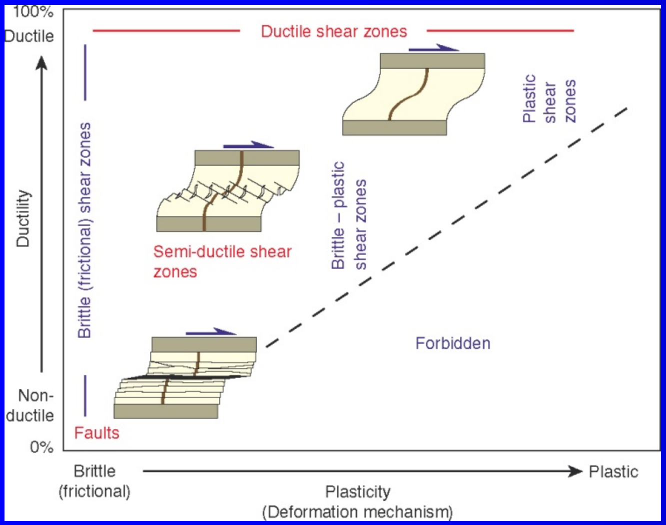
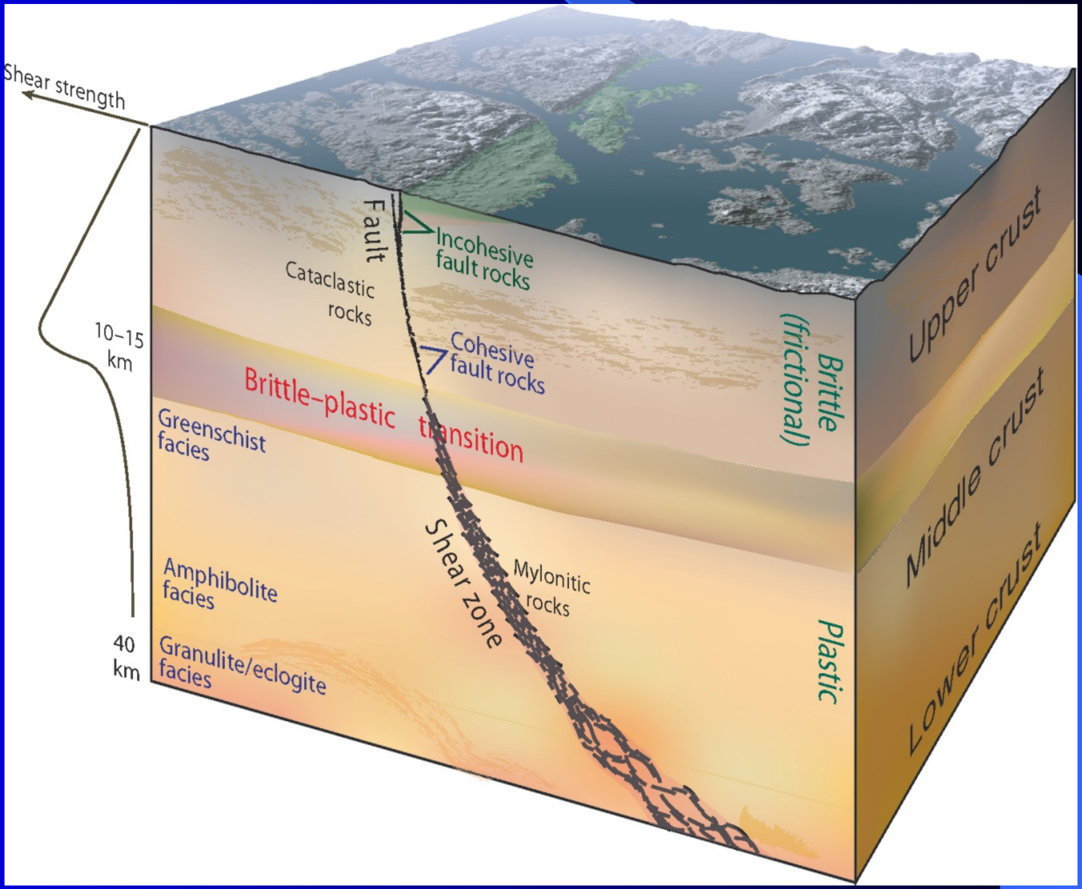
Shear Zones and Mylonites

A shear zone is a tabular zone in which strain is notably higher than in the surrounding rock.

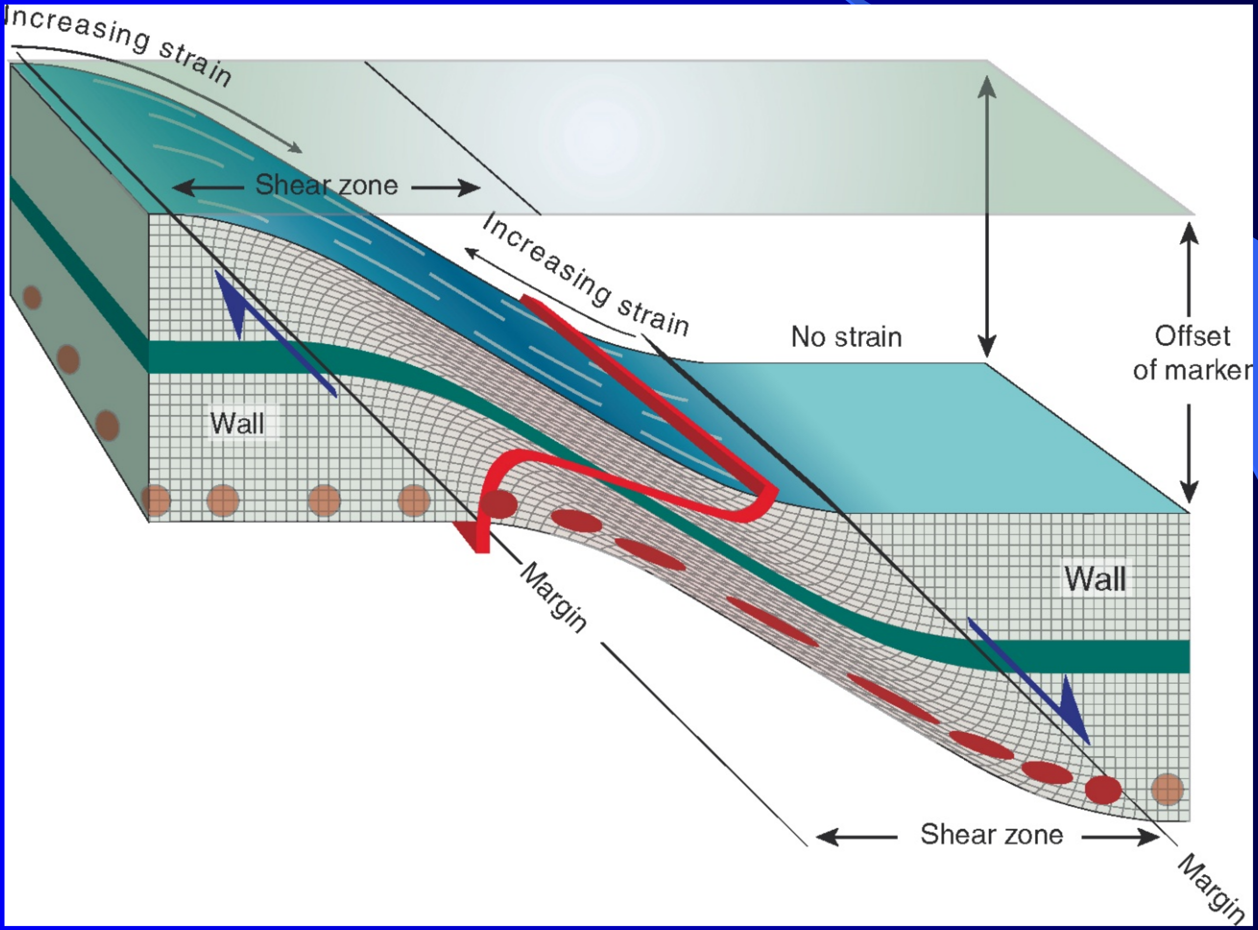
Simplified model of the connection between faults, which normally form in the upper crust, and classic ductile shear zones. The transition is gradual and known as the brittle-plastic transition. The depth depends on the temperature gradient and the mineralogy of the crust. For granitic rocks it normally occurs in the range of 10-15 km.

Simple classification of shear zones based on deformation mechanism (horizontal axis) and mesoscopic ductility (continuity of markers).

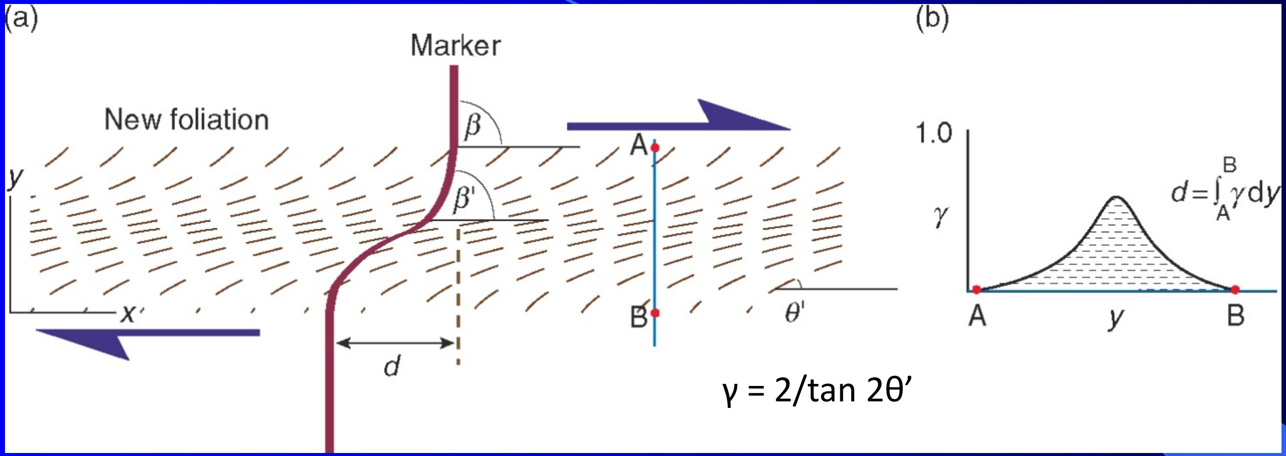




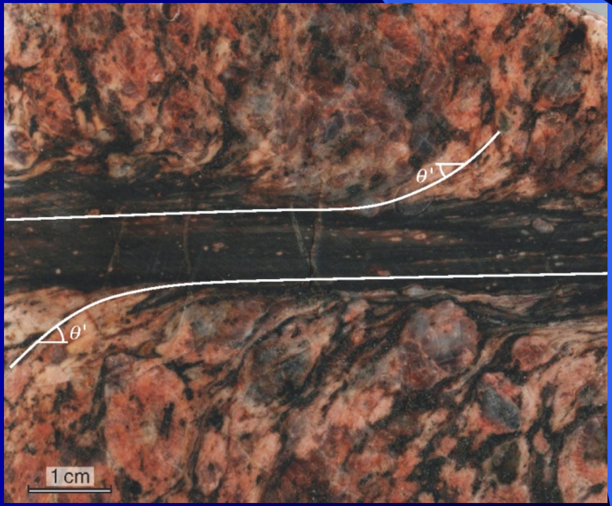
A shear zone is bounded by two margins or shear zone walls that separate the shear zone from its wall rock. The example below shows an ideal shear zone deforming a grid with two plane markers and circular strain markers. Note how the grid squares change shape and the planar markers change orientation and thickness across the zone. The strain is at its maximum in the central part of the shear zone.



(a) Shear zone with genetically related foliation. Note distortion of marker and angle (θ' between foliation and the margin of the shear zone. (b) The displacement can be found by measuring or calculating the area under the shear strain profile across the zone if the deformations is simple shear.

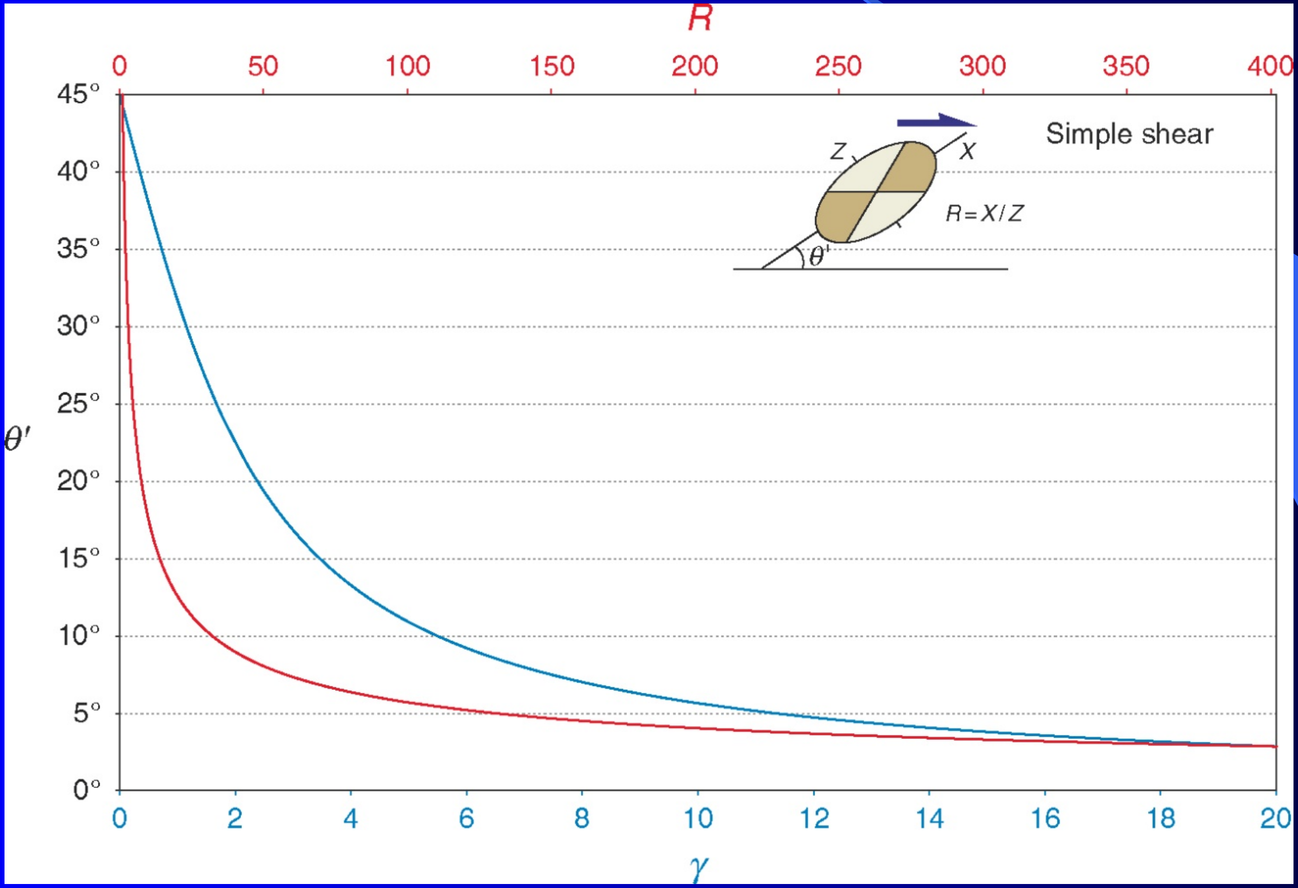


Ductile shear zone in greenstone. Feldspar aggregates get progressively more strained into the shear zone (downward).



Profound strain increase toward the central ultramylonitic part of zone shown by a change in orientation of the foliation and a marked decrease in grain size.

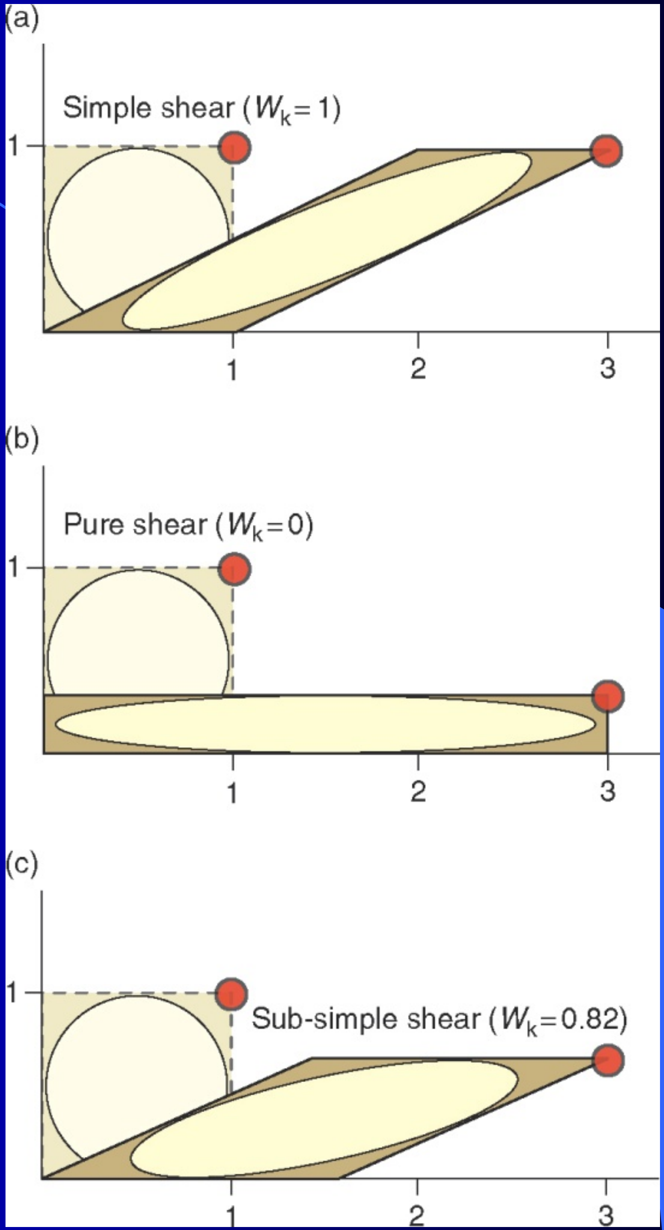
The relationship between θ‘, the shear strain (γ) and the maximum finite strain axis (X). The blue curve represents the shear strain the red curve the aspect ratio (R=X/Z) of the strain ellipse



Types of shear zones

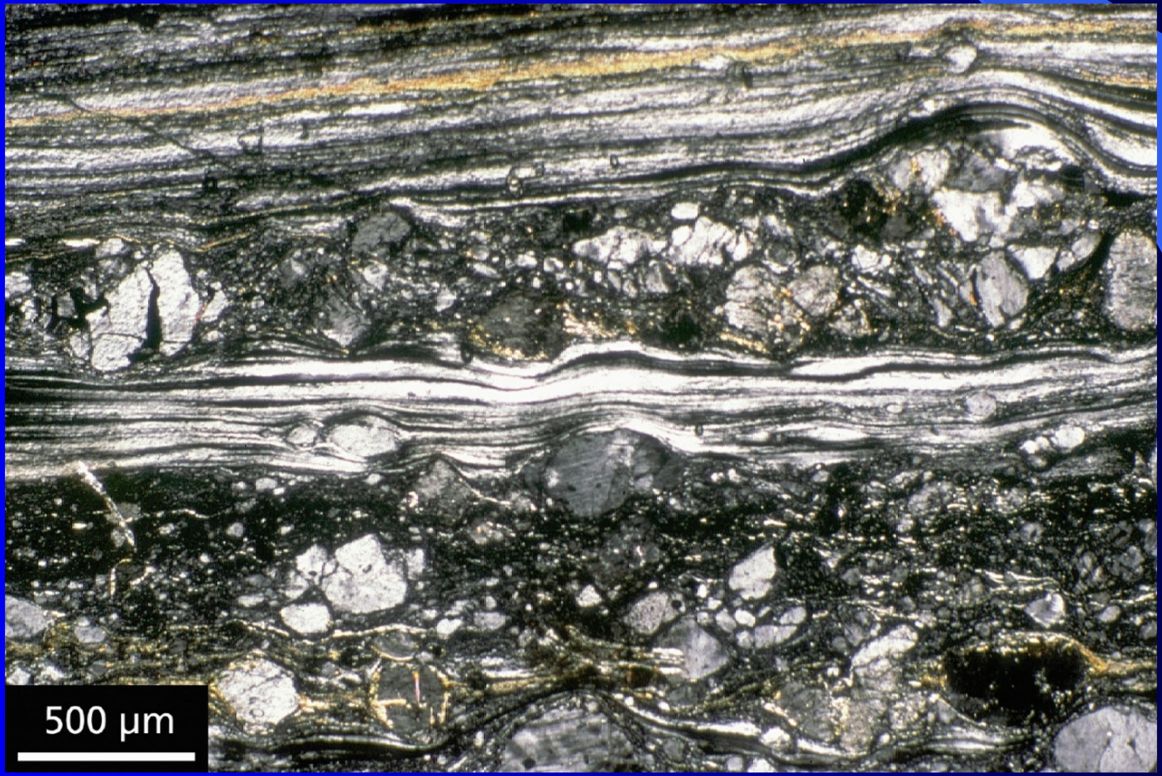
- Simple shear zones
- Pure shear zones
- Subsimple shear zones

Comparison of shear-zone parallel offset and strain. A square with a circle is deformed under simple shear, pure shear and subsimple shear so that the horizontal displacement of the upper right corner is the same in all cases. The resulting strain is greatest for pure shear and least for the chosen subsimple shear.

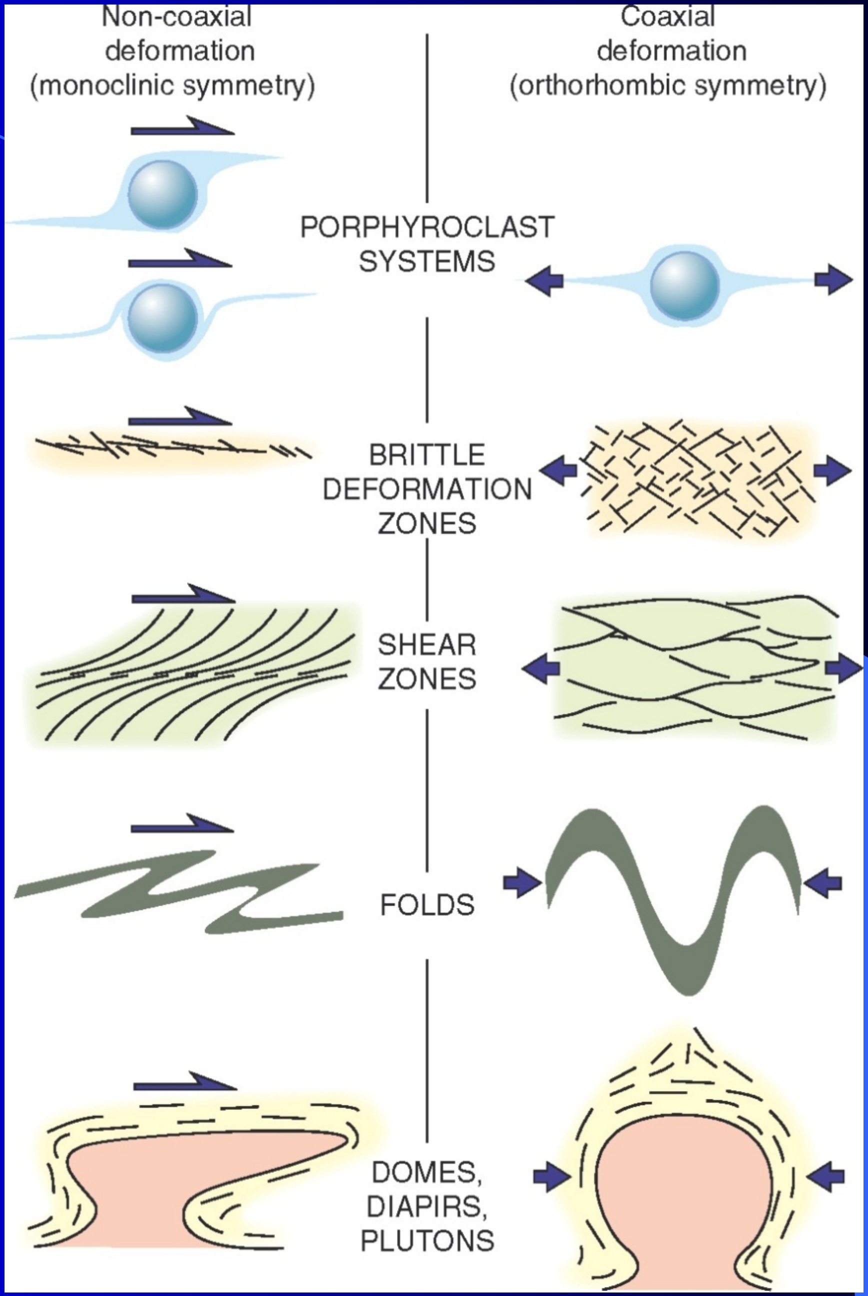


Mylonite – strongly deformed rock that has undergone grain size reduction due to plastic deformation. Mylonites are separated into three subgroups depending on how much of the original matrix is still intact (not recrystallized).

- Protomylonite: <50% matrix (new grains)
- Mylonite: 50-90% matrix
- Ultramylonite: >90% matrix

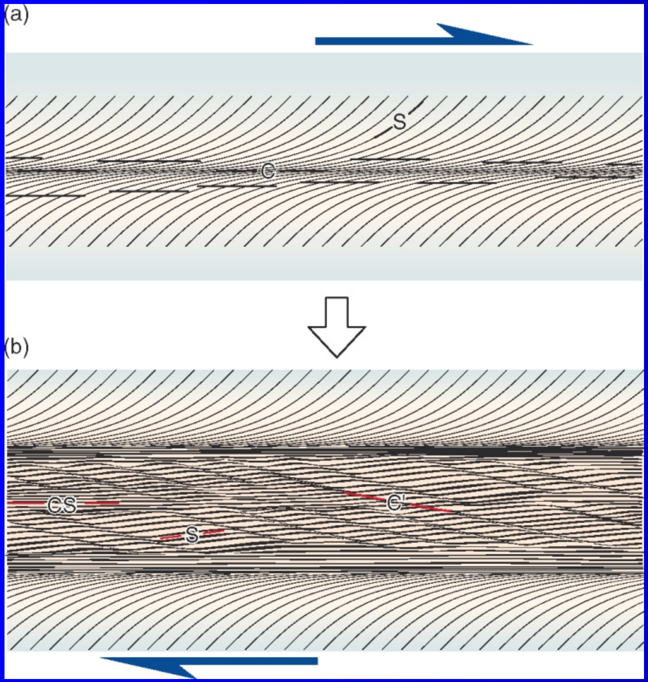


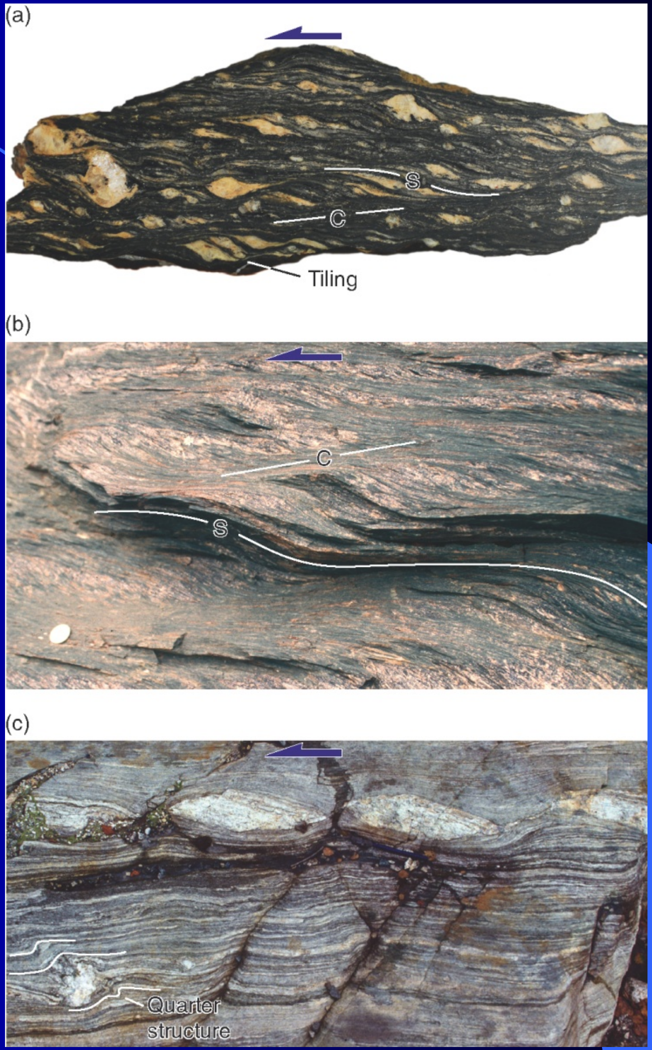
Kinematic indicators – asymmetric structures characterize non-coaxial deformations while coaxial deformations tend to result in more symmetric structures.



S-C mylonites are made up of two sets of planar structures, a foliation (S) and shear bands (C) that obliquely transect and often back-rotate the foliation.

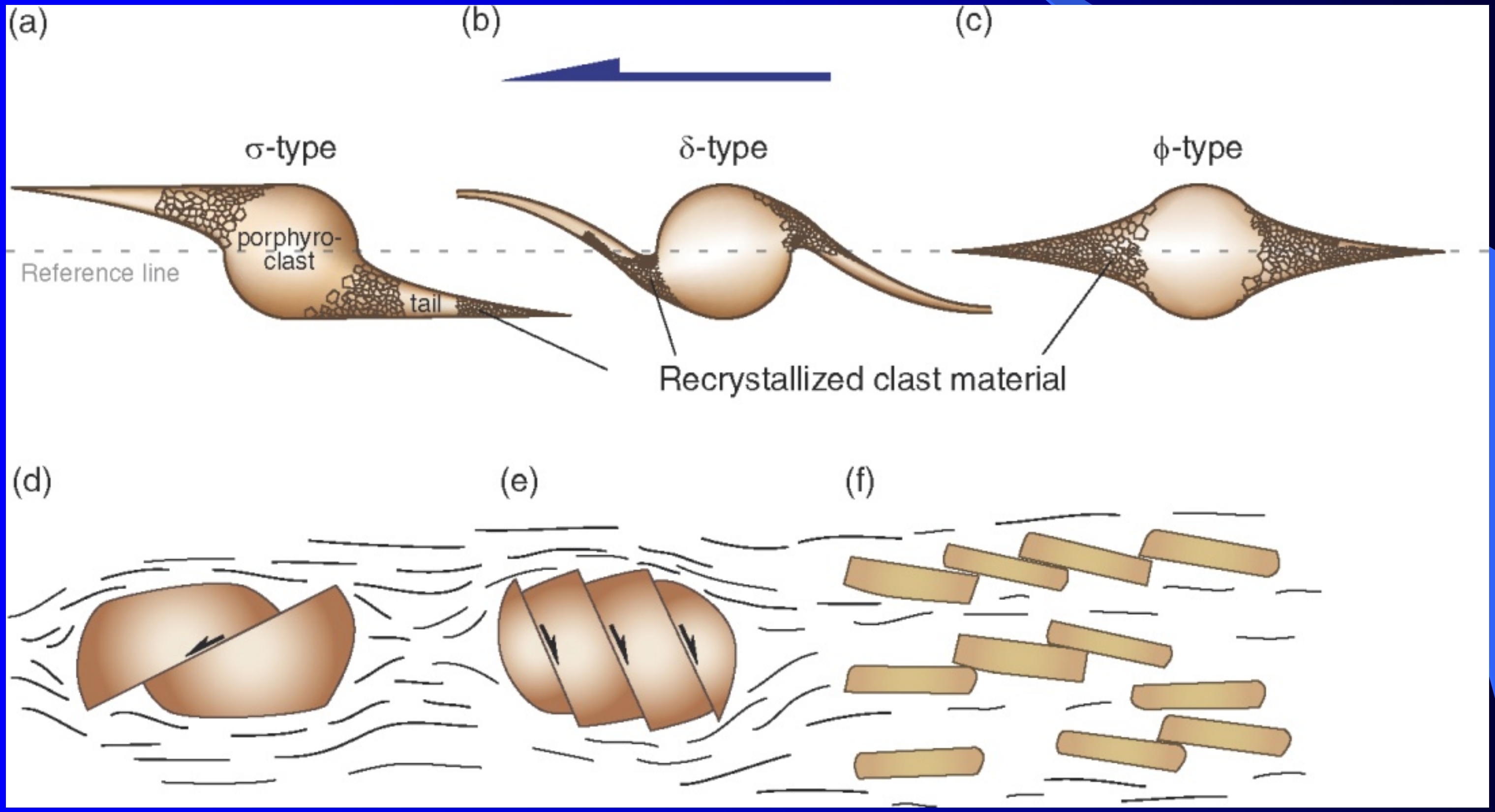
Schematic illustration of the development of S-C structures in a shear zone in a magmatic rock. (a) The new-formed foliation is cut by shear surfaces (C) that parallel the shear zone margins. (b) Continued deformation rotates S into close parallelism with C, together referred to as a CS-foliation. New and oblique shear bands (C') form and back-rotate the CS foliation, which is then called S.





(a) S-C structure in protomylonite granite. (b) Shear bands in phyllite. (c) Asymmetric boudins in granitic gneiss.

Porphyroclast systems. (a-c) Porphyroclasts with recrystallized tails, σ-type have tails that do not cross the reference line, δ-types have tails that cross the reference line, Φ-type are symmetric around the reference line. The first two types show monoclinic symmetry. (d) Fractured porphyroclast with synthetic fracture. (e) Anithetic shear fractures. (f) Tiling (imbrication of prophyroblasts). All structures, except (c), are consistent with sinistral shear.



Types of Shear Zones:

- Type I – strain hardening. Deformation in central part slows down as the zone thickens.
- Type II – strain softening. Deformation localized in central part.
- Type III – develop a fixed thickness and the entire zone keeps deforming without any sign of internal localization.
- Type IV – similar to Type I, but the entire shear zone remains active throughout the deformational history.