# Lineations

Lineation – a fabric element in which one dimension is considerably longer than the other two. Tectonic linear structures include elongated physical objects – stained mineral aggregates, conglomerate pebbles – lines of intersection between two sets of planar structures, and geometrically defined linear features such as fold hinge lines and crenulation axes.

Types of lineation

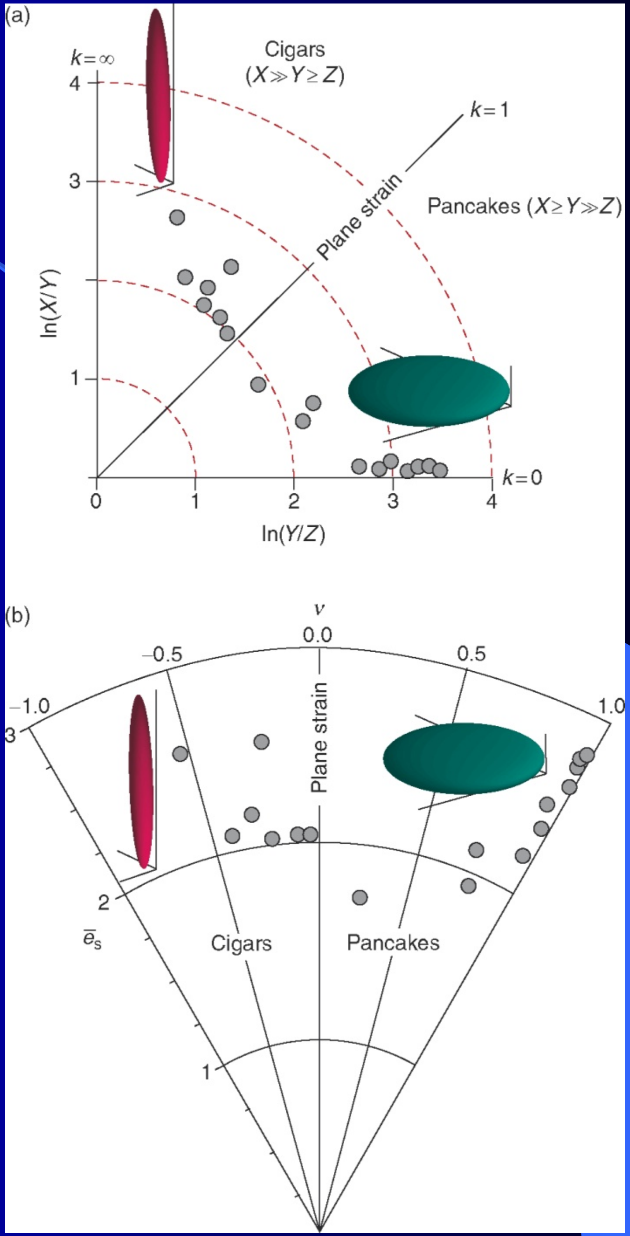
- Penetrative lineations which build up a linear fabric or L-fabric
- Surface lineations – restricted to a surface (e.g. slickenlines)
- Geometric lineations – fold axes and intersection lineations

Lineations related to plastic deformation

- L-tectonite – lineation forms the dominating fabric and the foliation (S-fabric) is weak or absent. Plot in the “cigar shape” part of a Flinn diagram.

- LS-tectonite – balanced combination of foliation (S-fabric) and a penetrative fabric (L-fabric). Plot close to the diagonal line in a Flinn diagram.

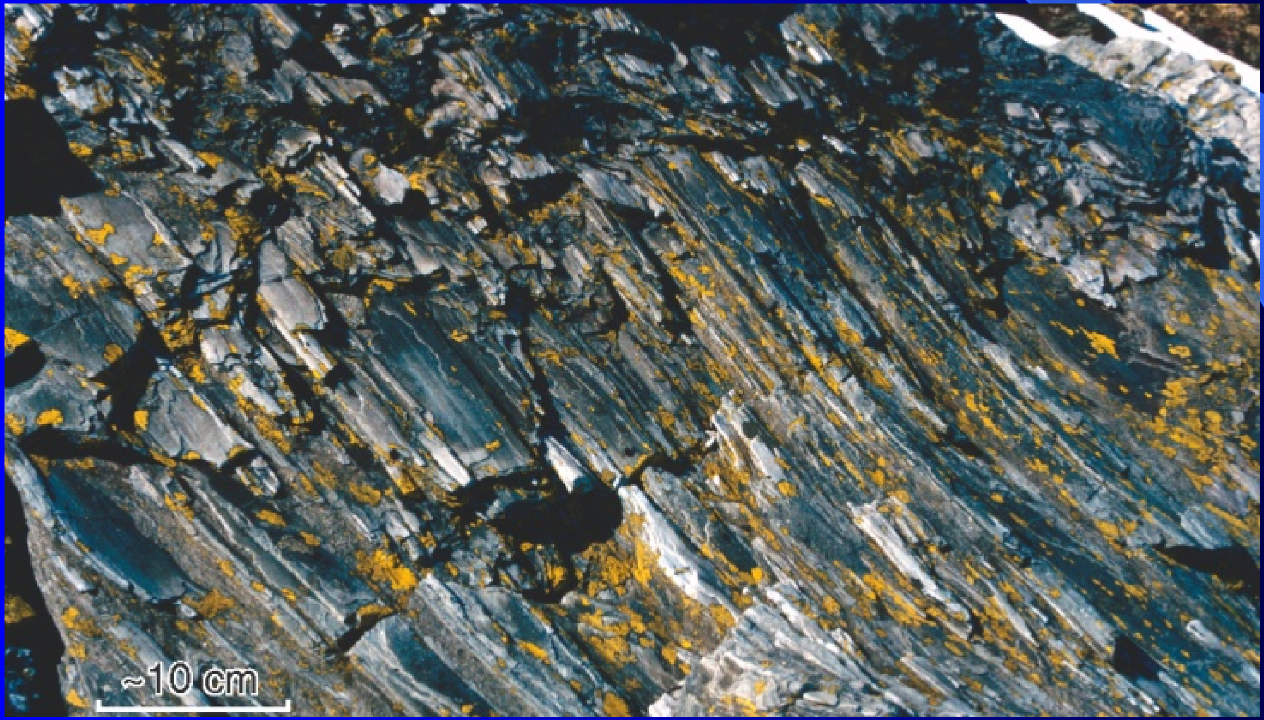
- S-tectonite – minor or no linear fabric. Plot in the “pancake shape” part of the Flinn diagram



# Mineral Lineations

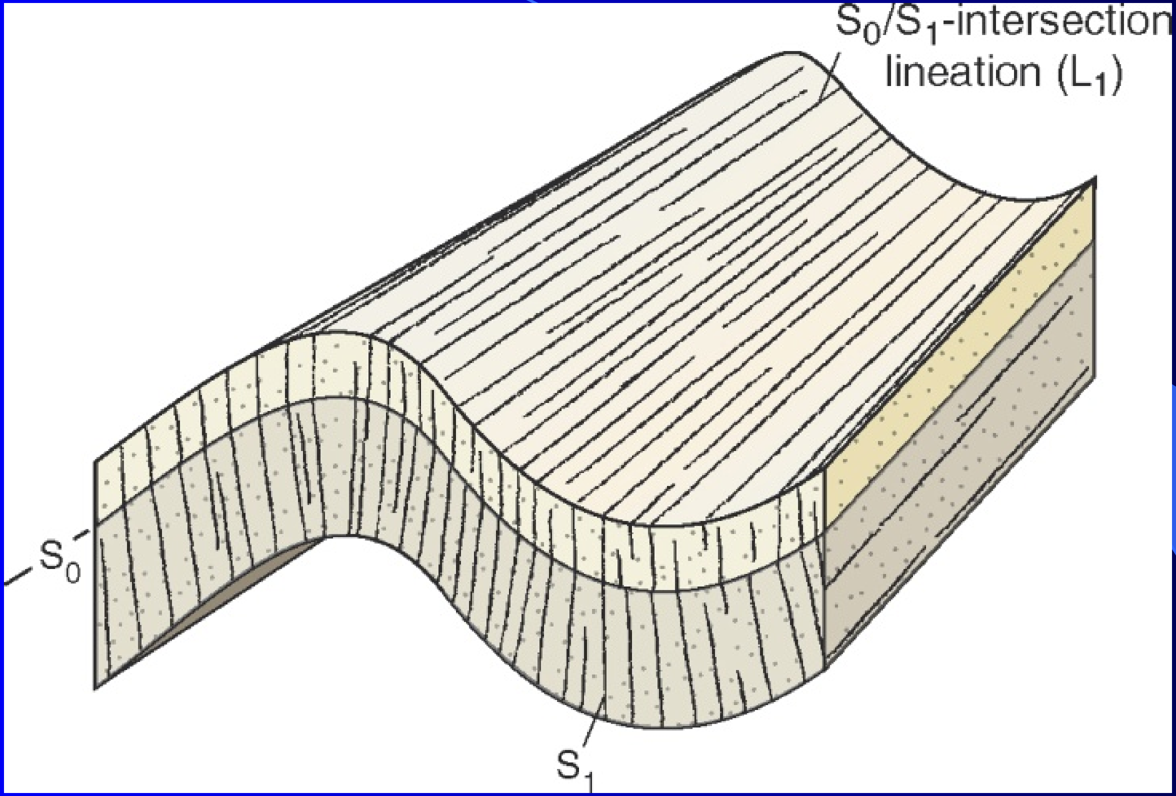
Minerals and mineral aggregates can form a linear fabric by means of recrystallization, dissolution/precipitation, or rigid rotation.

Stretching of minerals and mineral aggregates into a penetrative stretching lineation forms the most common type of lineation in deformed metamorphic rocks.



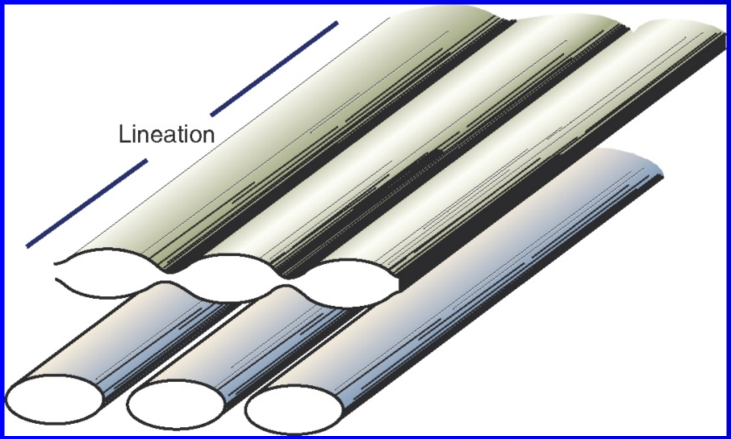

Stretching lineation in quartzite conglomerate. Long axes of pebbles are plunging to the right.

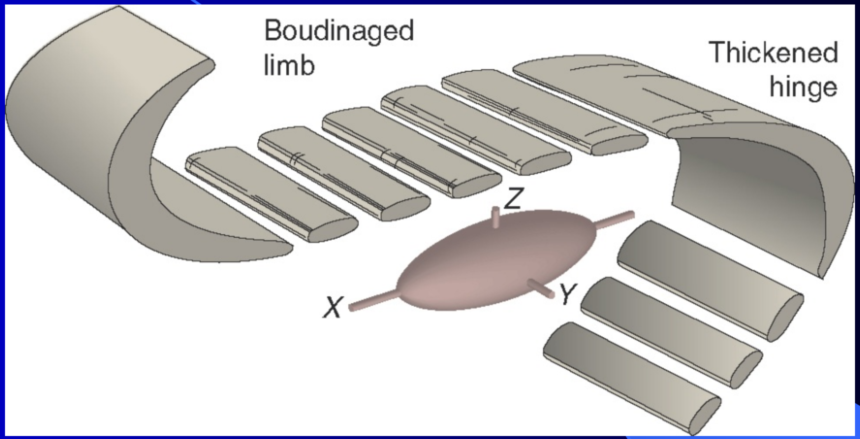
Intersection lineations are formed by the intersection of two planar fabrics.



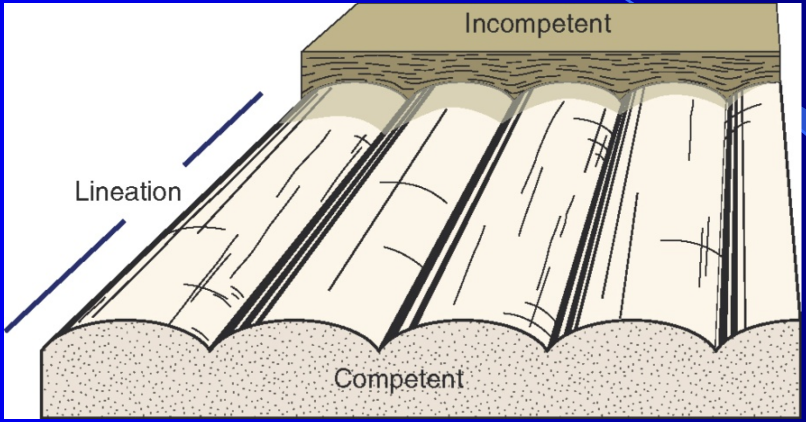

If a rock has a high enough density of parallel fold axes a lineation can develop. Consider a mica-rich rock in which layers of mica flakes can be identified as individual fold layers.

Boudinage occurs when more competent rock layers in less competent layers are stretched into segments. Individual boudins are much longer in one dimension than the other two.



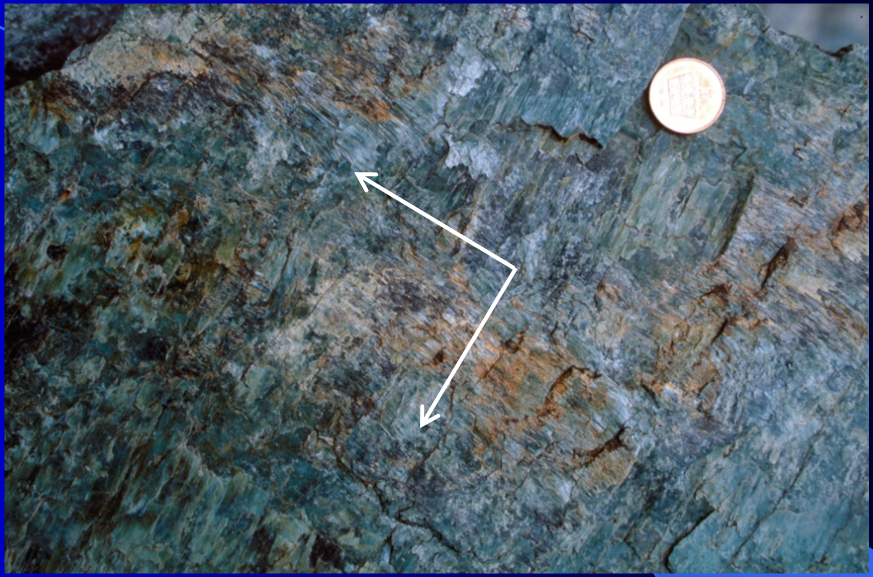




Mullin – linear deformation structures that are restricted to the interface between a competent and an incompetent rock. The cusp shapes of the mullions always point into the more competent rock.




Lineations in the brittle regime tend to form on fracture surfaces. They are not fabric-forming elements.

- Mineral growth in extension fractures
- Striations carved on the walls of shear fractures and faults
- Intersections between fractures
- Fracture curvatures that form early during fracturing (these represent a change in direction)



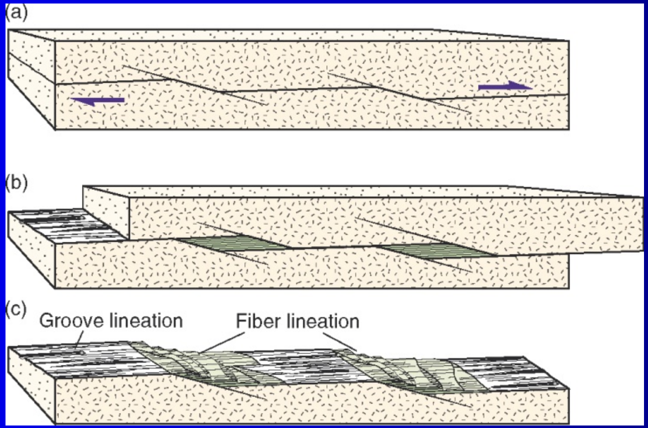
Two perpendicular sets of mineral lineations on a fault surface in serpentinite.

Fiber lineations in extension fracture where the fibers have grown perpendicular to the fracture walls as the fracture opened.

There are two principal types of slickenlines

- those that form by mechanical abrasion (striations)

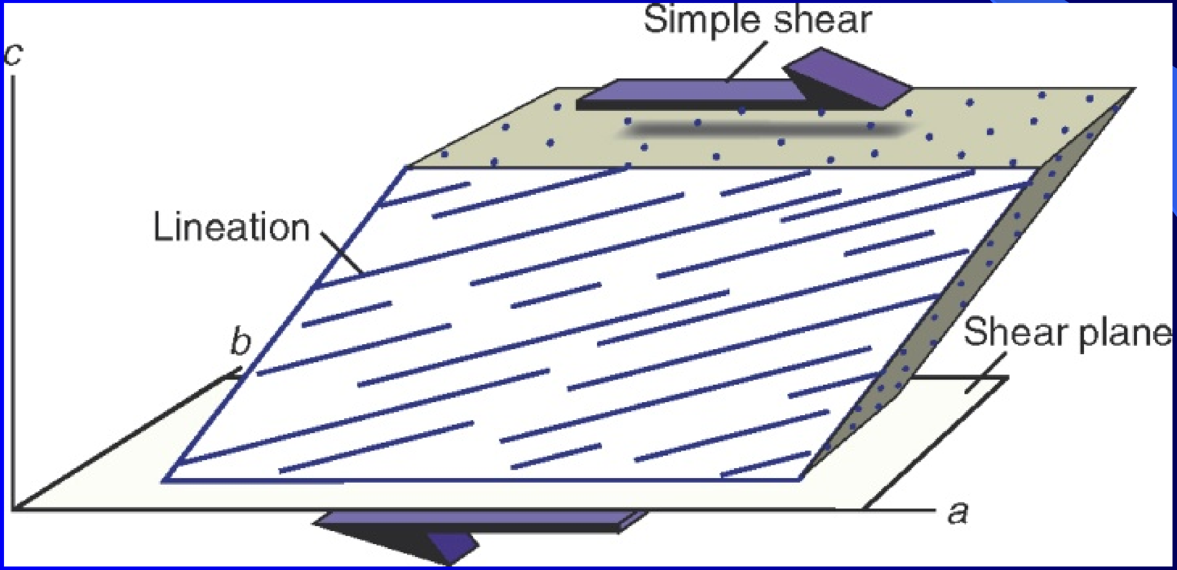
- those that form by fibrous growth (slip fiber lineations)



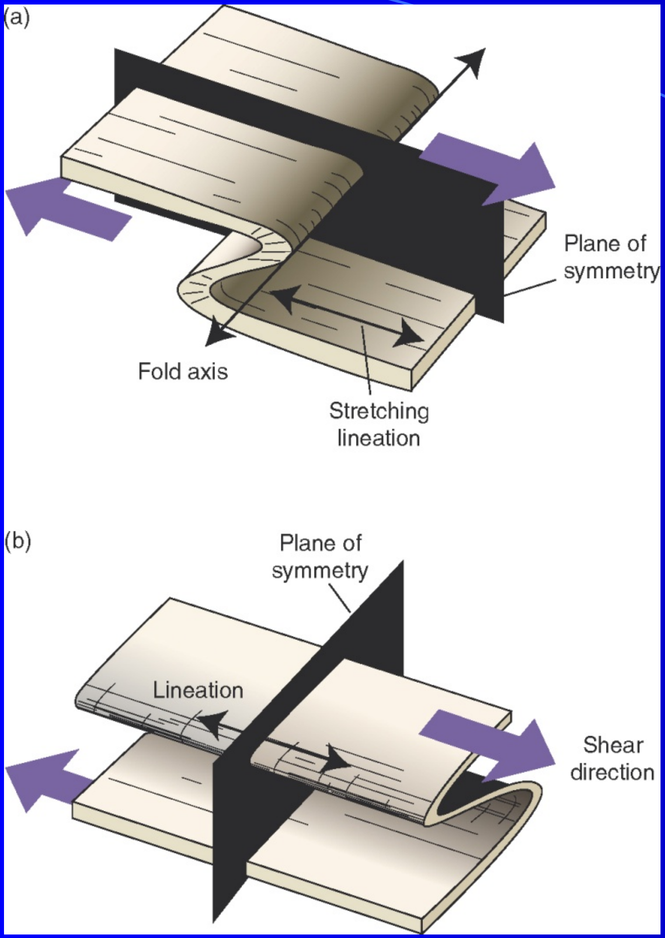

Formation of fiber lineation in irregular shear fractures. (a) Early stage. (b) Final Stage. (c) Upper block removed for inspection

Lineations in the brittle regime – slickenlines, striase and several other lineations associated with faults parallel the movement direction, but do not in themselves reveal the sense of shear.

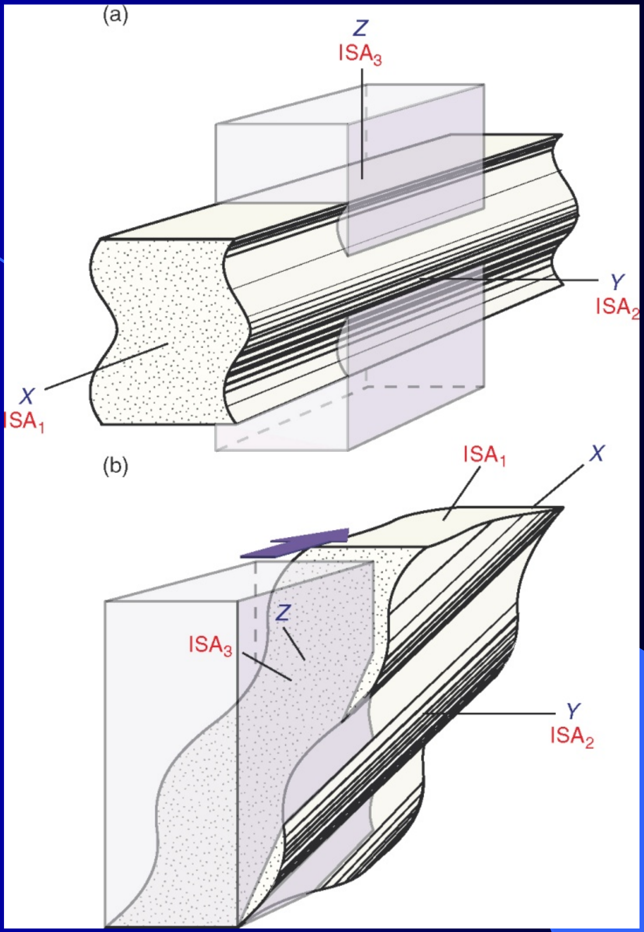
Lineations in the plastic regime – stretching lineations that commonly indicate the direction of transport when projected onto the shear plane.




The stretching lineation and its relation to Sander's kinematic (now strain) axes for simple shear. The lineation rotates towards the kinematic a-axis (the shear or transport direction) by increasing strain.




Folds and symmetry. Folds may have axes that are parallel or perpendicular to the stretching lineation.




Folds and stretching lineations formed under pure shear (top) and simple shear (bottom). The fold axes and stretching lineation become perfectly parallel for pure shear and subparallel for simple shear.