Structural Geology Part II

Fractures (Faults and Joints)

Classification of faults

There are two type of classification of faults

1- Geometric classification

2- Genetic classification

Geometric classification: this classification is strictly based on the attitude of the fault. There are five geometric classification such as

1- the rake of net slip,

2- the attitude of the fault relative the attitude of the adjacent rock,

3- the pattern of fault

4- the angle at which fault dip,

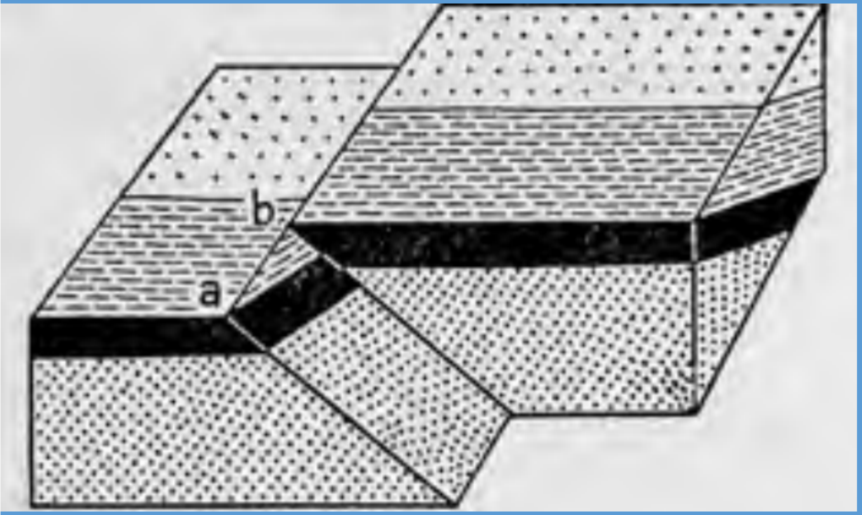
5- the apparent movement on the fault

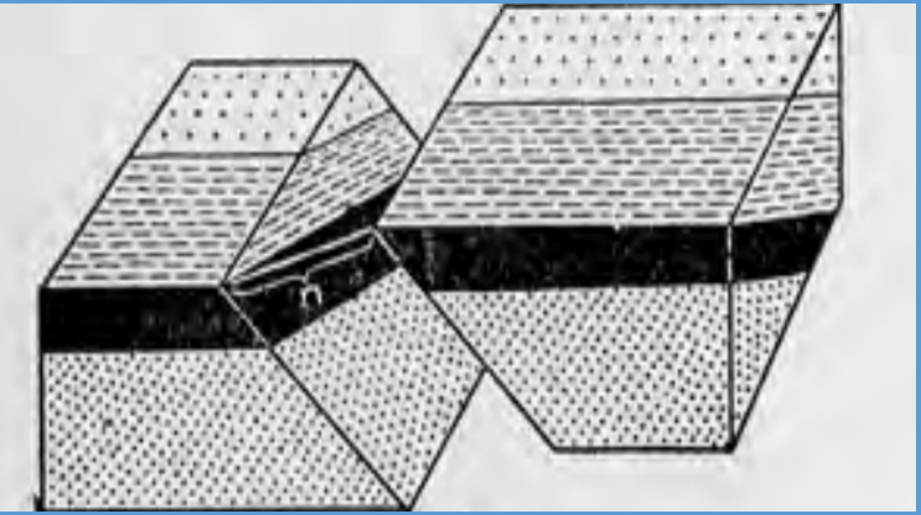
Rake of net slip

Strike slip fault where the net slip is parallel to the fault and rake of net slip is equal to zero.

Dip slip fault Here the net slip is equal to the dip slip. Rake of the net slip is 90.

Diagonal slip fault here is both strike slip and dip slip components and rake of net slip 0 to 90.





The attitude of the fault relative the attitude of the adjacent rock

Strike fault where the strike of the fault is parallel to the strike of the rock bed.

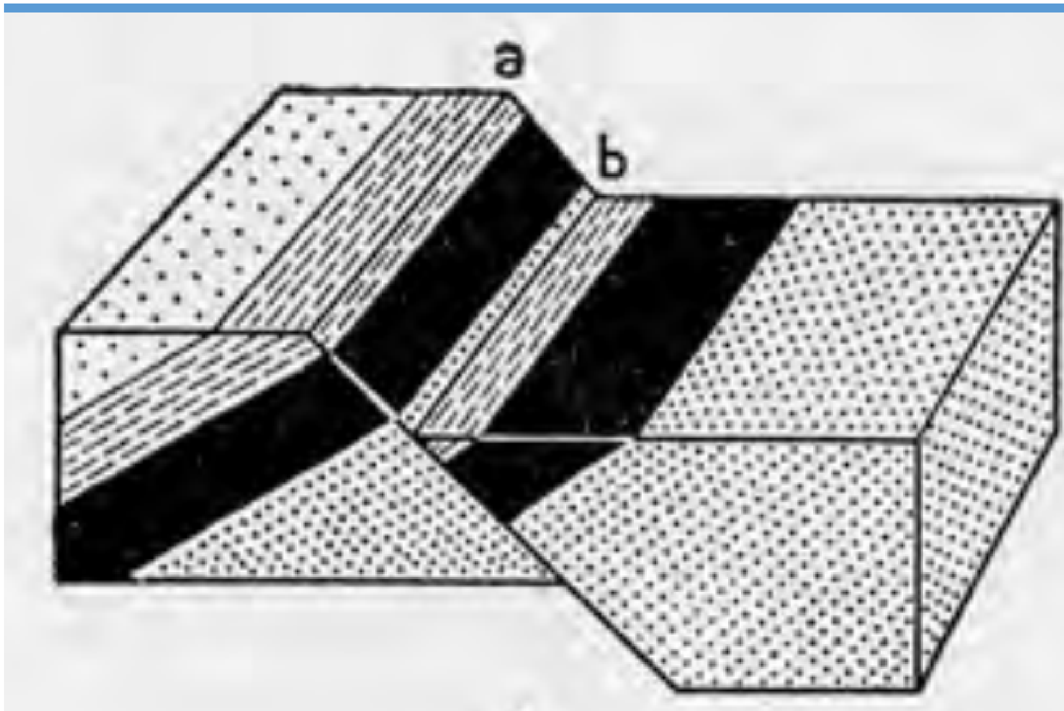
Dip fault where the strike of the fault is parallel to the dip of the surrounding rocks

Diagonal fault It is also known as oblique fault, which strikes diagonally to the strike of the adjacent rocks.

Bedding fault In this case the fault plane is parallel to planes of the adjacent rocks.

Longitudinal fault Here the fault strike parallel to the strike of regional structure.

Transverse fault Strikes perpendicularly or diagonally to the strike of the regional structure.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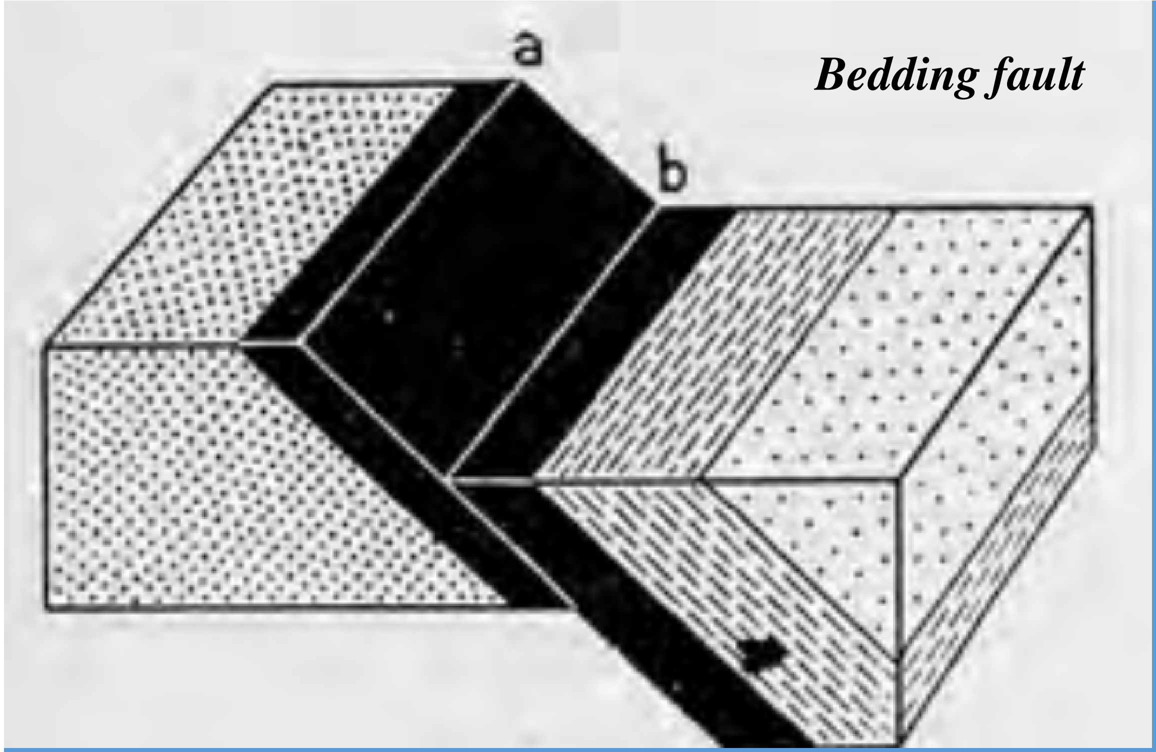
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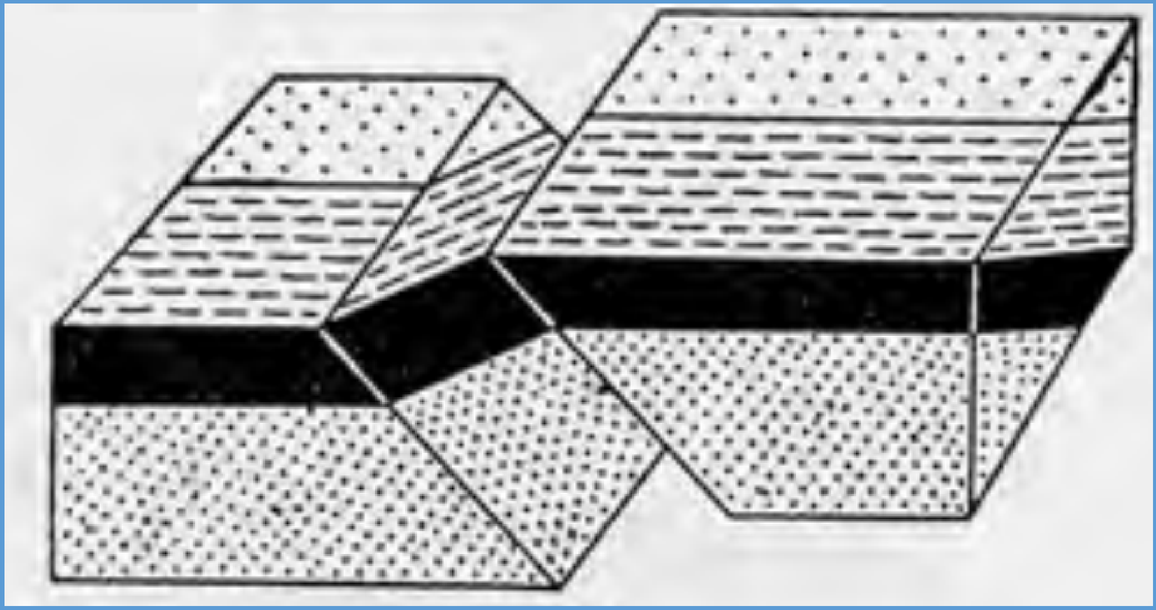
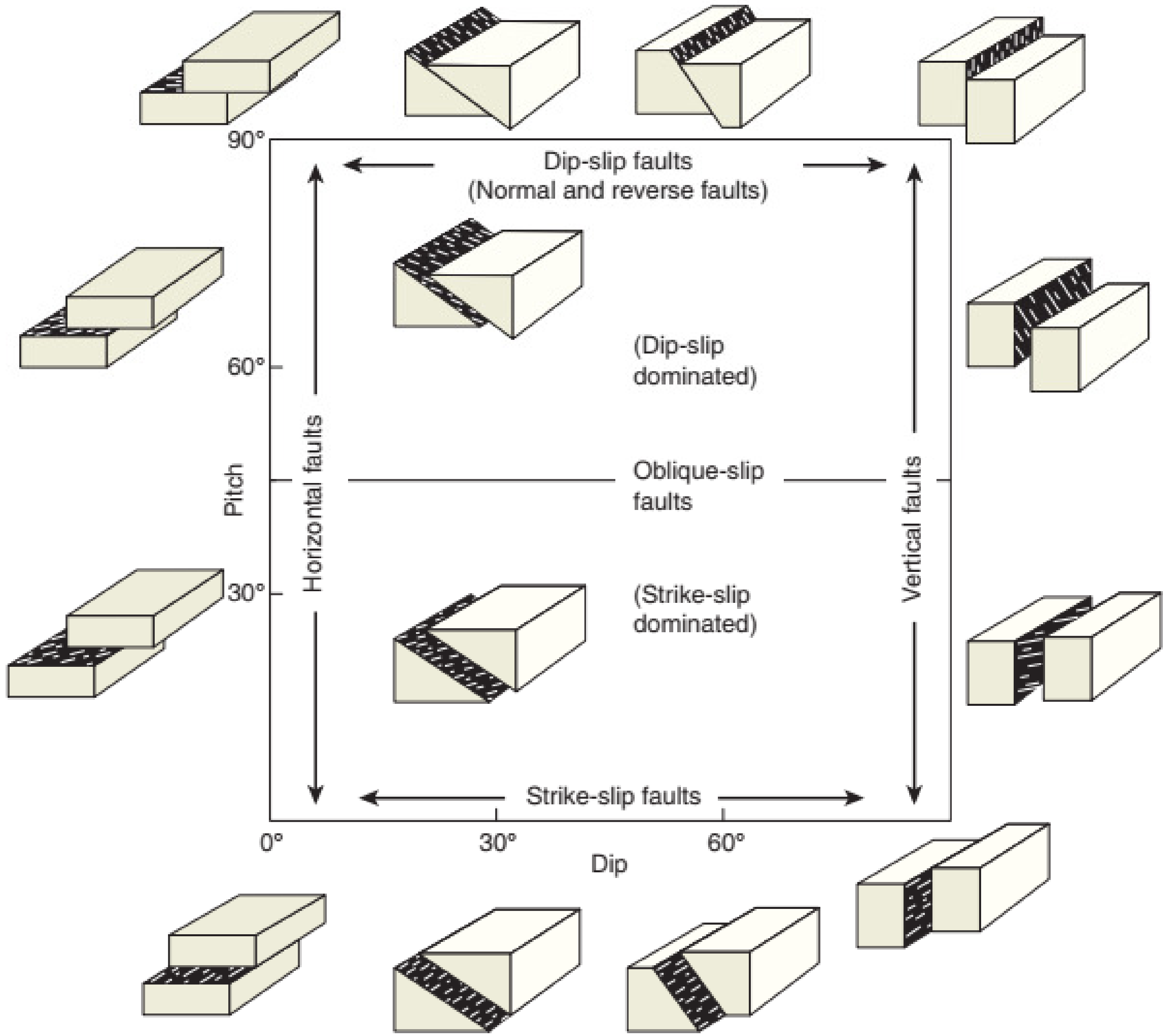
Bedding fault



Classification of faults based on the dip of the fault plane and the pitch, which is the angle between the slip direction (displacement vector) and the strike. Based on Angelier (1994).



high-angle faults and ***low-angle faults*****,** depending on whether the dip is greater or less than 45. A low-angle reverse fault is called a *thrust*. The term *overthrust* is commonly used for a thrust with dip $\delta = 0–10$.

Slickenstructures

There may be features on the plane of the fault called slickenstructures, which include *slickenplanes* and *slickenlines.*

These are formed by abrasional or depositional processes acting during slip.

	Generic term	Abrasion	Growth
Planar feature	Slickenplane	Slickenside	Slickenzone
Linear feature	Slickenline	Slickenstriae	Slickenfiber

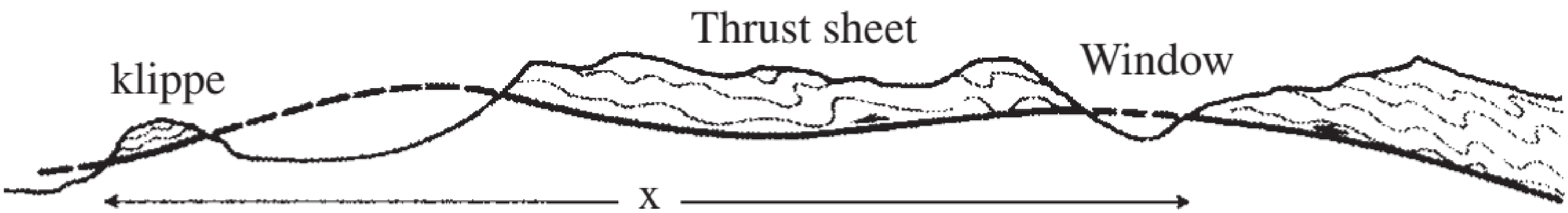
Polished fault surfaces produced by wear during slip are called *slickensides*. If present, grooves or scratches on these surfaces are *slickenstriae* and these give the direction of slip, although if there have been several differently oriented episodes of movement, only the last will be recorded.

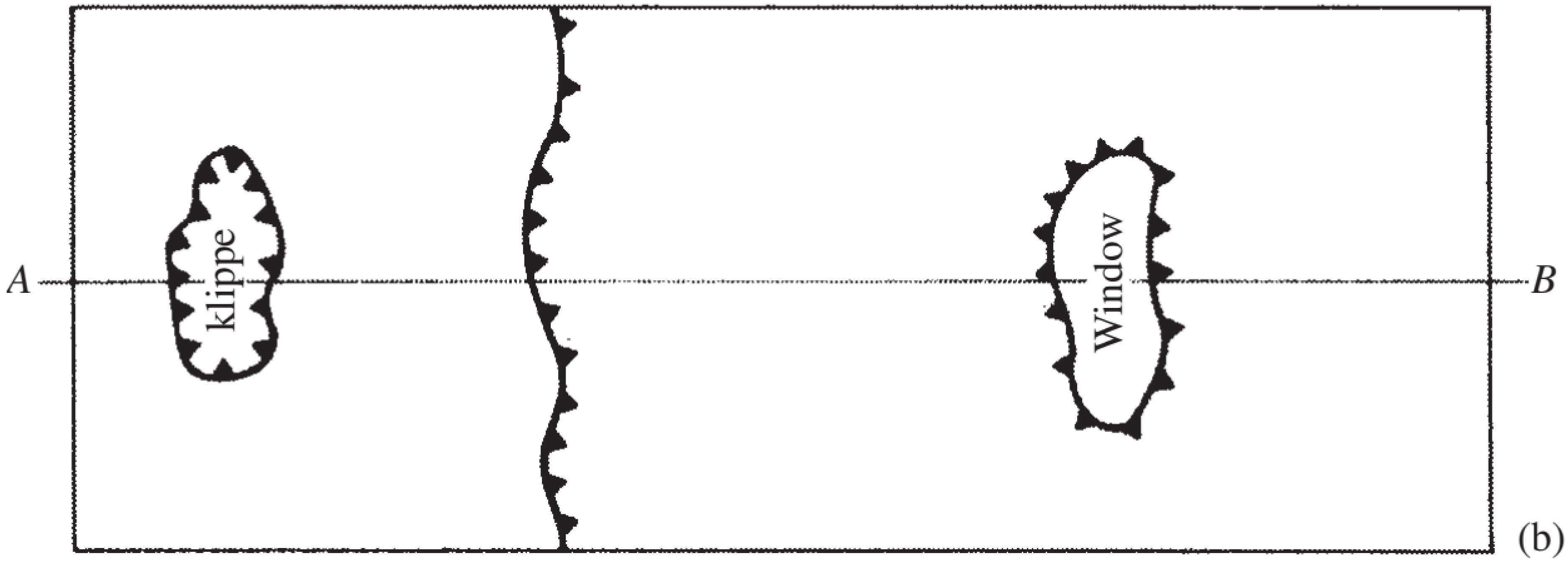
There also may be minute step-like features on these polished planes called *slickensteps*, which are approximately perpendicular to the slickenlines. The direction in which these steps face has been used as an indication of the sense of slip.

Thin fibrous coatings or *slickenzones* are found on some movement planes. These are formed by the deposition, commonly of calcite or quartz, from aqueous solutions during sliding, and the orientation of the *slickenfibers* identifies the latest slip direction and in some cases also the sense of slip.

Klippe* and *window

Low-angle thrusts have a number of special and important features which deserve additional treatment. There are also some special problems – because of their flat-lying nature, structures below the thrust sheet are usually concealed. Slips of tens of kilometers are not uncommon and such large displacements compound the problem of trying to match features above and below the fault plane. Because of the low angle, the outcrop pattern of the thrust plane is strongly influenced by erosion. One result is that an erosional outlier, called a *klippe*, may be produced. Similarly, erosion may also expose the footwall block in a *window*.





Klippe and window: (a) cross section; (b) map showing both features depicted by closed curves

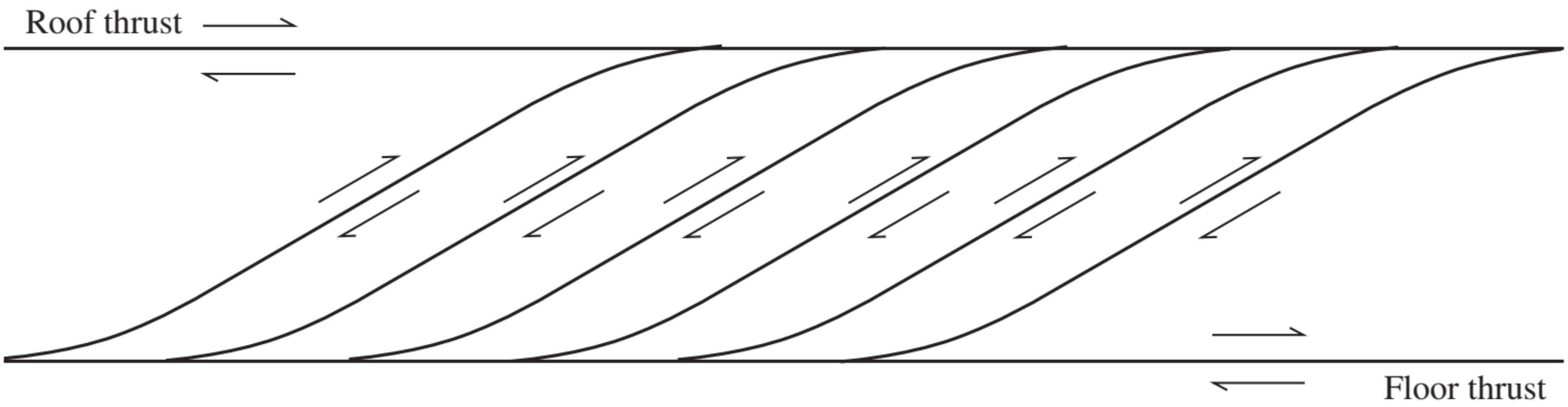
Drag folds can be used to determine the direction and sense of slip during faulting. Drag folding is a distortion of bedding (or other rock layering) resulting from shearing of rock bodies past one another.

rollover anticline

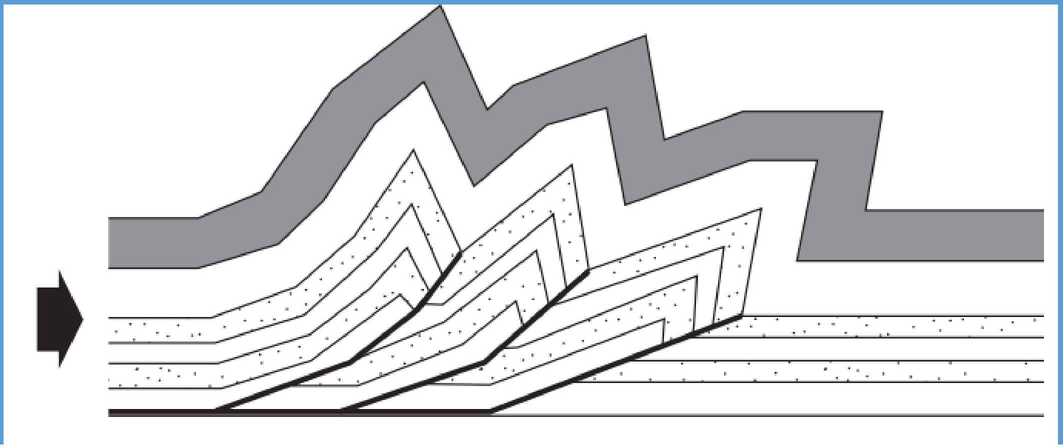
Originally horizontal bedding in the hanging wall of a normal-slip fault can become folded in such a way that it actually dips toward the fault surface, thus forming a rollover anticline.

Duplexes

A *duplex* is an imbricate family of horses – “a herd of horses”. The faults bounding a thrust duplex top and bottom are called *roof* and *floor* thrusts. The lowest thrust of the group is commonly referred as the sole thrust.



Thrust faults typically occur in systems. One common system is marked by imbricate fans.



If a number of such thrusts are present, the effect is to break the hangingwall block into a series of curved slabs, and this is described as *imbricate* structure .

FAULT ROCKS

There are several types of fault rocks, depending on lithology, confining pressure (depth), temperature, fluid pressure, kinematics etc. at the time of faulting. It is useful to distinguish between different types of fault rocks, and to separate them from mylonitic rocks formed in the plastic regime.

Sibson (1977) suggested a classification based on his observation that brittle fault rocks are generally non-foliated, while mylonites are well foliated.

He further made a distinction between cohesive and non-cohesive fault rocks.

Further sub classification was done based on the relative amounts of large clasts and fine-grained matrix.

Sibson's classification is descriptive and works.
The relationship of microscopic deformation mechanism is also clear, since mylonites, which result from plastic deformation mechanisms, are clearly separated from cataclastic rocks .

Fault breccia is an unconsolidated fault rock consisting of less than 30% matrix. If the matrix fragment ratio is higher, the rock is called a **fault gouge**. These unconsolidated fault rocks form in the upper part of the brittle crust. They are conduits of fluid flow in non-porous rocks, but contribute to fault sealing in faulted porous rocks.

Pseudotachylyte consists of dark glass or microcrystalline, dense material. It forms by localized melting of the wall rock during frictional sliding. Pseudotachylyte can show injection veins into the sidewall, chilled margins, inclusions of the host rock and glass structures. It typically occurs as mm- to cm-wide zones that make sharp boundaries with the host rock. Pseudotachylytes form in the upper part of the crust, but can form at large crustal depths in dry parts of the lower crust.

Crush breccias/ Fault Breccias are characterized by their large fragments. They all have less than 10% matrix and are cohesive and hard rocks. The fragments are glued together by cement (typically quartz or calcite) and/or by micro - fragments of mineral that have been crushed during faulting.

Cataclasites are distinguished from crush breccias by their lower fragment–matrix ratio. The matrix consists of crushed and ground-down micro-fragments that form a cohesive and often flinty rock. It takes a certain temperature for the matrix to end up flinty, and most cataclasites are thought to form at 5 km depth or more.