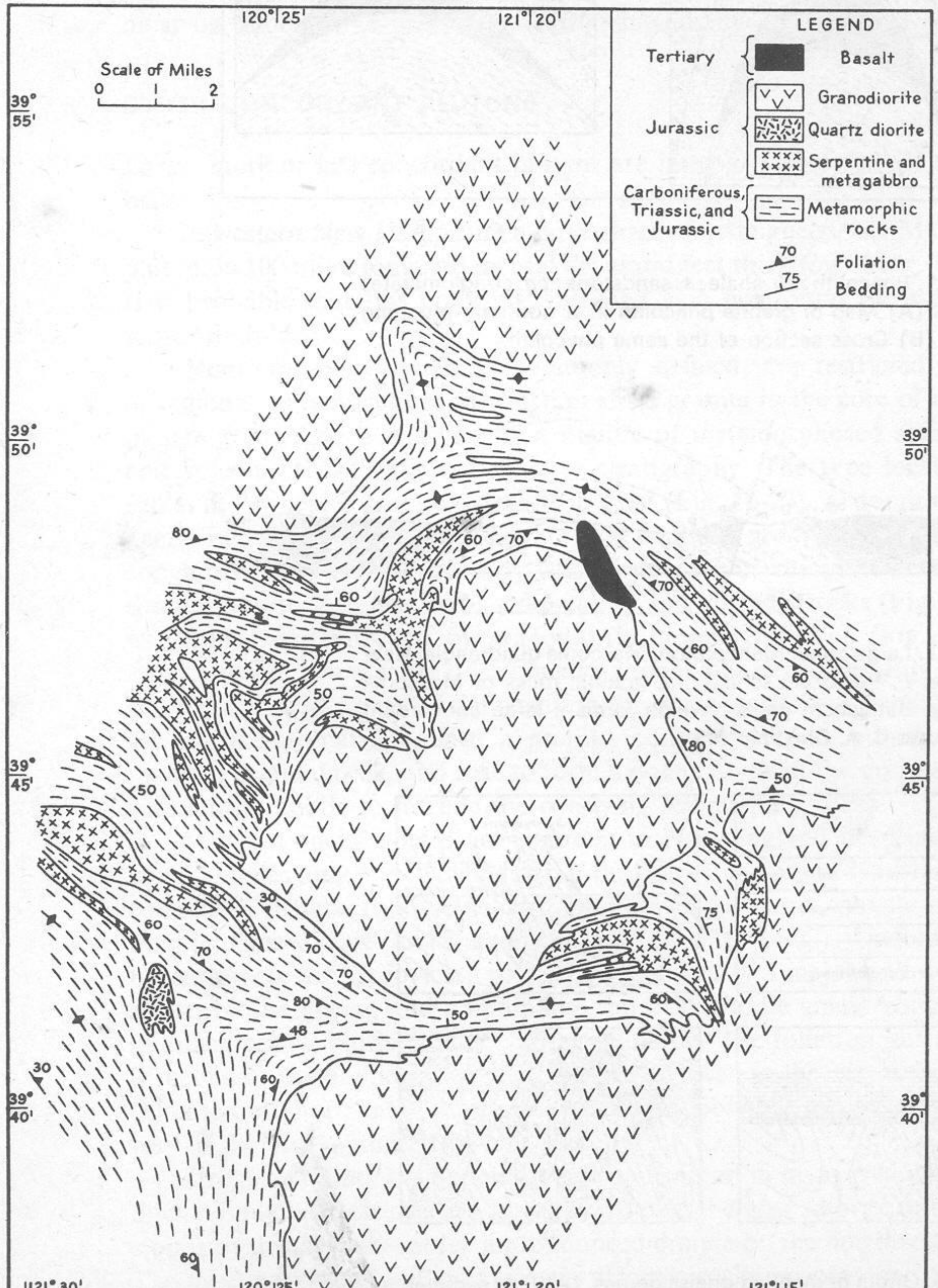


Fig. 16-24. Irregular cylindrical intrusion, composed of granodiorite. Geological map of Merrimac area, California. (After A. Hietanen.[18])

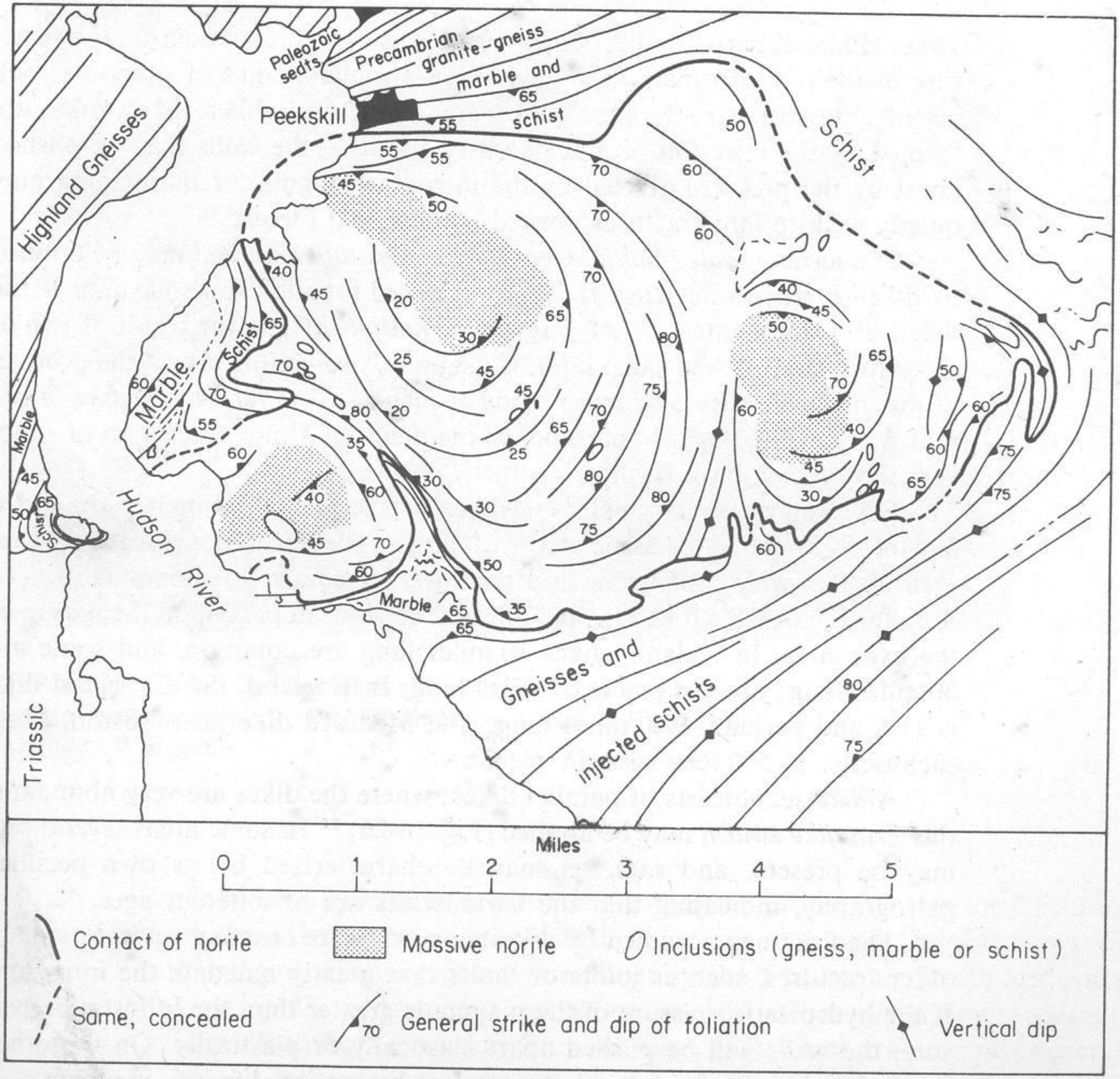


Fig. 16-25. Funnel structure shown by foliation in norite, Cortlandt complex, New York. (After Balk and Shand.[19])

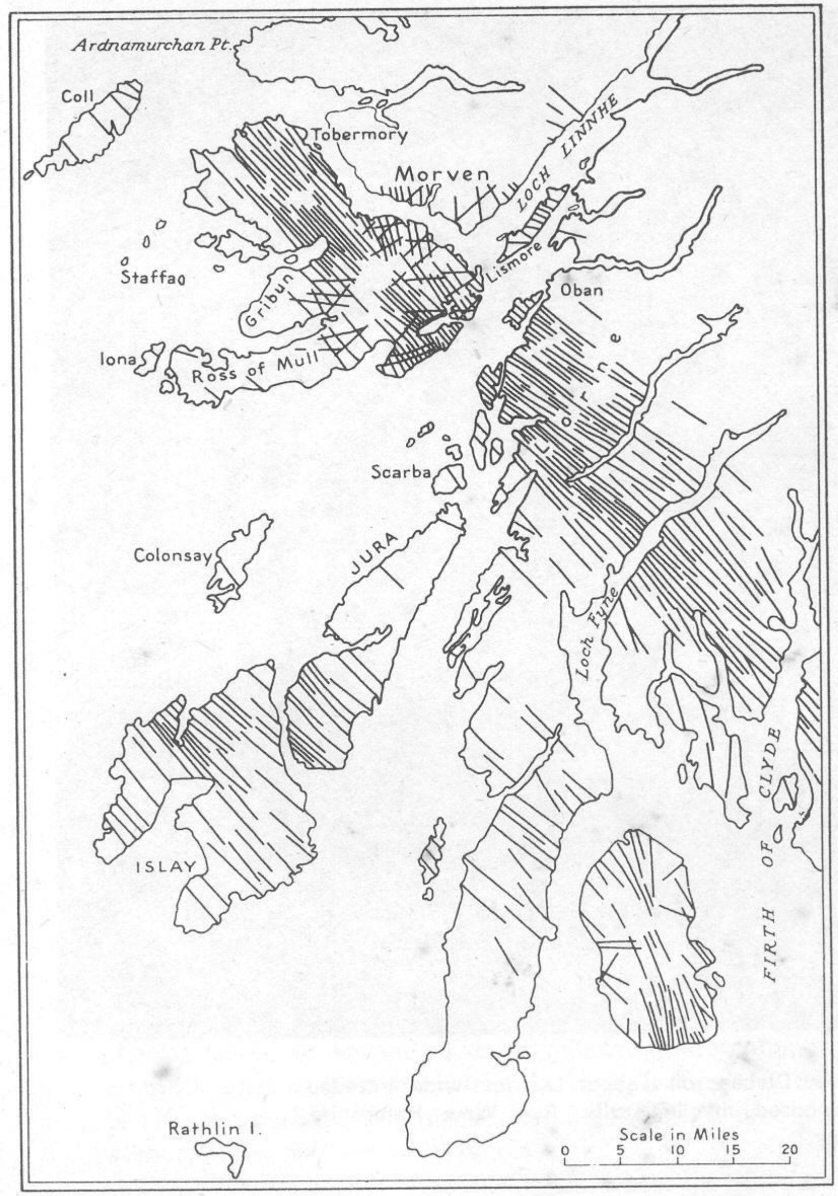


Fig. 16-26. Dike swarm. Tertiary dikes of the Southwest Highlands of Scotland. The map is diagrammatic in the sense that: (a) each line represents 10 to 15 dikes; (b) each dike is only a few feet wide, and not as wide as the scale implies; and (c) individual dikes canot be traced for the long distances that the map implies. (After J. E. Richey,[23] with permission of the Controller of Her Britannic Majesty's Stationery Office.)

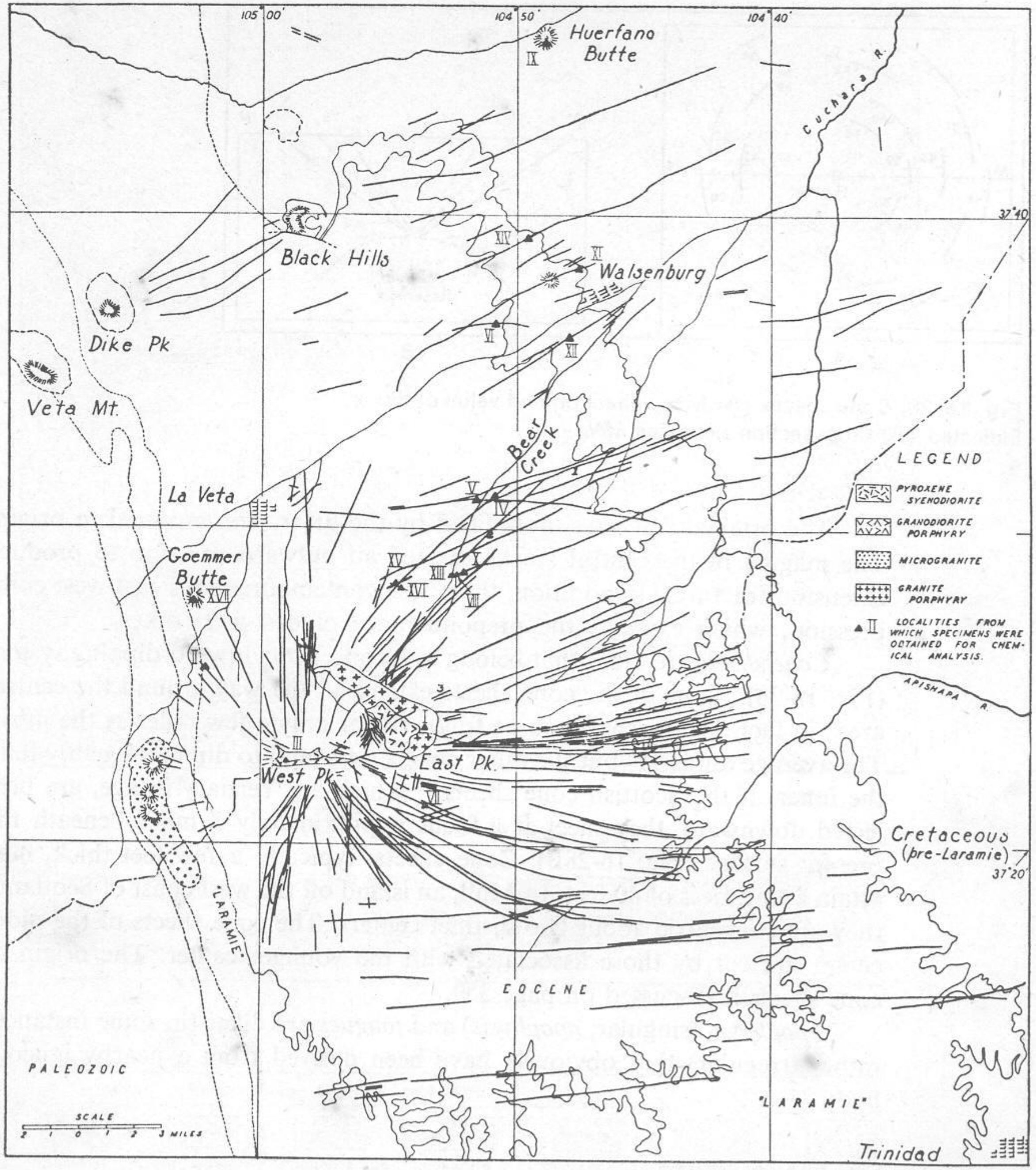


Fig. 16-27. Radiating dikes around Spanish Peaks, Colorado. (After Knopf.[21])

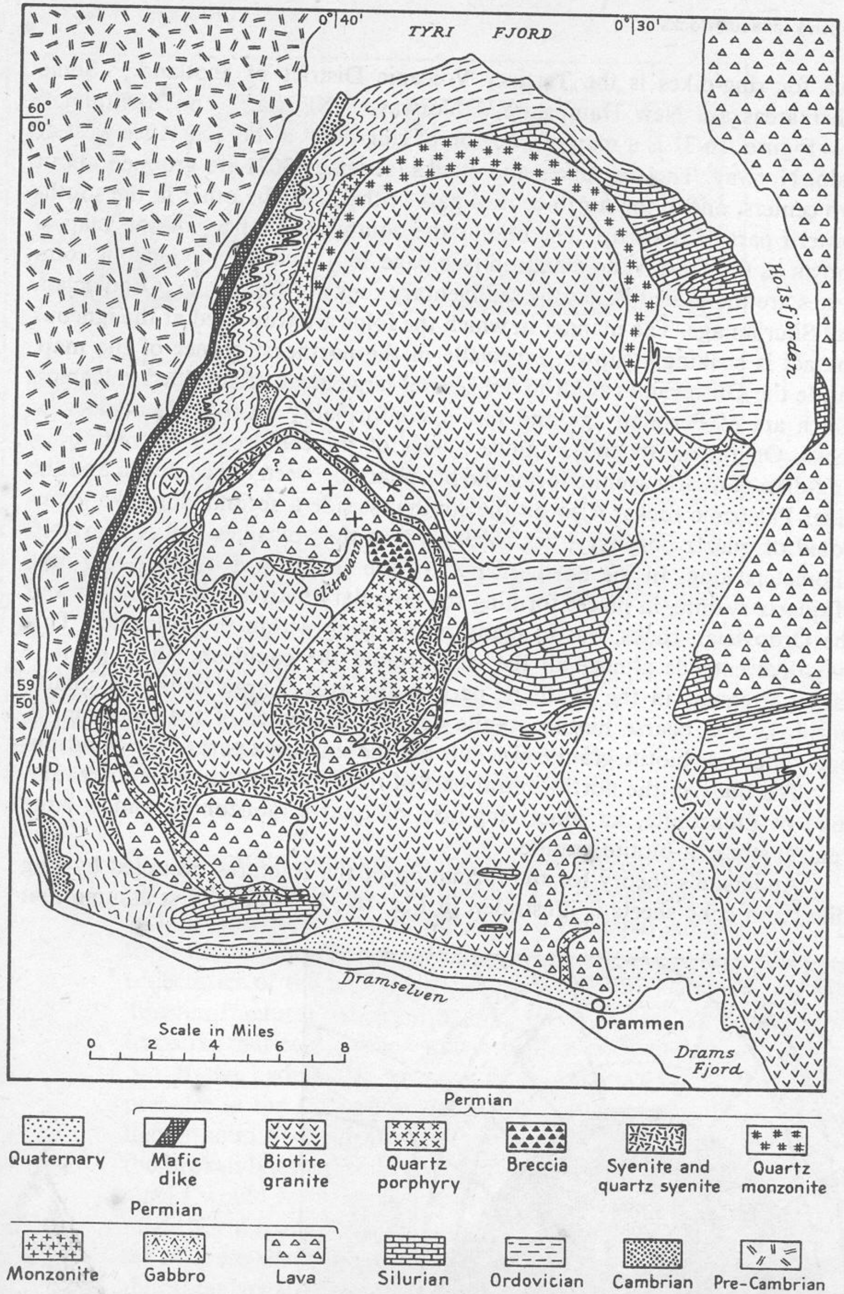


Fig. 16-31. Ring-dikes and stocks. Oslo region, Norway. Longitude is measured west from Oslo. Dip-strike symbols show attitude of volcanic rocks. *D*, downthrown side of gravity fault. (Based on maps by W. C. Brögger, J. Scheltig, and C. Oftedahl.[26])

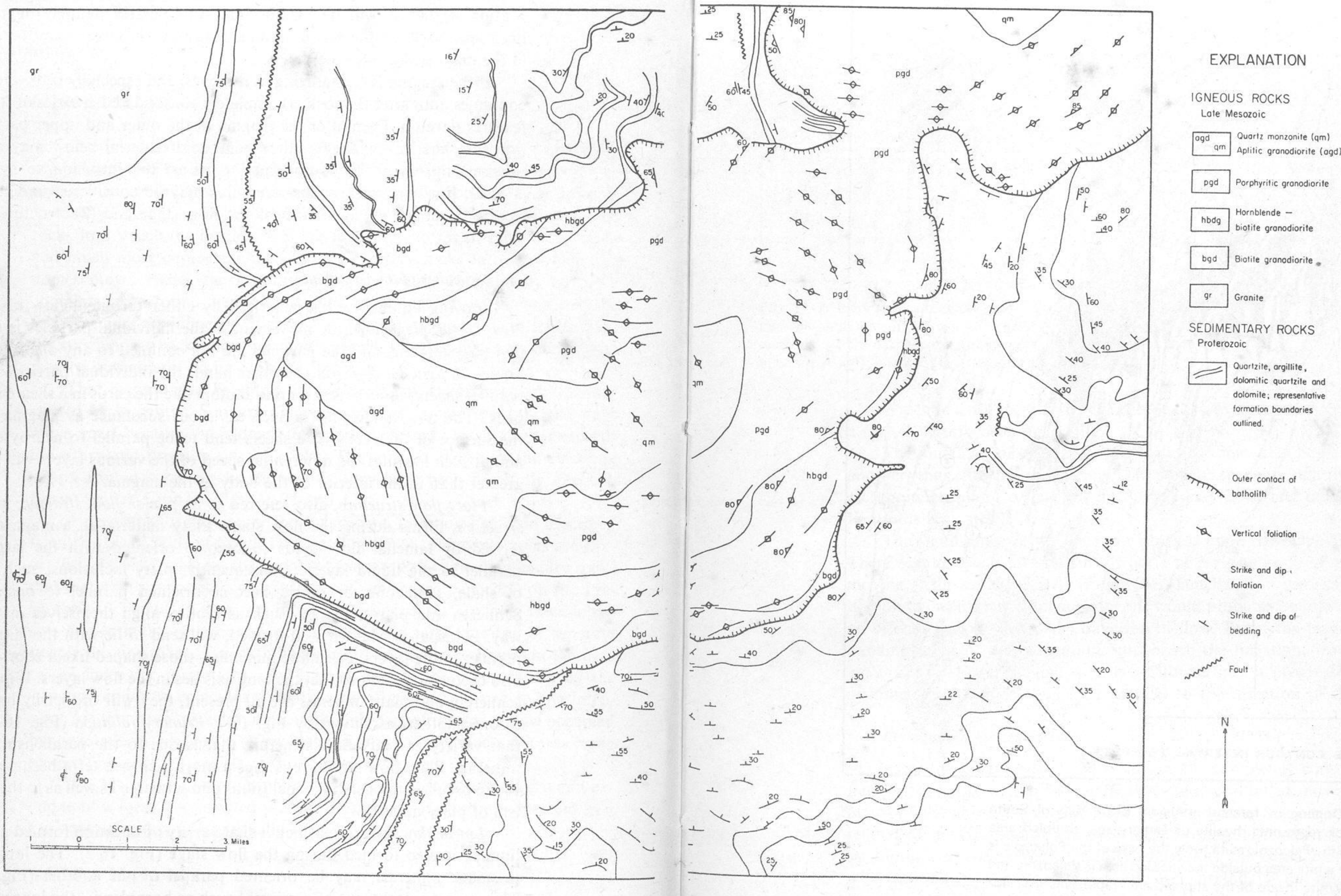


Fig. 17-5. Forceful injection. Mesozonal batholith of Mesozoic age. White creek batholith, British Columbia. (After Buddington.[4])

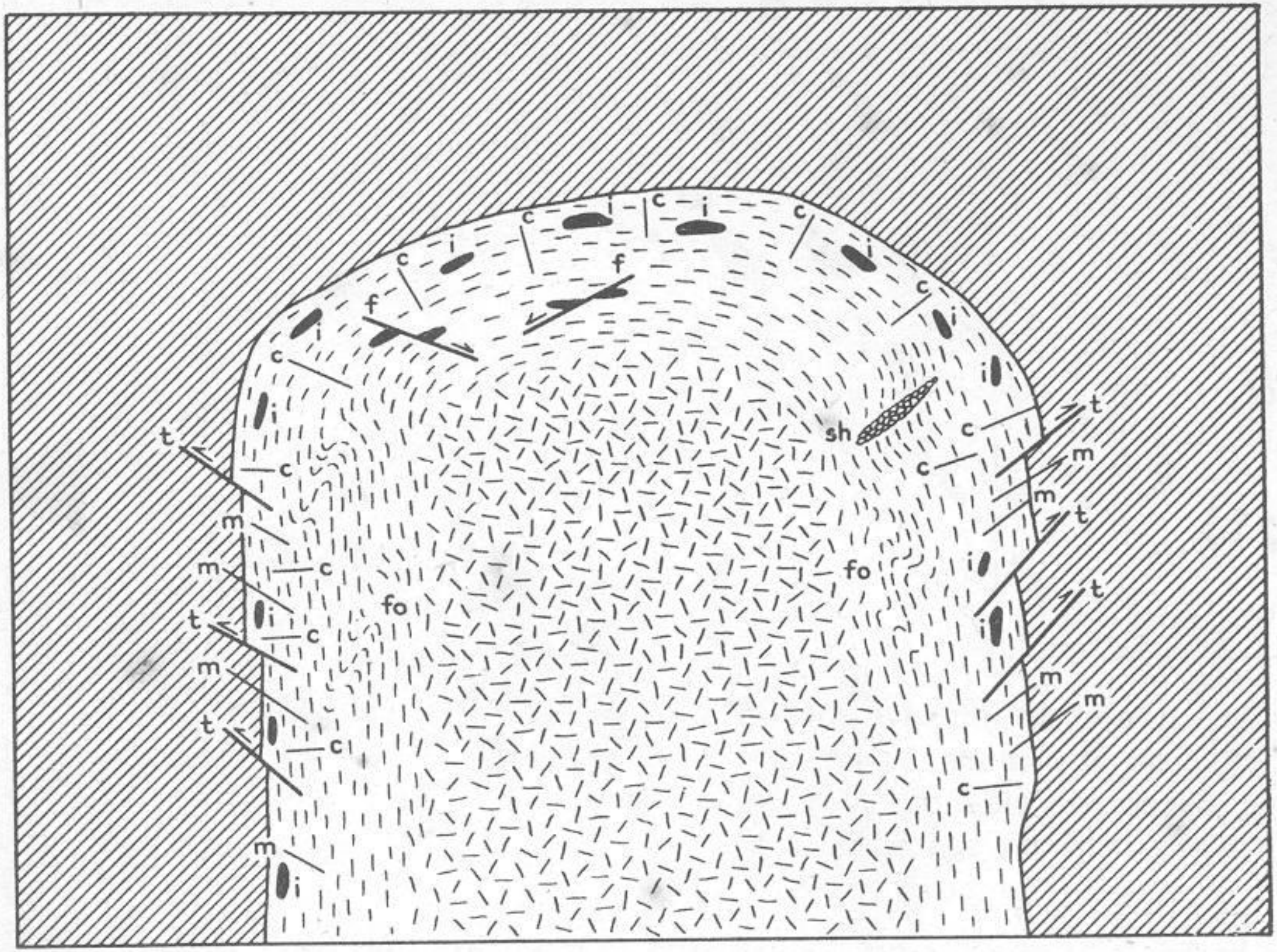


Fig. 17-8. Cross section of a hypothetical pluton. Section is parallel to strike of the linear flow structure. Short dashes are platy minerals ; *i*, inclusion ; *fo*, flexure ; *sh*, shear filled with pegmatite or coarse granite ; *c*, cross joint ; *m*, marginal fissure ; *t*, marginal thrust ; *f*, flat-lying normal fault.

DIAPIRS

- A diapir or piecement structure results from the upward intrusion of a more light material into/through overlying strata.
- As ancient seas evaporated they left salt deposits that were buried by sediment.
- The salt deposits were less dense than overlying rock the buoyant mass of salt ballooned upward, intruding into the overlying rocks through weak spots, the intruding "salt bubble" is called a salt diaper.
- The flow may be produced by gravitational forces (heavy rocks causing underlying lighter rocks to rise), tectonic forces (mobile rocks being squeezed through less mobile rocks by lateral stress), or a combination of both. Diapirs may take the shape of domes, waves, mushrooms, teardrops, or dikes

Diapir - Structure
Diapiric - Force
Diapirism - Process

All derived from Greek work – “DIAPERIGN” – Meaning “To Pierce through”

- Concept was originally confined to injection of Sedimentary strata
- The rocks commonly involved are evaporites (rock salt, gypsum, anhydrite) Shale and Serpentine
- Concept gradually expended to include all type of piercement including Magmatic Injection

Salt Diapir - Due to density contrast and Buoyancy

Igneous Diapir - Mostly due to emplacement by horizontal forces

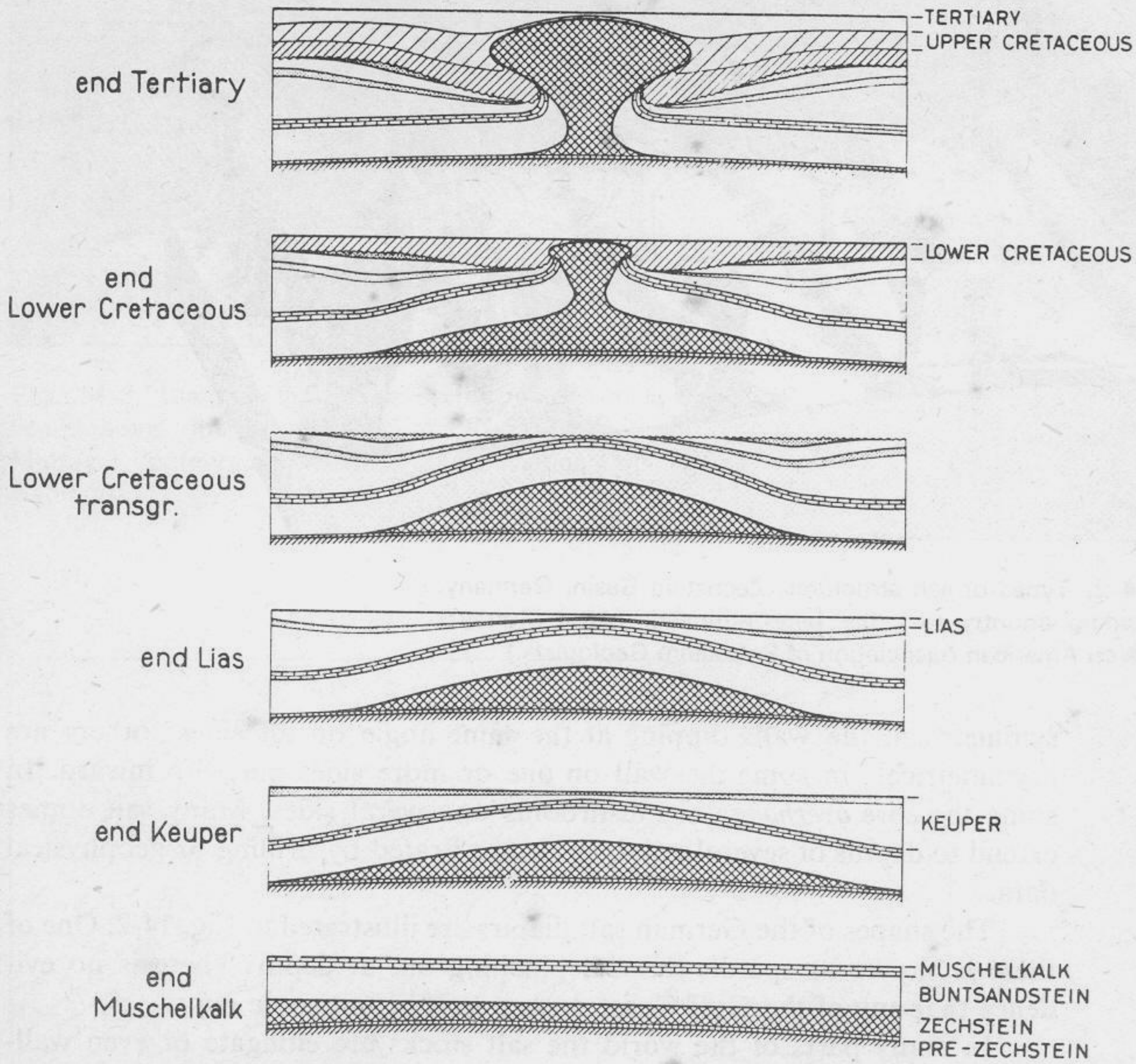


Fig. 14-1. Hypothetical development of a salt stock in northwest Germany. (After Sannemann;[3] permission American Association of Petroleum Geologists.)

Salt Dome / Evaporite Diapir

Chiefly consist of Halite (sometime anhydrite and gypsum)

Shape

- **Circular or elongate in plan with one to few miles**
- **Walls dips steeply outward**
- **Top may be flat or domical**
- **Some are symmetrical with well dipping at same angle**
- **Some walls may dip inward and some are over hanging or mushrooms**

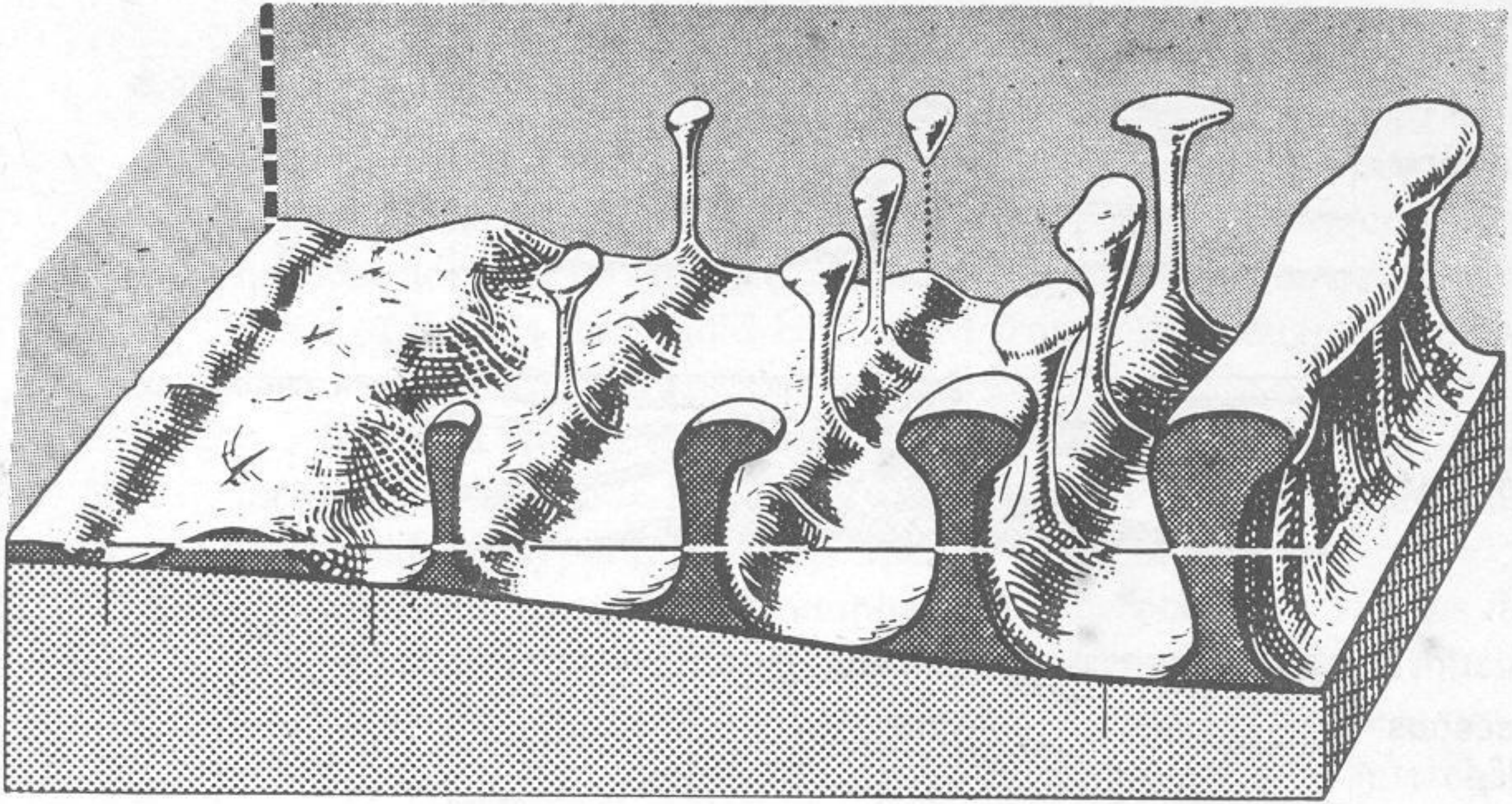


Fig. 14-2. Types of salt structures, Zechstein Basin, Germany. Surrounding country rock has been removed. (After Murray;[1] permission American Association of Petroleum Geologists.)

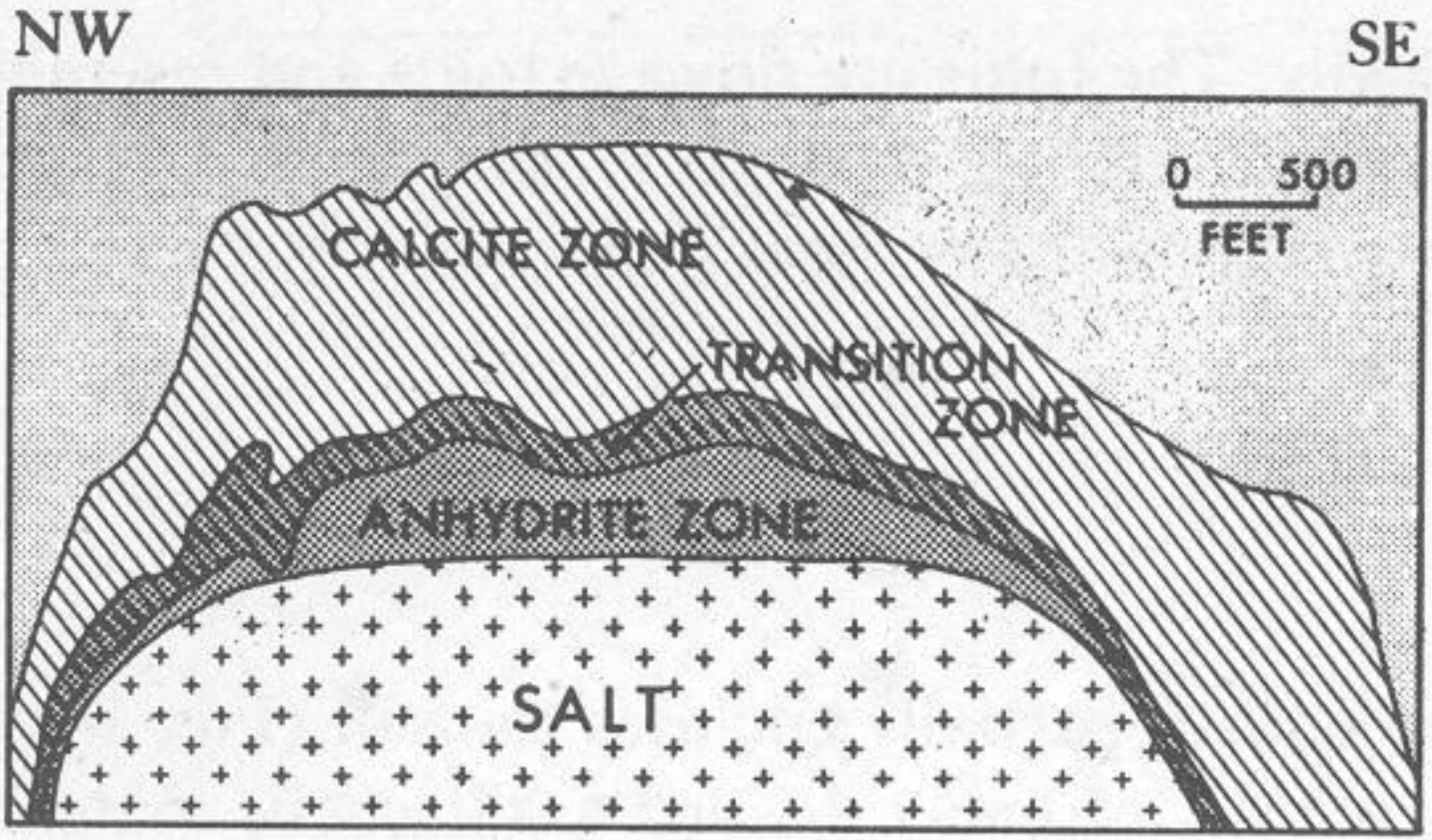


Fig. 14-3. Diagrammatic cross section of cap rock, Jefferson Island dome, Iberia and Vermilion Parishes, Louisiana. (After Murray;[1] permission American Association of Petroleum Geologists.)

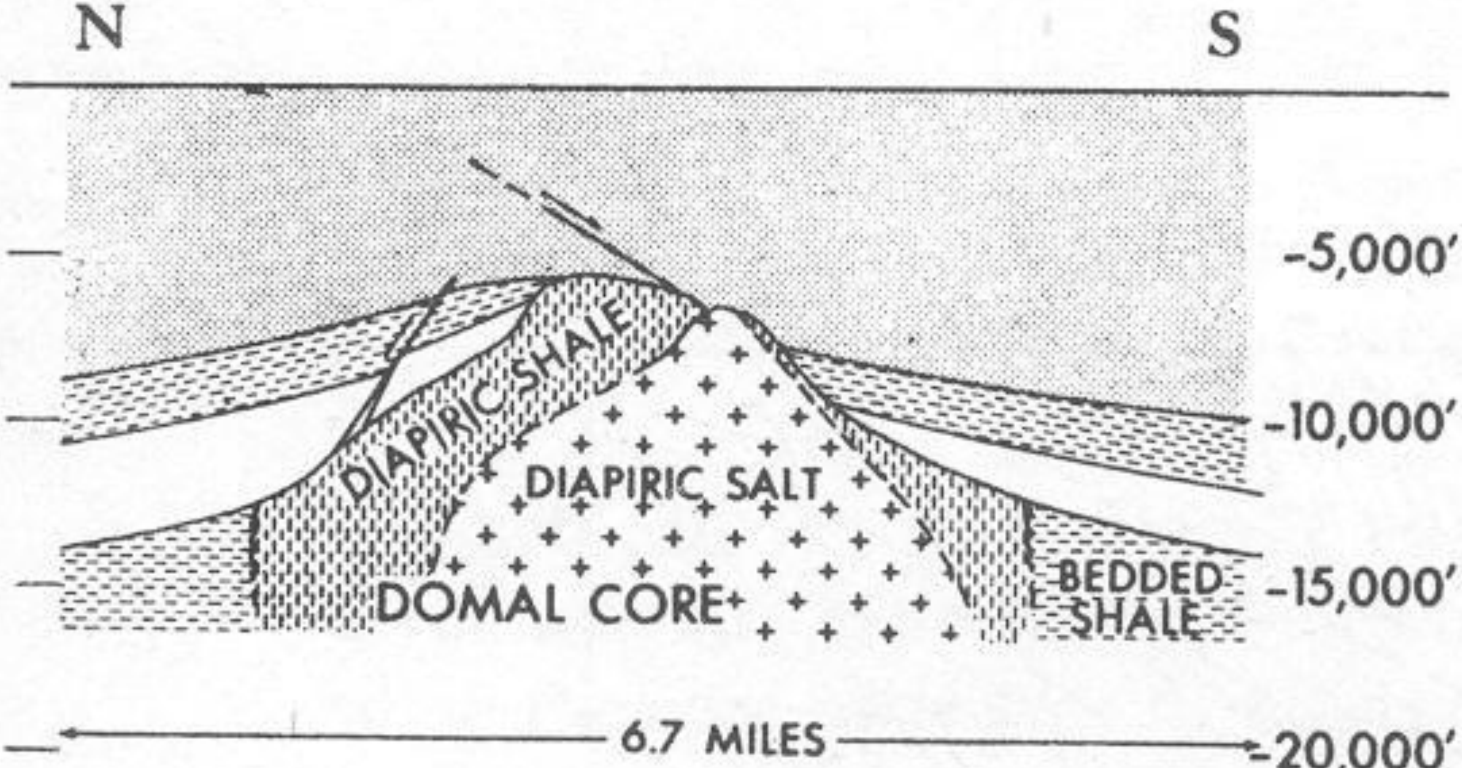


Fig. 14-5. Diapiric shale associated with a salt dome. North-south cross section of Valentine dome, Louisiana. (After Murray;[1] permission American Association of Petroleum Geologists.)

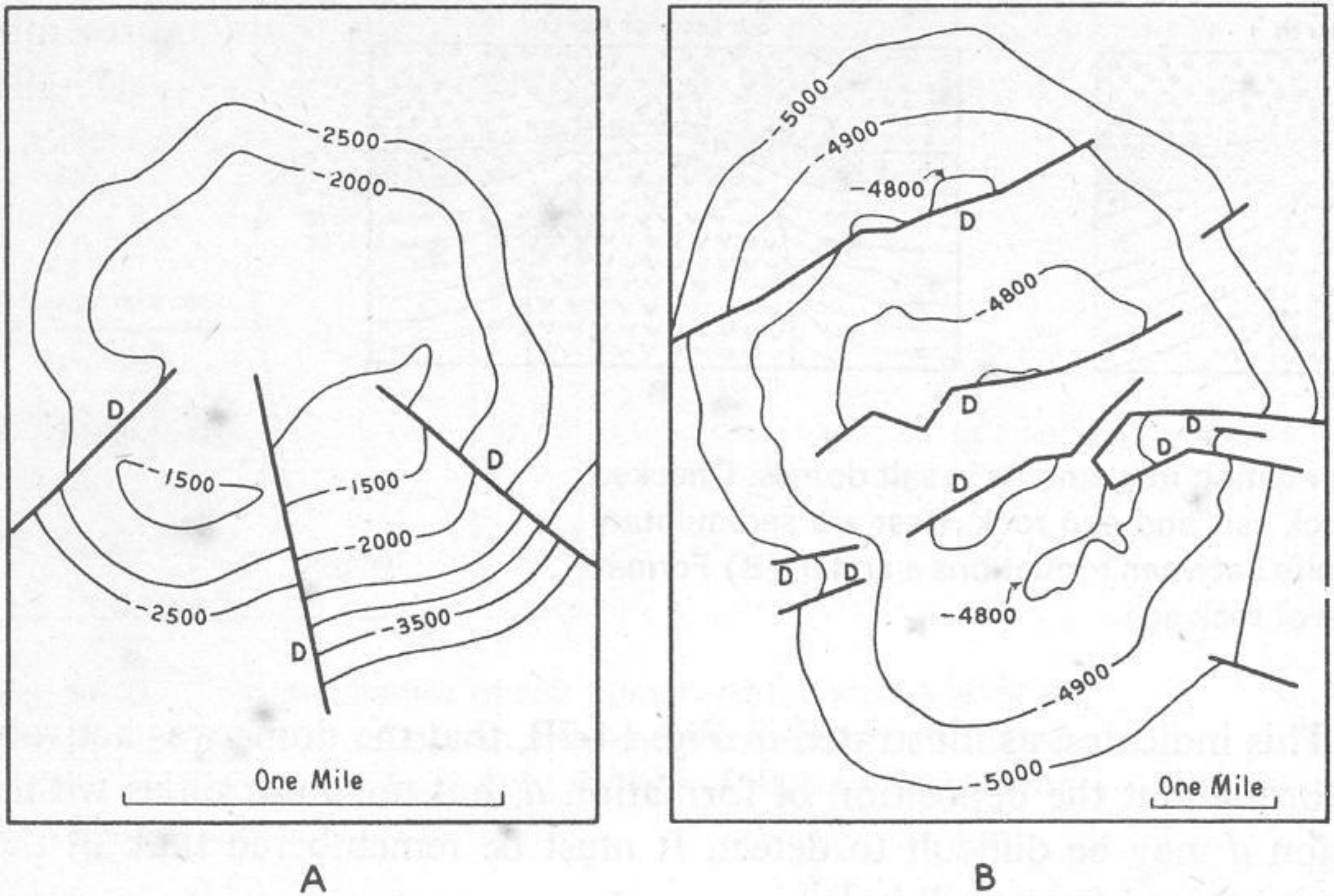


Fig. 14-6. Faulting on salt domes. Heavy black lines are faults; *D* is the downthrown side. (A) Clay Creek salt dome, Texas; structure contours on top of cap rock; contour interval 500 feet. (After W. B. Ferguson and J. W. Minton.) (B) Conroe oil field, Texas; structure contours on top of main Conroe sand; contour interval 100 feet. (After F. W. Michaux, Jr., and E. O. Buck. Data from *Bulletin American Association Petroleum Geologists.*)

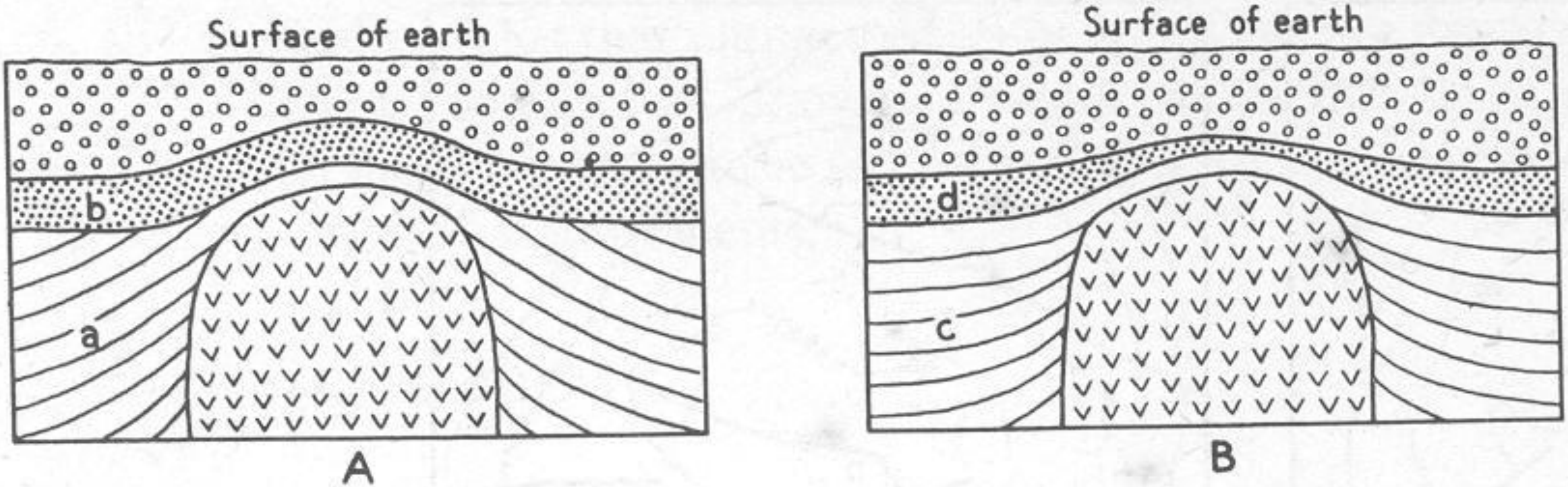


Fig. 14-7. Criteria for dating movements in salt domes. Checked area is the core of rock salt and cap rock. Rest are sedimentary rocks. (A) Unconformity between formations *a* and *b*. (B) Formation *d* thins over core of rock salt.

Internal Structures

- Vertical walls
- Ceilings show isoclinal, attenuated, refolded, faulted folds with vertical plunge
- All the above folds are due to flowage
- Salt moved upward as lobes and spins a series of differential movements so the complex flow folds are develops.

Origin

- Intrusion of solid halite into surrounding sediments
- Difference in density between salt and the overlying sediments
- Rock salt has got uniform density (2.2 g/cm2) invariable of its depth (but changes with amount of anhydrite and temperate)
- But sediments (average density 1.9 to 2.2 g/cm2 upto 2000 feet)
- But below 2000 feet sediment change its density progressively to a value of 2.46 at 20,000 feet.
- Under this unstable gravitational condition of density variation at depth below a 2000 feet or so the salt tends to more upward (similar to lighter fluid moves upward through heavier fluid)
- This movements initiated where there is a minor anticlinal flexure exist on top of the original salt bed.

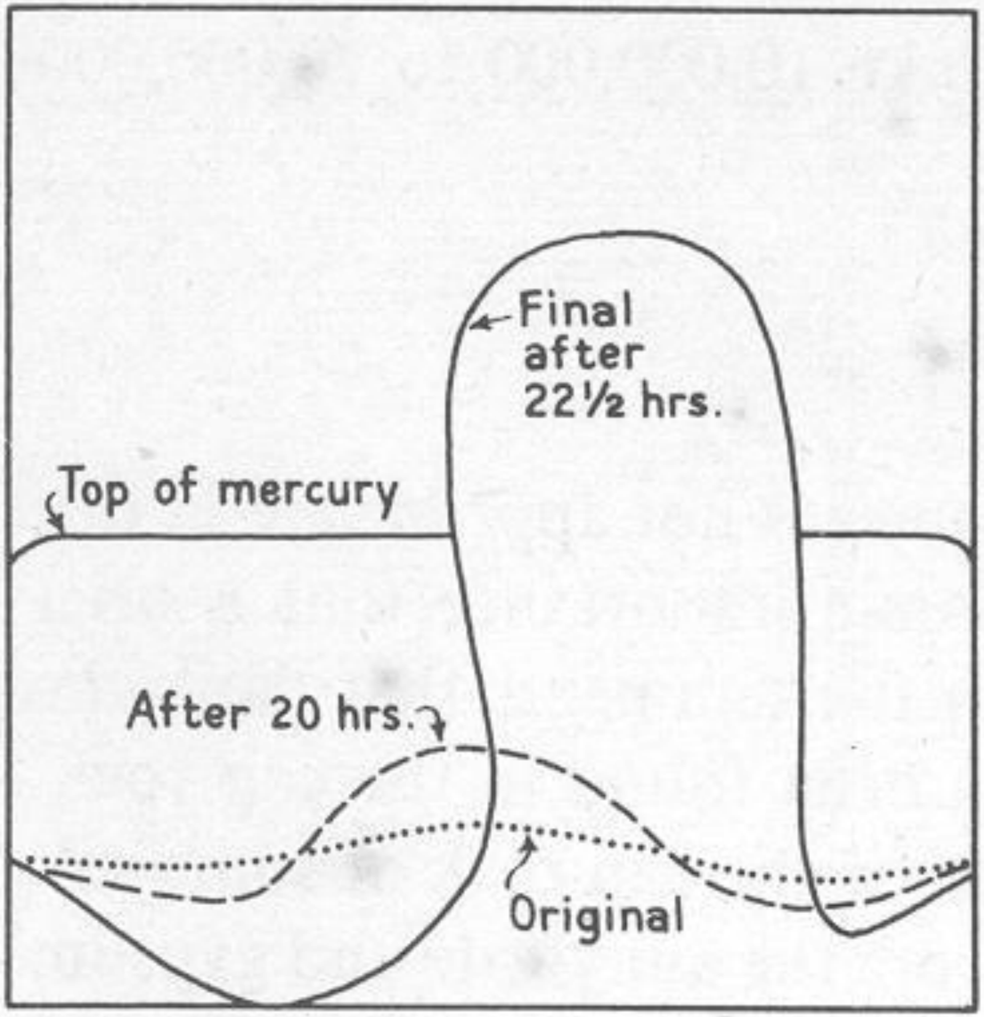


Fig. 14-8. Fluid mechanics of salt domes. At the start a layer of paraffin lies beneath the dotted line, and the mercury lies above. (After L. L. Nettleton.[8] Data from *Bulletin American Association Petroleum Geologists.*)

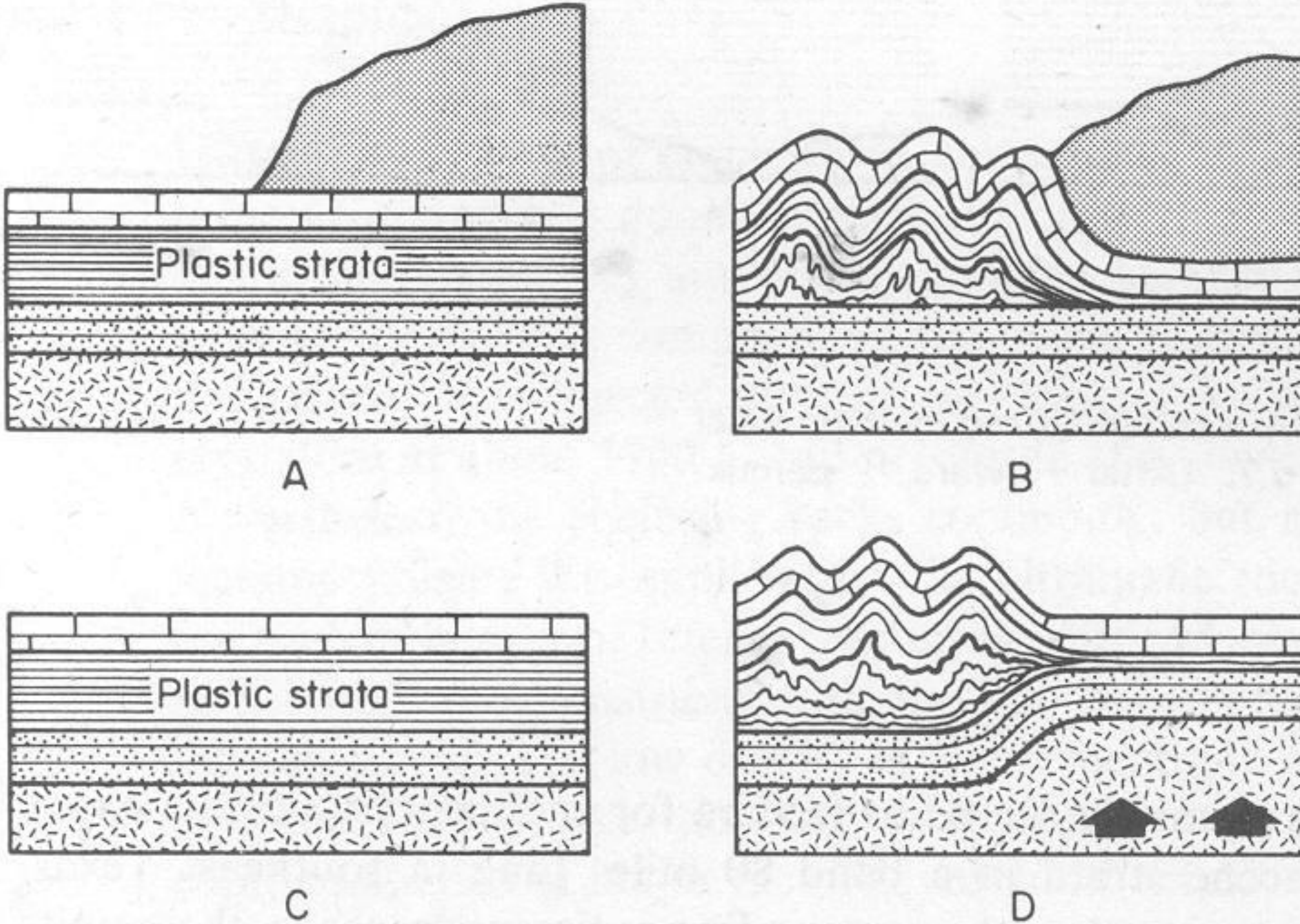


Fig. 14-11. Injection folding. (After Beloussov.)

SHEAR ZONE

SHEAR ZONE

Shear zones are defined as planar or curvi planar zones of higher deformation which are long relative to their width (5:1) which are surrounded by rocks showing lower state of finite strain.

Types of Shear zone.

Ductile Shear - Deformation state varies continuously from wall to wall across the zone.

Brittle Shear - Walls are separated by a clearly defined discontinuity of fracture surface – (eg. Fault).

Brittle–ductile Shear - Where the tangential (wall parallel) movement along the Zone is associated with both ductile shearing and brittle fault.

In many regions the Ductile and Brittle - Ductile shear zones may be the deep level counterparts and brittle shear zones and faults seen at high level in the crust.

Recognition of Shear Zone

- An unusually regular layering of constant thickness.
- A straight linear shapes fabric in the plane of the layering
- Presence of isoclinal and sheeth folds in the layering with fold axes sub parallel to the lineation.

SENSE OF SHEAR

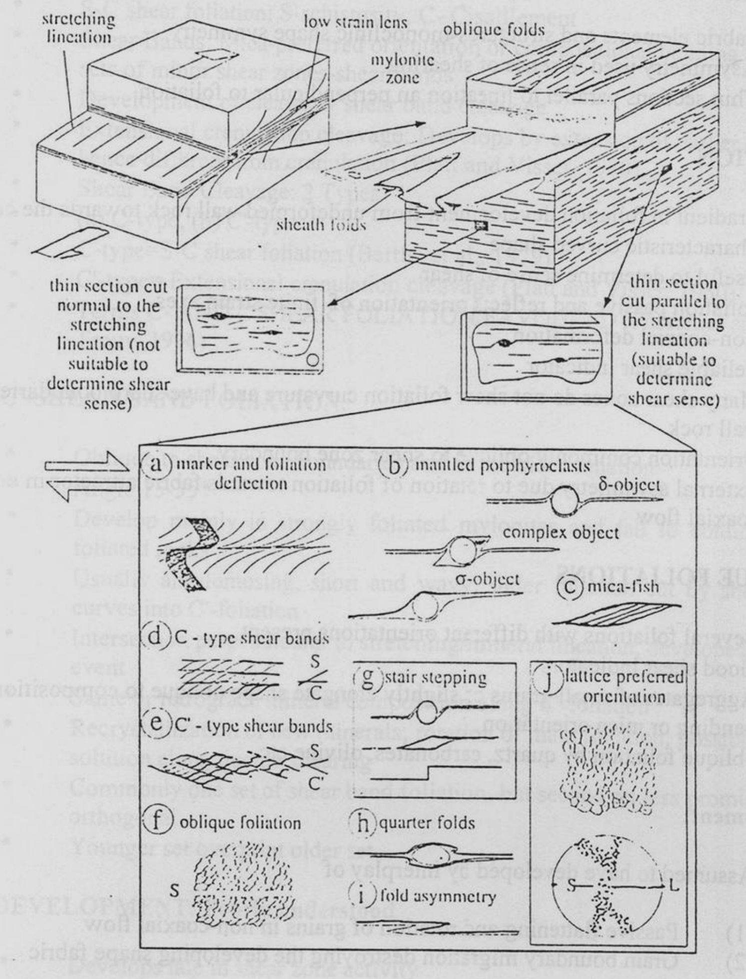


Figure 4: Geometry of a ductile shear zone and various shear criteria used for deciphering sense of displacement.

Shear Zone rocks

"MYLONITE"

In the very coarse grained rock (Granite or Quartzite) the coarse grains are strained and drastic grain reduction takes place mainly through recrystallisation (large grains / Porphyroclasts / Residual mega crysts surrounded by fine grained matrix.)

Protomylonite	-	Mylonite Orthomylonite	-	Ultramylonite
50:50	-	50 – 90 % Matrix	-	10 : 90 Matrix

The process of grain refinement is often associated with extreme stretching along newly formed foliation.

Fabric – foliation and lineation

S – C Fabric S = Schistosity; C = Cisaillement

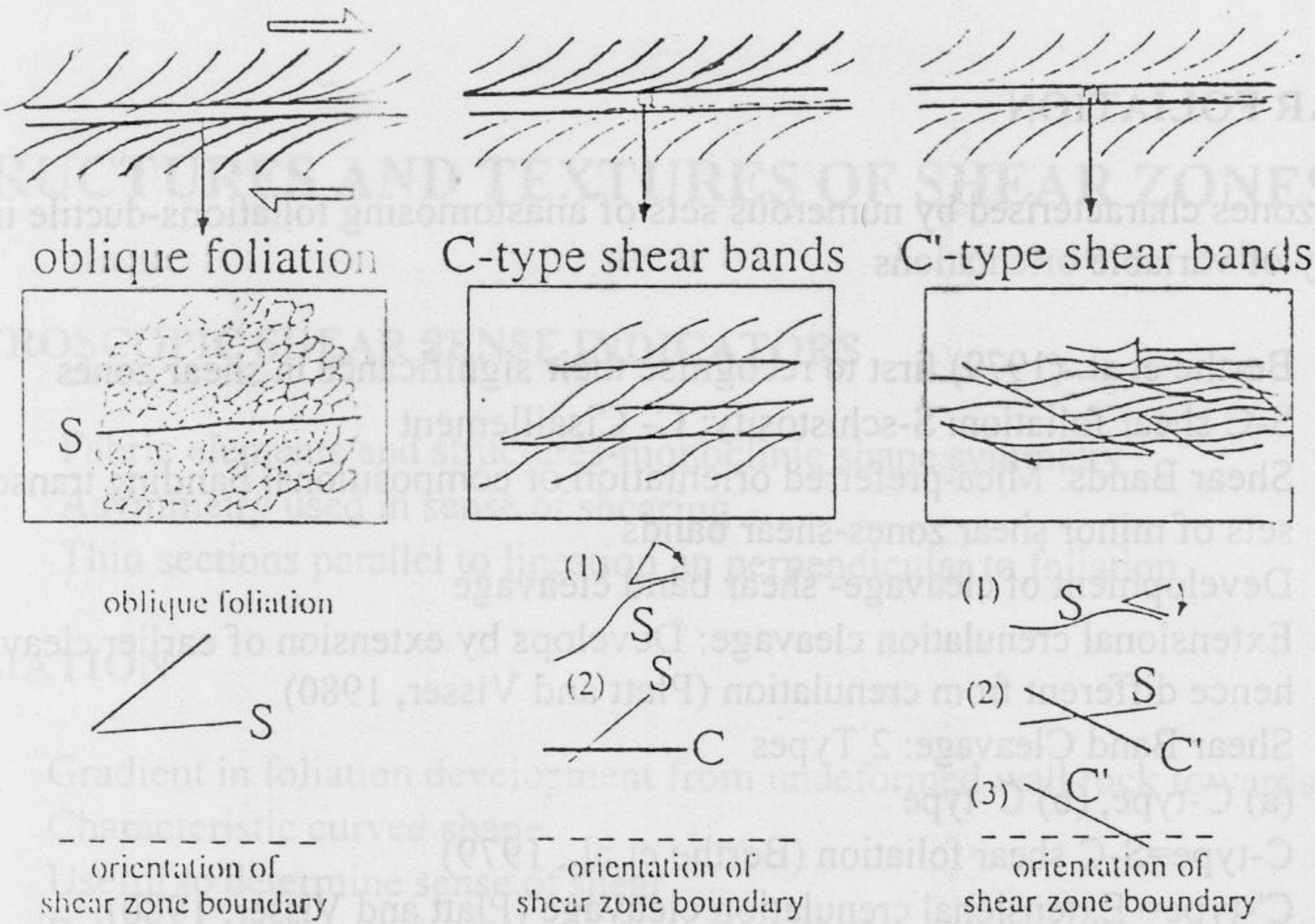


Figure 5: **Different kinds of foliations characteristic of ductile shear zone**

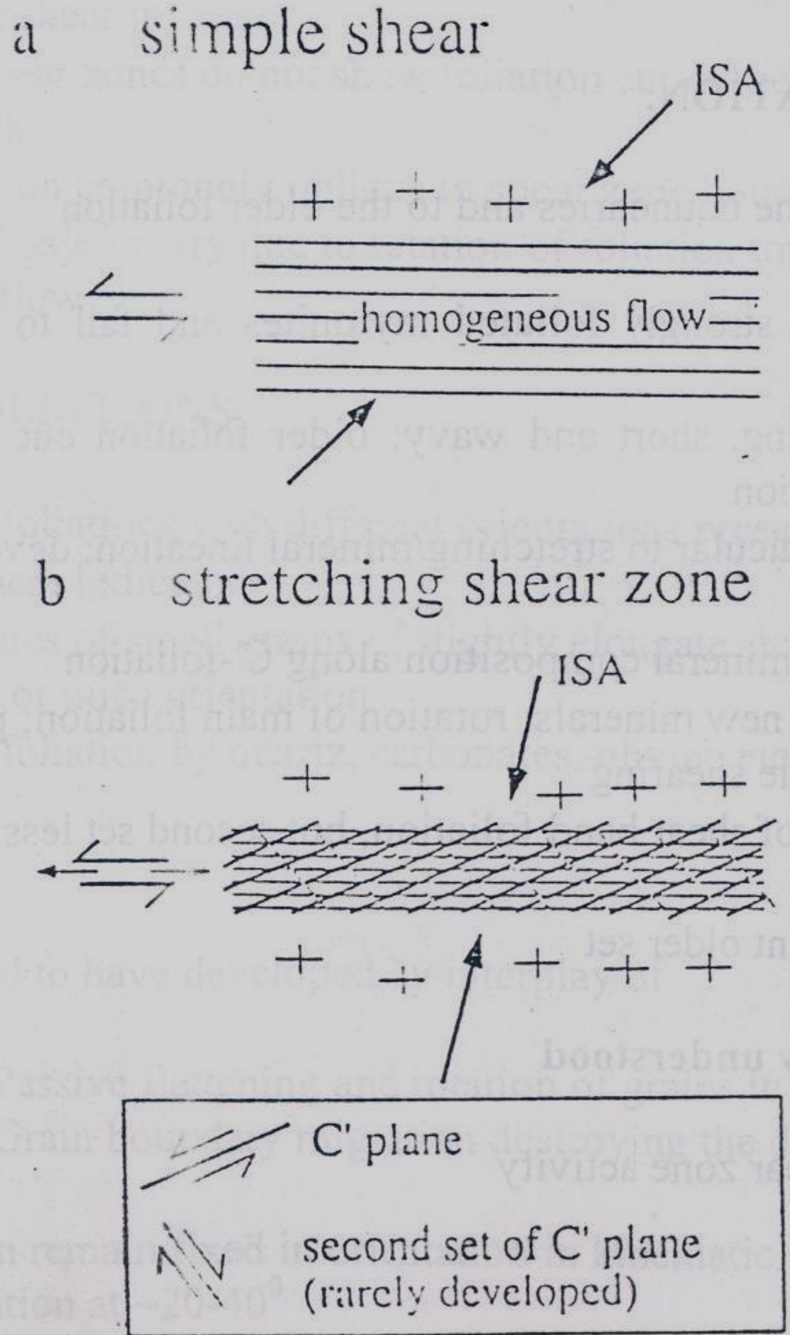


Figure 6: Development of C' and C" foliations in present ductile shear zones

CATACLASTITE:

Grain refinement is by the cataclastic process
Deformation is by sliding and rotation of grains

Protocataclastite –	Cataclastite –	Ultracataclastite
50 : 50	50 – 90 % Matrix	10 : 90 Matrix

Both Mylonite and Cataclastite are the product of Cohesive shear zone.

Non – Cohesive rocks (Fault Breccia & Gouge)

Mainly produced by crushing on the fault surface

Fault breccia – large grains in a pulverized groundmass.
Gouge – Extremely fine rock flour (fully pulverized material)

Pseudotachylite :

- Developed from local melting due to frictional heating
- Angular rock fragments in a glassy matrix
- Matrix might have undergone various degree of re – crystallization but does not show any preferred orientation of recrystallised grains
- Psudotachylite is considered important because it is assumed that they are the indicators of ancient earth quake at depth (Sibson 1975)
- But association of psudotrachylite and mylonite puts a ? to the above inference.

  Psudotrachylite – fault indicator (brittle faults)
  Mylonite -- Shear zone indicator (Show plastic process)

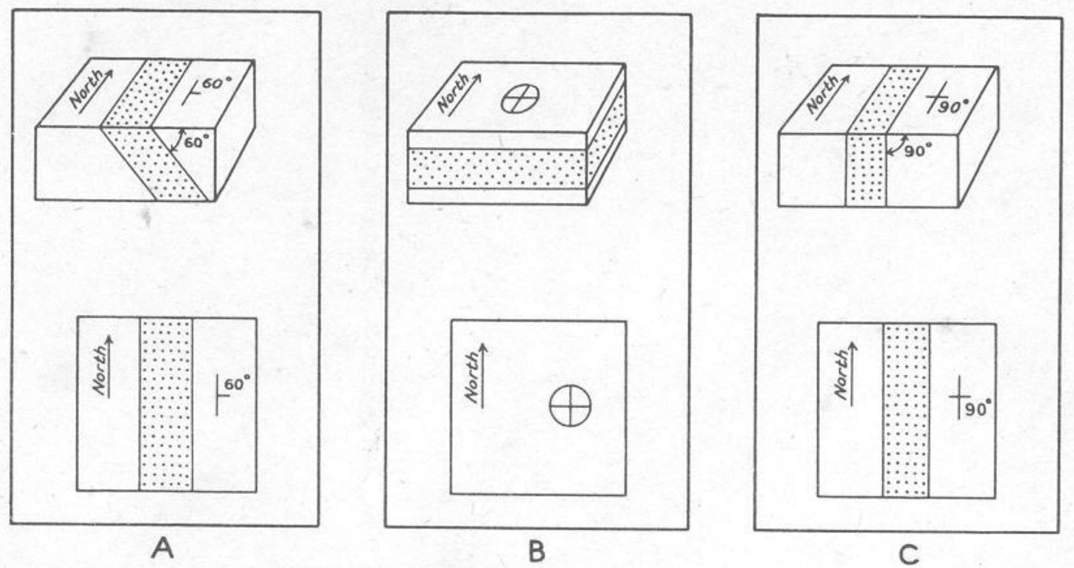


Fig. 3-1. Dip-strike symbols used for inclined, horizontal, and vertical strata. Block diagram above, map below. (A) Inclined strata. (B) Horizontal strata. (C) Vertical strata. The position of the 90° may be used to indicate the top side of the bed (see page 81).

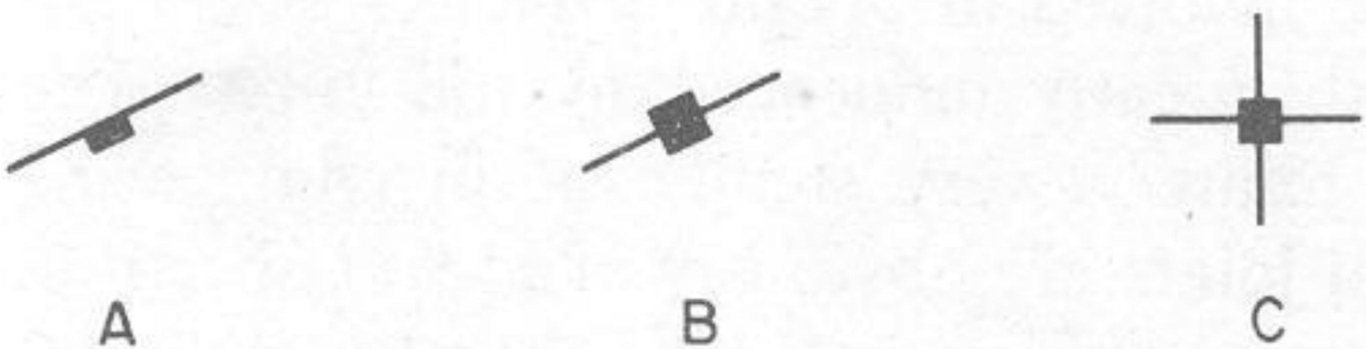


Fig. 7-3. Map symbols for joints. (A) Strike and dip of inclined joint. (B) Strike of vertical joint. (C) Horizontal joint.

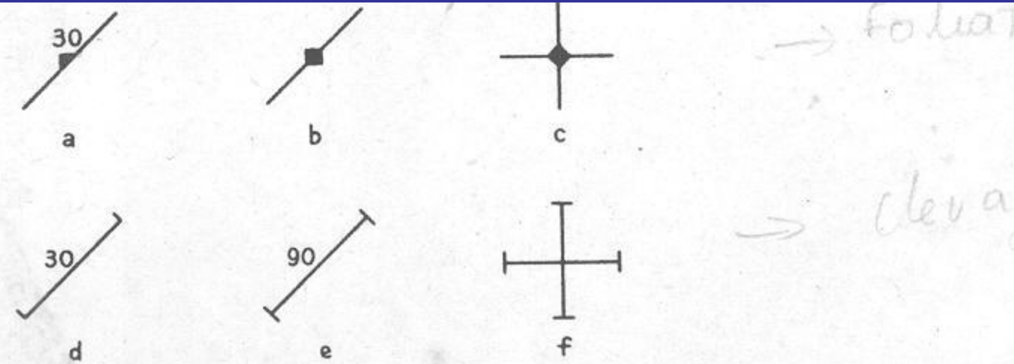


Fig. 18-1. Symbols for foliation. Upper line shows symbols for foliation in general. Lower line shows symbols for cleavage. (a) Strike and dip of foliation. (b) Strike of vertical foliation. (c) Horizontal foliation. (d) Strike and dip of cleavage. (e) Strike of vertical cleavage. (f) Horizontal cleavage.

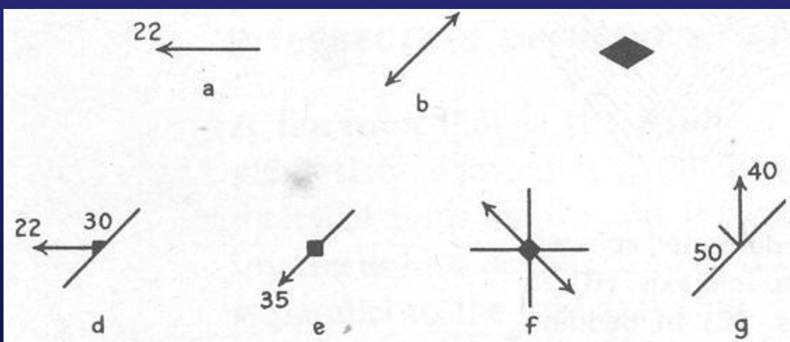


Fig. 19-4. Map symbols for lineation. (a) Lineation plunging 22°W. (b) Horizontal lineation striking NE. (c) Vertical lineation. (d) Foliation striking N. 45°E., dipping 30° NW.; lineation plunging 22°W. (e) Vertical foliation striking N.45°E., lineation plunging 35°SW. (f) Horizontal foliation, with horizontal lineation striking N.45°W. (g) Bedding striking N.45°E., dipping 50°NW.; lineation plunging 40°N.

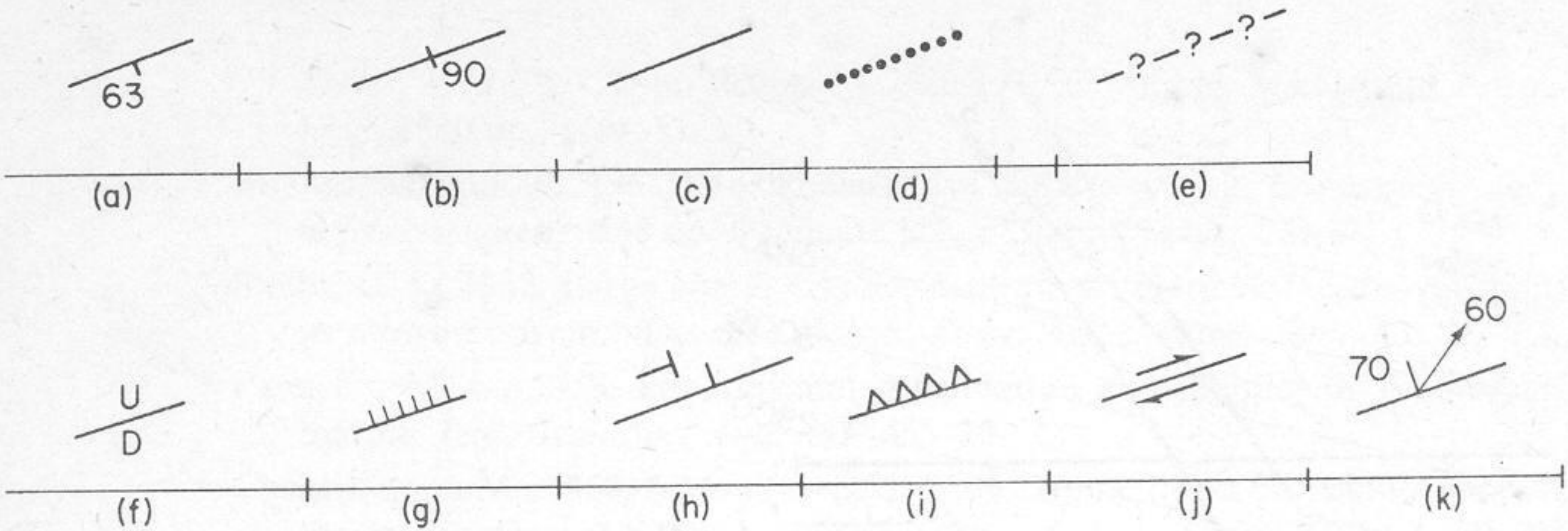


Fig. 9-12. Map symbols for faults. (a) Fault, showing strike and dip. (b) Strike of vertical fault. (c) Strike of fault, dip uncertain. (d) Concealed fault, i.e., fault overlain by younger beds not affected by fault. (e) Possible fault. (f) Normal fault; *U* on upthrown block, *D* on downthrown block. (g) Normal fault, hachure on downthrown block. (h) Thrust; *T* on upthrown block. (i) Thrust, sawteeth on upthrown block. (j) Strike-slip fault, showing relative movement. (k) Fault with dip, also shows bearing and plunge of slickensides.

Remote Sensing and GIS Based Mapping Techniques Of Igneous intrusion and Diapir:

- Surface manifestation of such domes need through understanding and mapping

- Doming up character need to be established by

  Circular or arcuate trend lines and drainage

  Radiating drainages (Centrifugal)

  Radiating fractures / faults

  Central core represented by igneous / salt

  Circular or elongate shape

  Contrasting tonal variation

  Contrasting vegitational variation

  Steep dip / qua-qua versal dip