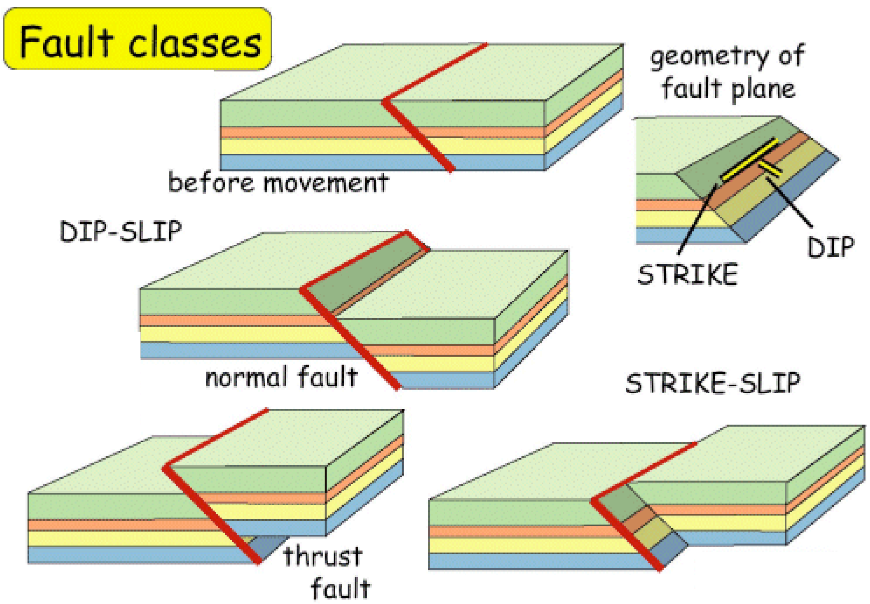
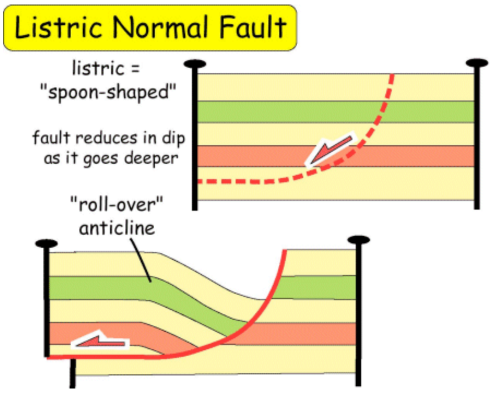
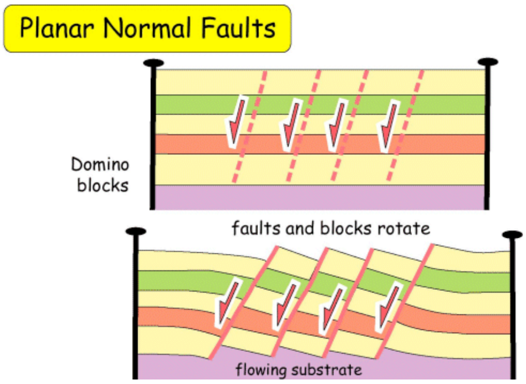
構造地質学II-3

断層
Faults

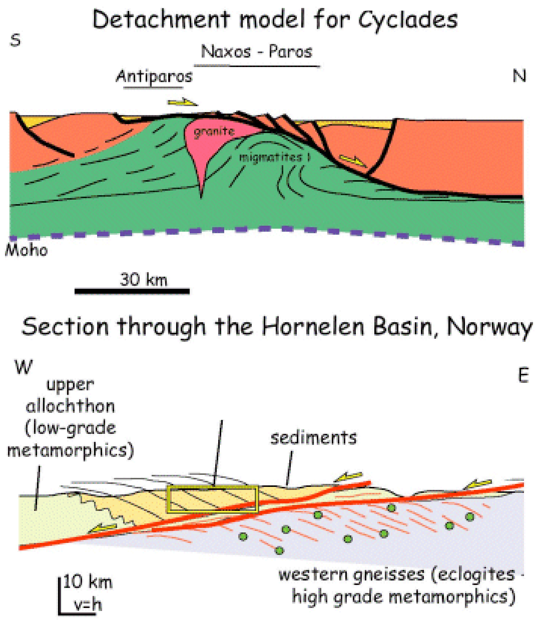


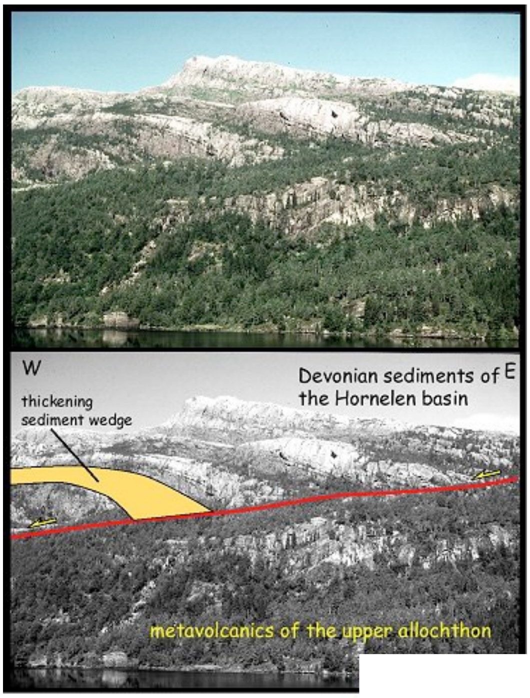
Normal Fault (正断層）





Detachment faults

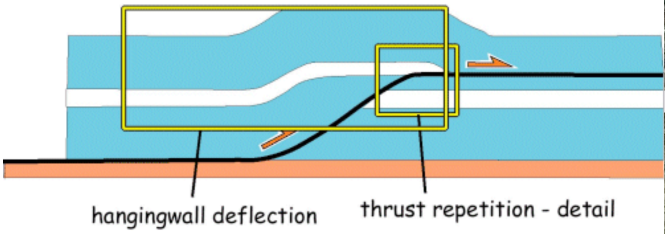




Important! for exhumation of high-grade metamorphic rocks

Thrust (衝上斷層)

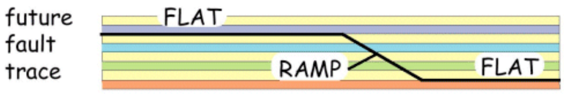
Thrust geometry



Thrust shape

Thrusts cut up-section - but rarely as planar faults.

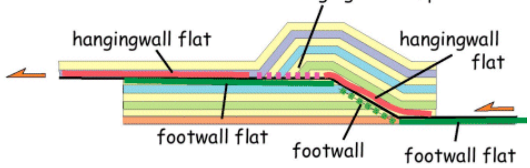
Instead they cut a staircase



what happens
after movement?

For originally horizontal rocks
FLAT - is parallel to bedding

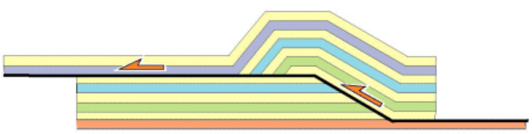
RAMP - cuts across bedding
(ideally at less than 30 degrees)



ramp and flat terms refer to the
ORIGINAL state - and hence are
in a bedding reference frame

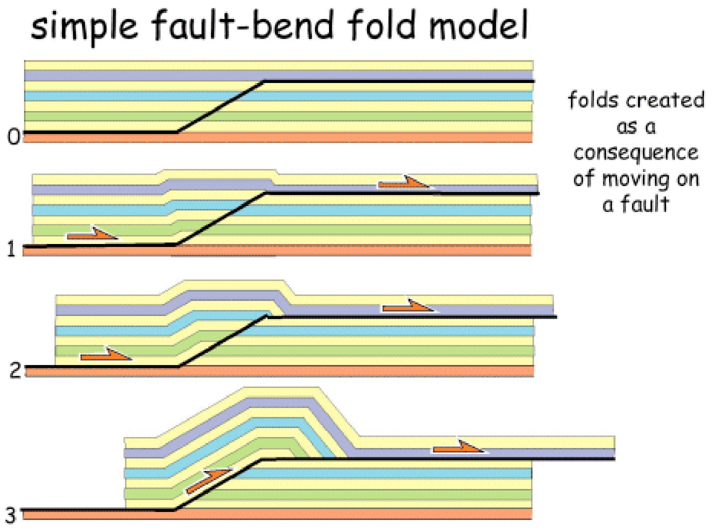
notice that the terms only
refer to one side of the fault

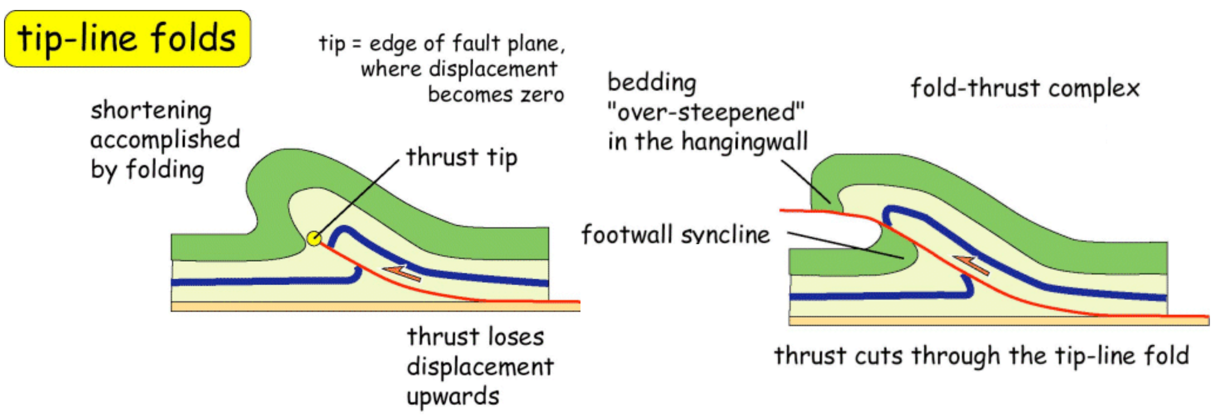
Fold created in hanging-wall



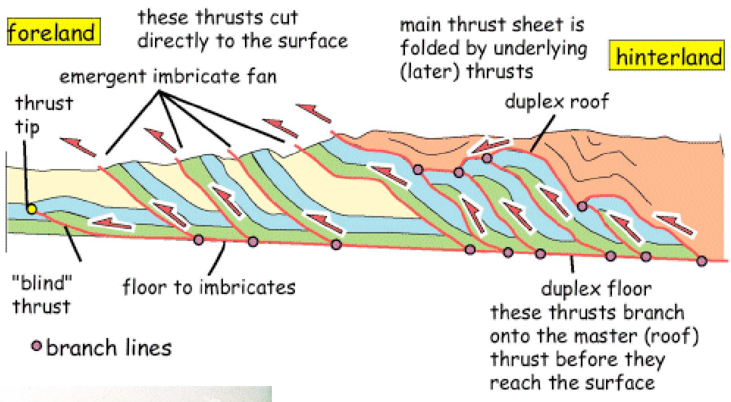
footwall remains undeformed

there are various relationships
created between bedding on
either side of the fault

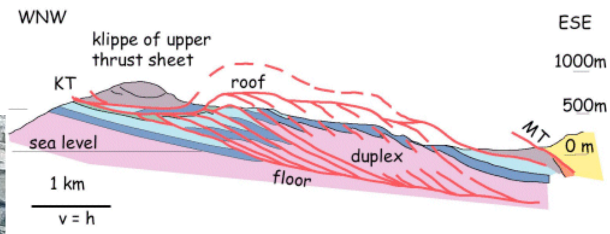

simple fault-bend fold model
folds created as a consequence of moving on a fault
0
1
2
3


tip-line folds
tip = edge of fault plane, where displacement becomes zero
shortening accomplished by folding
thrust tip
thrust loses displacement upwards
bedding "over-steepened" in the hangingwall
fold-thrust complex
footwall syncline
thrust cuts through the tip-line fold

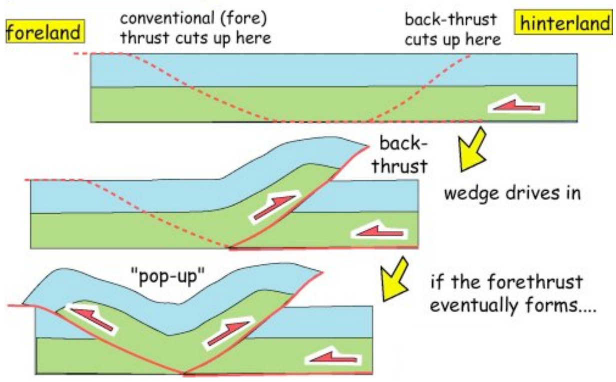
thrusts and mountain structures

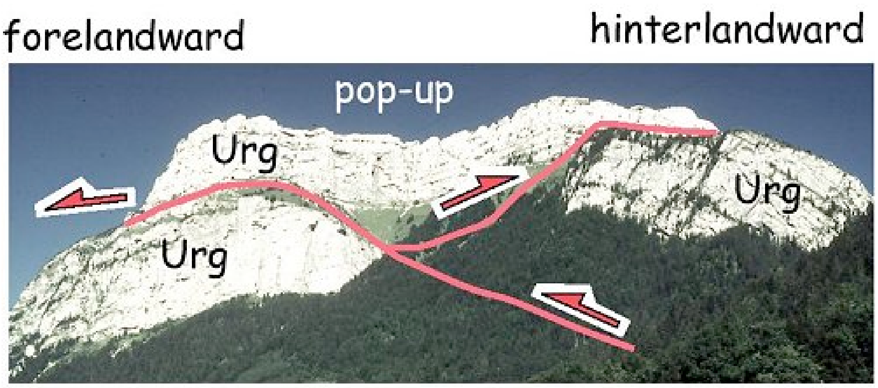


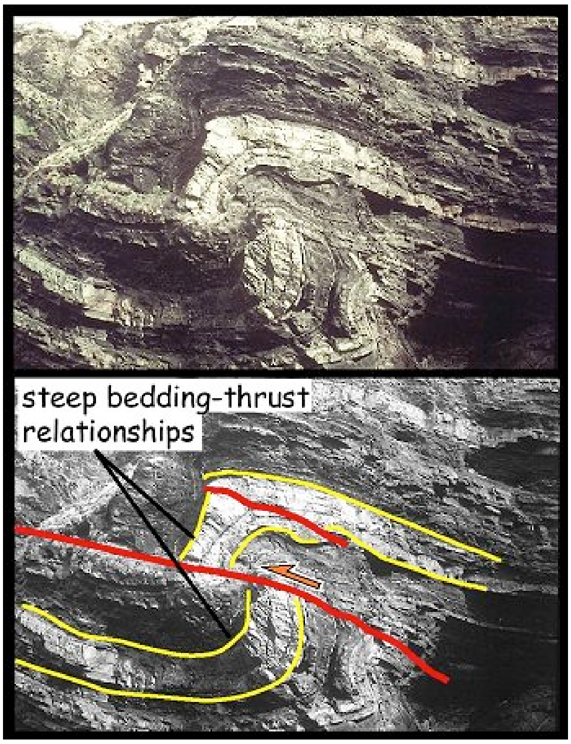
example of duplex from NW Scotland

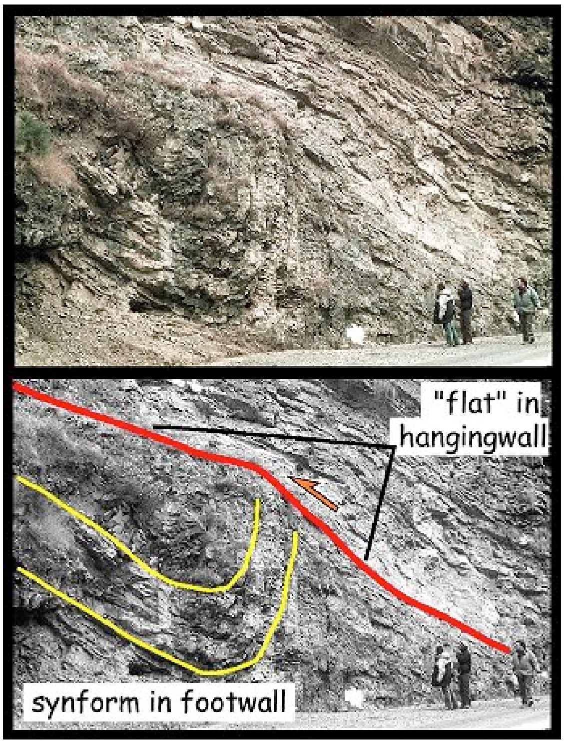


back-thrusts

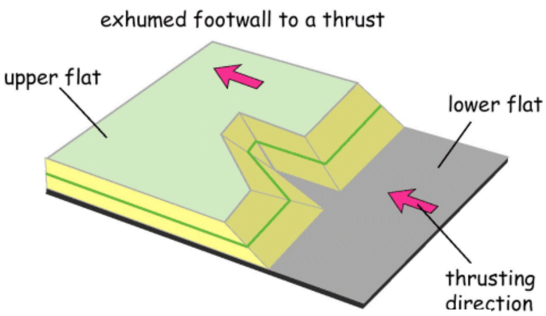


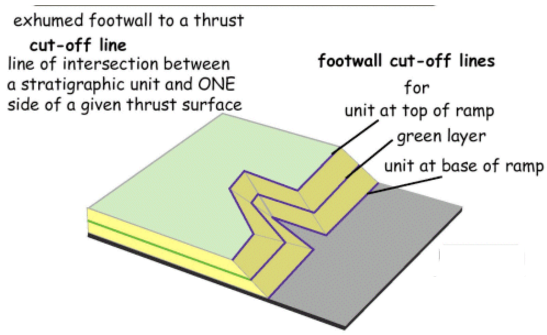


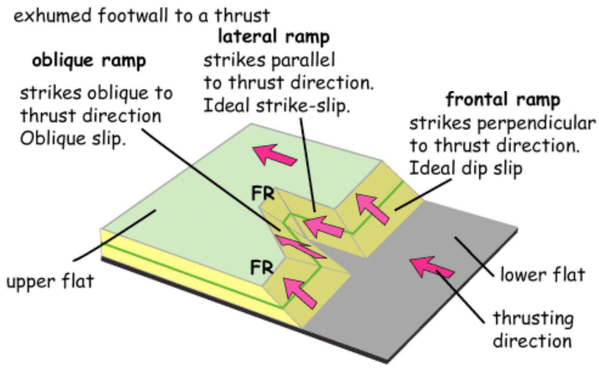


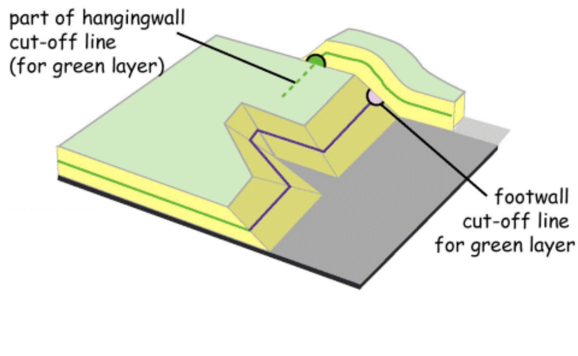


Describing a thrust surface in 3D

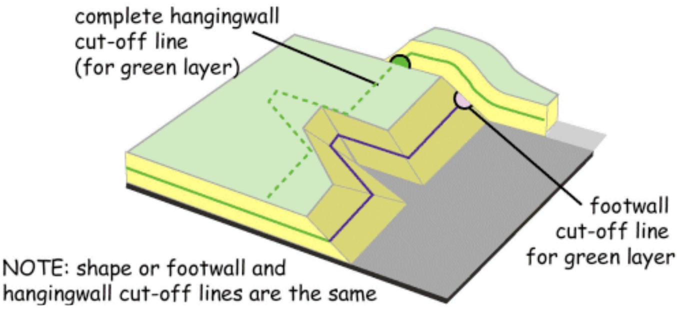




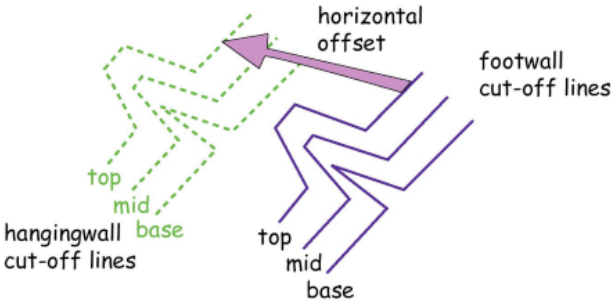




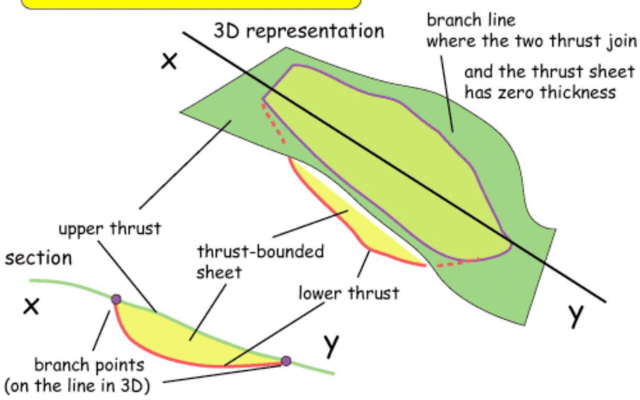
Describing a thrust surface in 3D



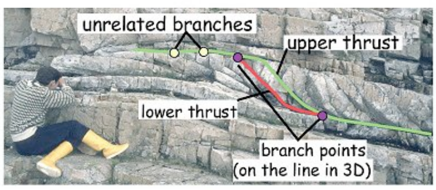
cut-off lines on a map



What is a branch line?

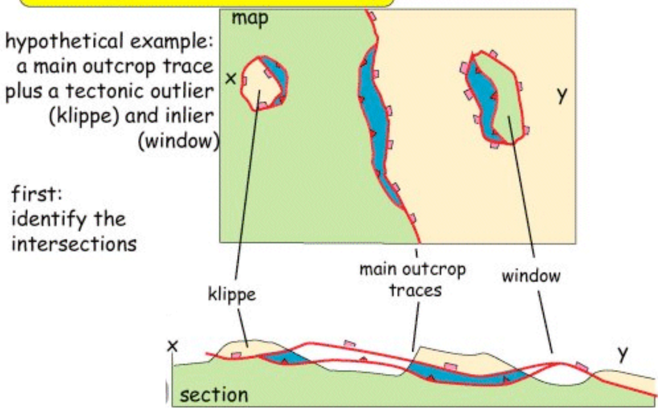


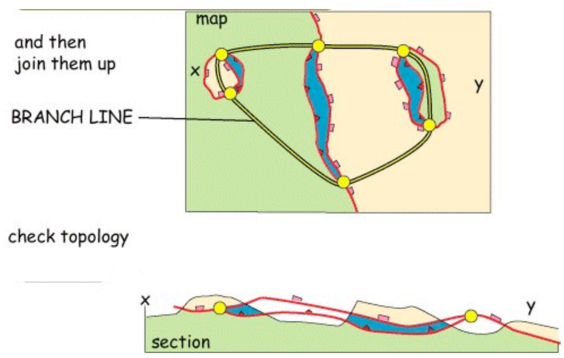
example of branch lines

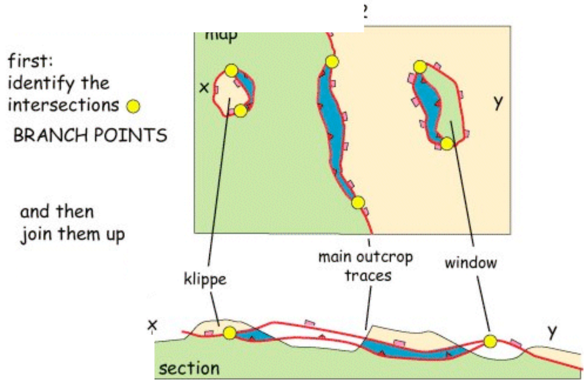


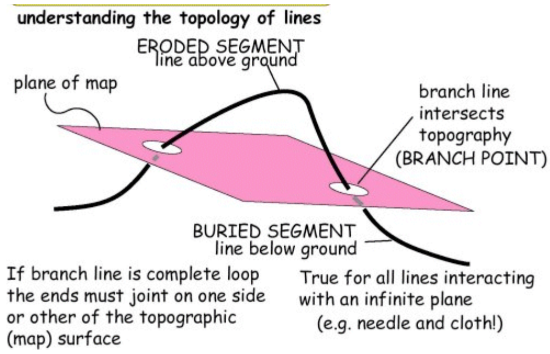
note that branch lines are constructed between two SPECIFIC thrusts

Making a branch line map



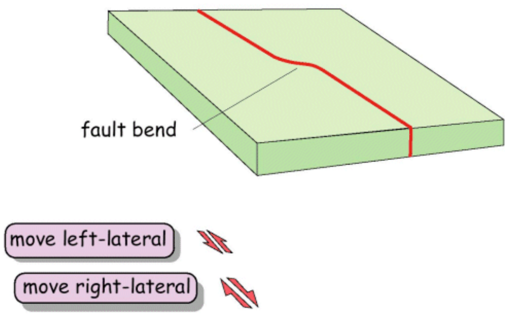


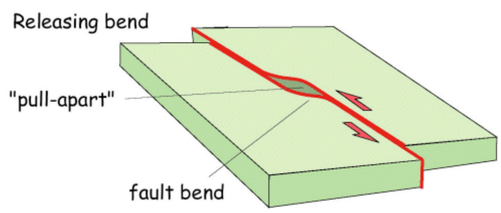


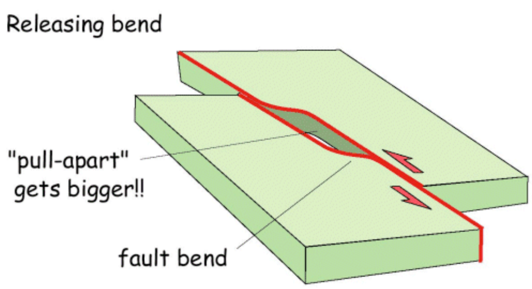


Strike-slip fault(横ずれ断層)

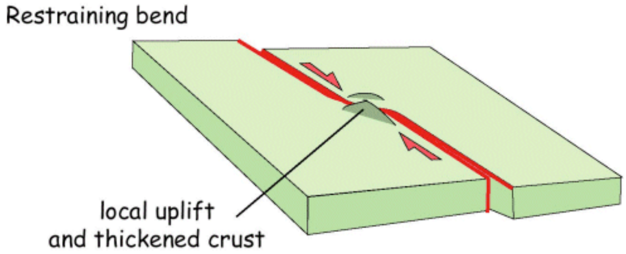
Bends on strike-slip faults

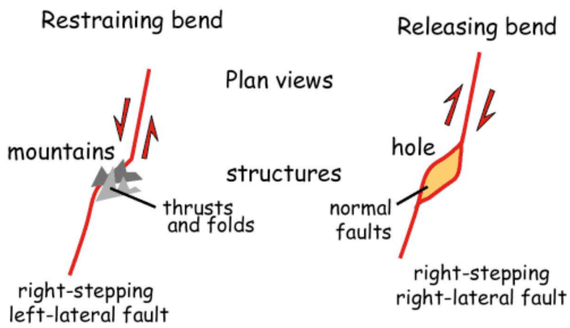




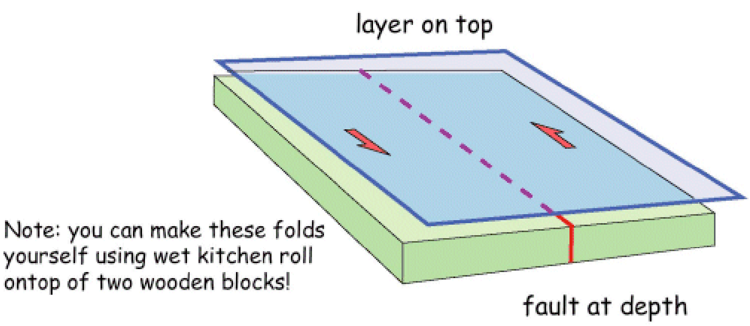


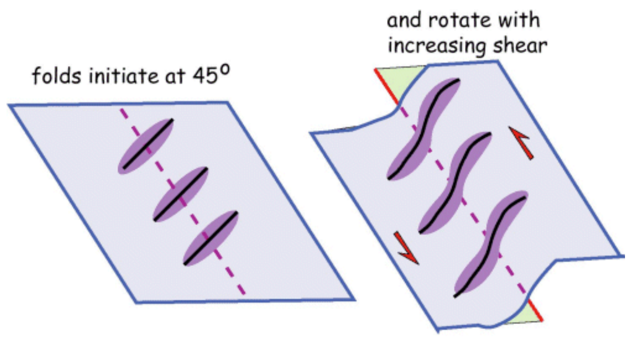
Bends on strike-slip faults





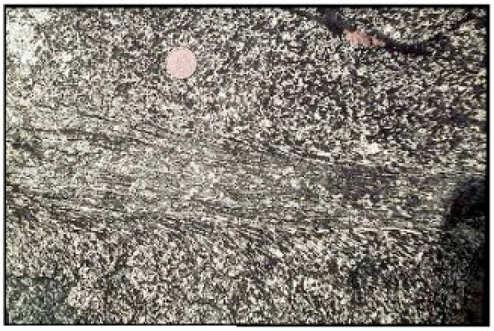
Folds in strike-slip zones





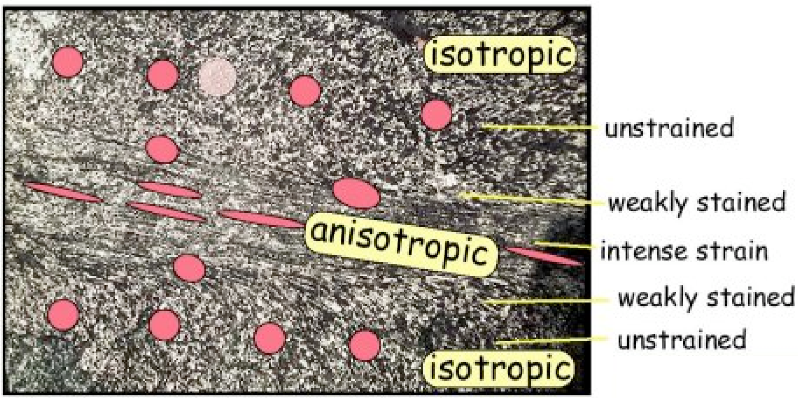
Shear zone (剪断带)

Shear zones - what's the problem?

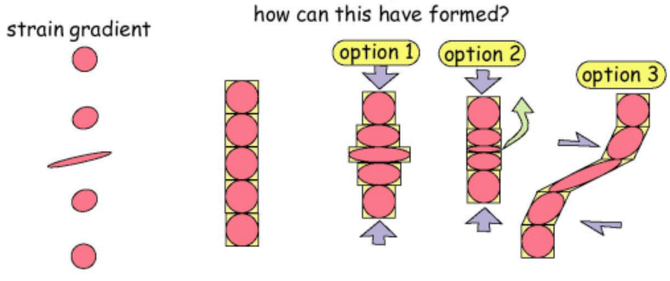


This is one of the type examples of shear zones - from the Outer Hebrides. Originally described by Ramsay & Graham (1970) - it shows a belt of deformed rock within undeformed. What type of strain would allow this?

Shear zones - what's the problem?



how can this have formed?



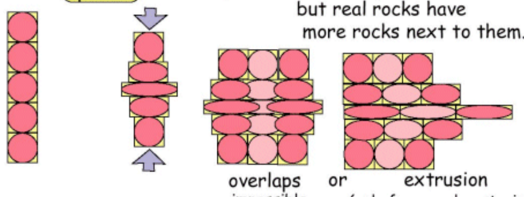
which option is most likely?

Shear zones - what's the problem?

how can this have formed?

option 1 heterogeneous flattening

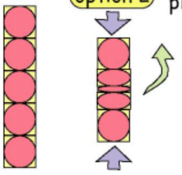
but real rocks have more rocks next to them....



These strains are said to be incompatible

how can this have formed?

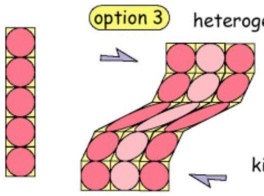
option 2 heterogeneous flattening plus volume loss



but if formed by solution then shear zones would become enriched in insoluble minerals. This is NOT a general observation - so for rocks where shear zones have the same composition as their walls - we need another explanation

how can this have formed?

option 3 heterogeneous simple shear



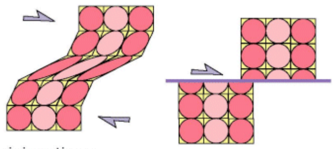
This is COMPATIBLE

generally now believed that shear zones are the products of heterogeneous simple shear

kinematically - rather like faults

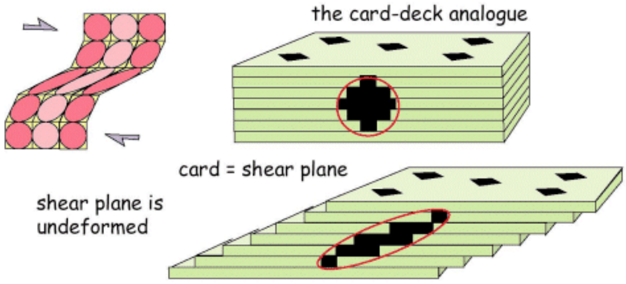
Shear zones - kinematic equivalents of faults

both accommodate relative displacement



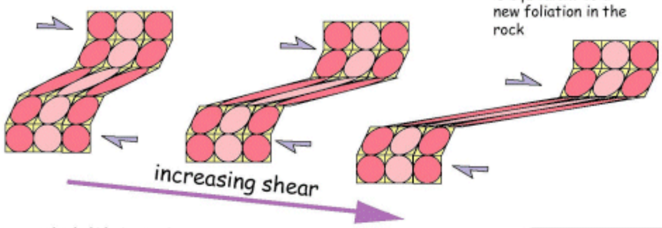
Characteristics of shear zones

the card-deck analogue



Seen in profile, the ellipse rotates towards shear plane with increasing strain.
Ellipticity increases with increasing strain.

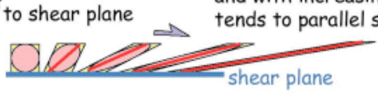
long axis of ellipse is equivalent to a new foliation in the rock



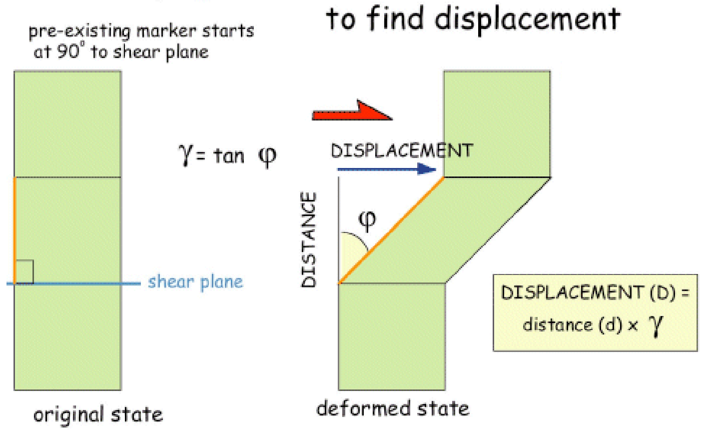
long axis initiates at 45° to shear plane

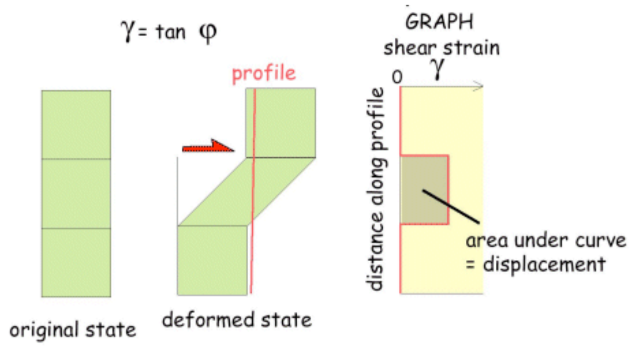
and with increasing strain.... tends to parallel shear plane

quantify this



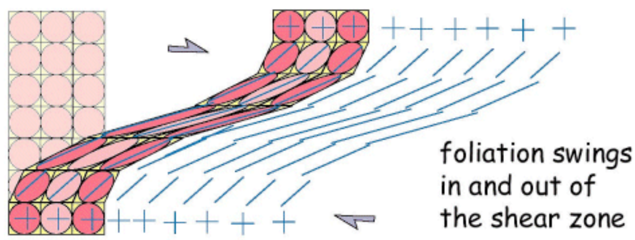
Quantifying shear strain..... to find displacement



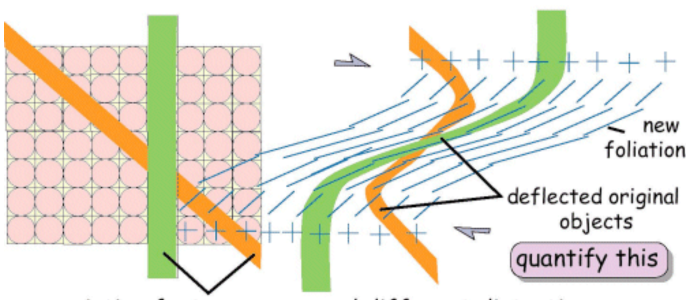


integrate the distance vs shear strain curve to find total displacement

Characteristics of shear zones

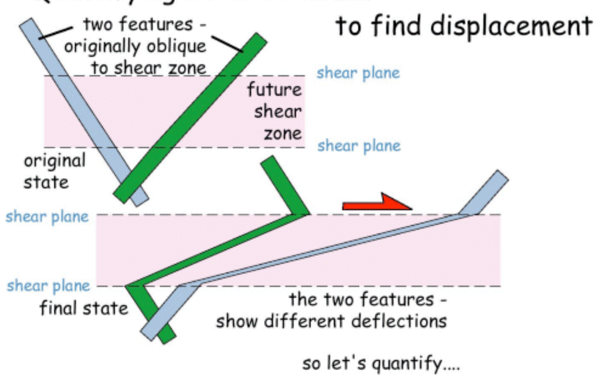


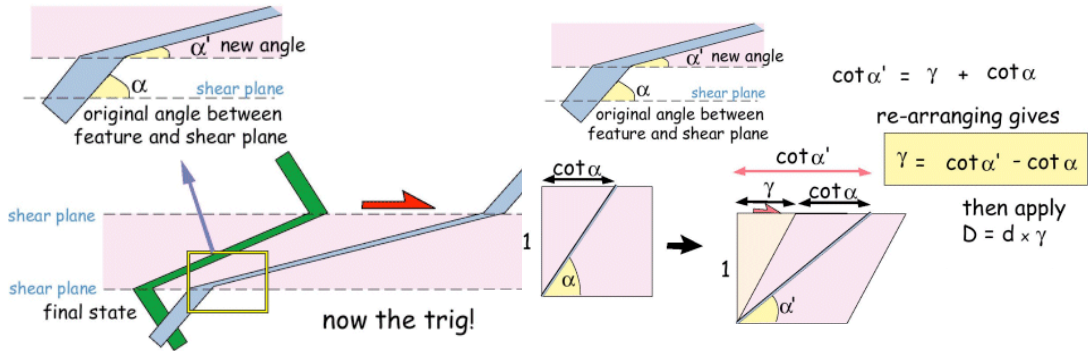
sense of swing gives sense of movement



pre-existing features... record different distortions....
....depending on their initial orientation

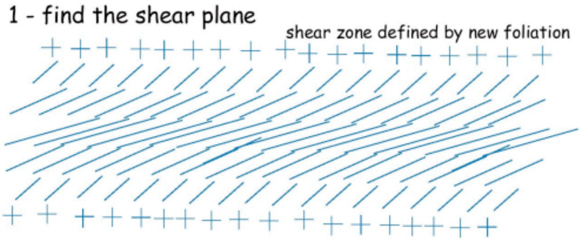
Quantifying shear strain.....





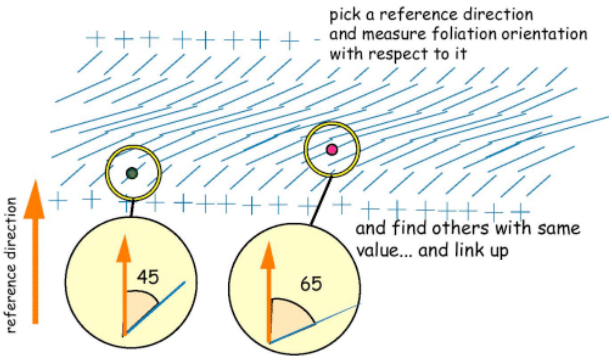
Analysing shear zones

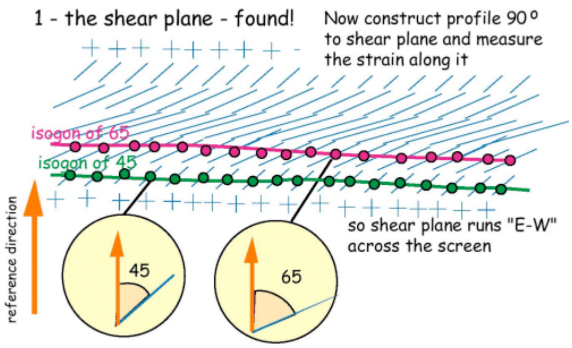
1 - find the shear plane



by constructing isogons

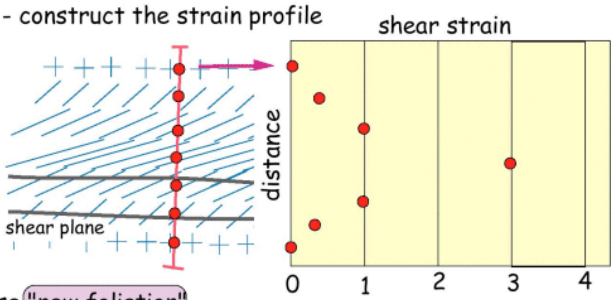
Isogon - a contour of equal value of angle...





Analysing shear zones

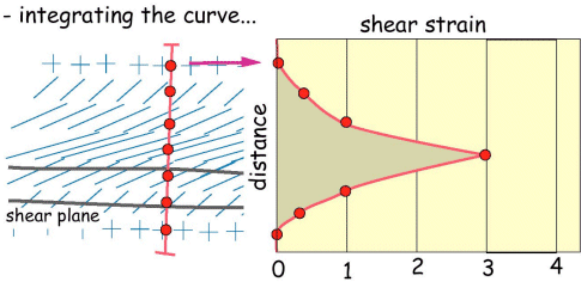
2 - construct the strain profile



use "new foliation" method

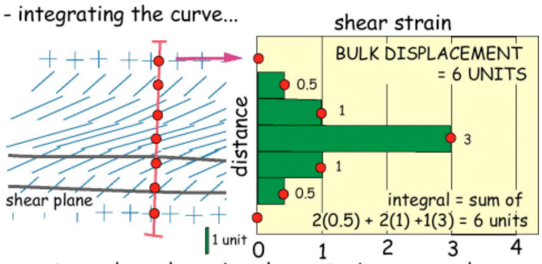
and integrate it...

3 - integrating the curve...



Fit a continuous curve.... but a BETTER OPTION IS...

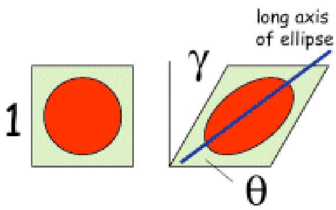
3 - integrating the curve...



Use a stepped graph - using shear strain measured in unit distances across shear zone

Quantifying shear strain.....

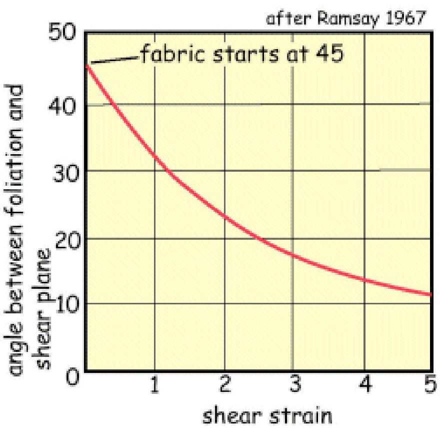
using new foliation



$$\theta = 0.5 \tan^{-1} 2/\gamma$$

re-arrange...

$$\gamma = 2/\tan 2\theta$$

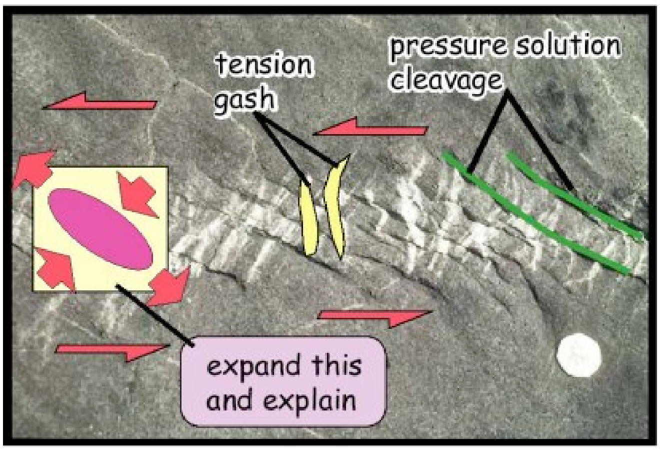


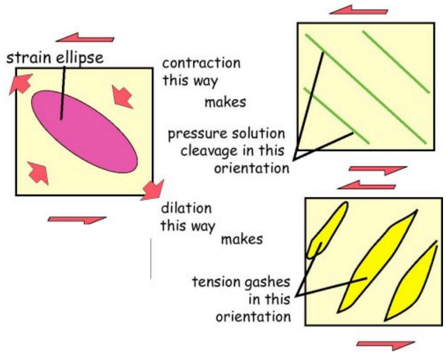
剪断帯と拡散物質移動(Diffusion Mass Transfer)

Shear zones and DMT - how do they work ?

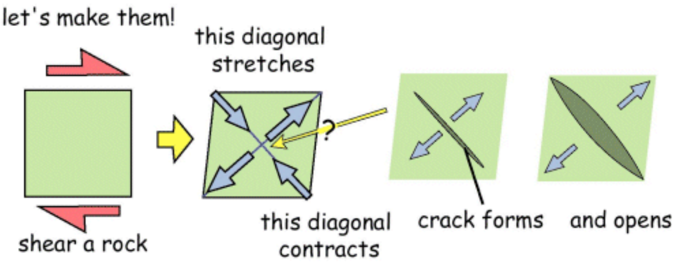
This photograph is of a bedding plane in grits. The white veins are quarts, formed in tension gashes, while the diagonal seams are zones of enhanced pressure solution. Together these DMT features form a shear zone. HOW?

この変形に何を見るか？

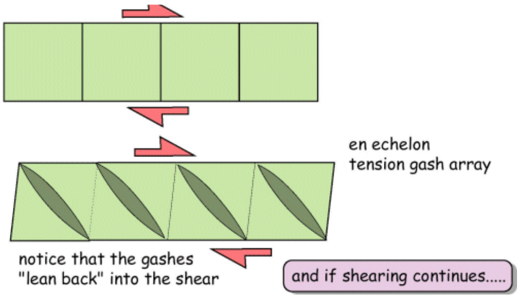


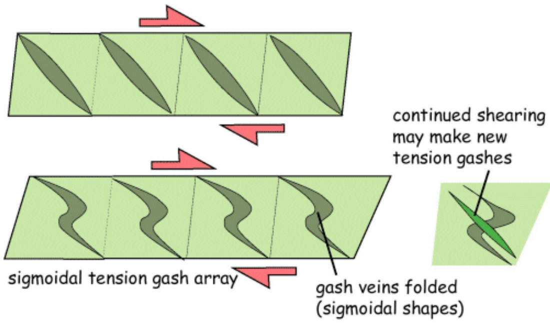


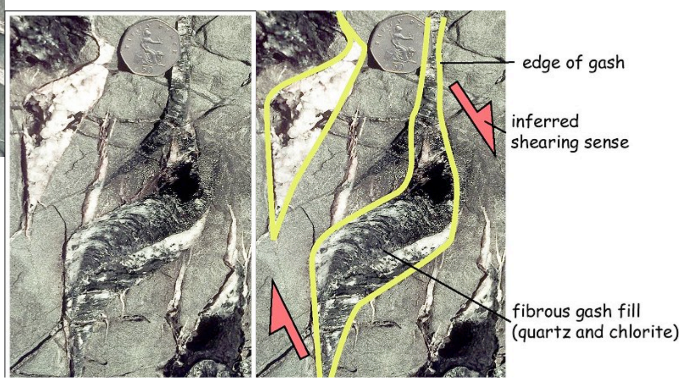
Tension gashes



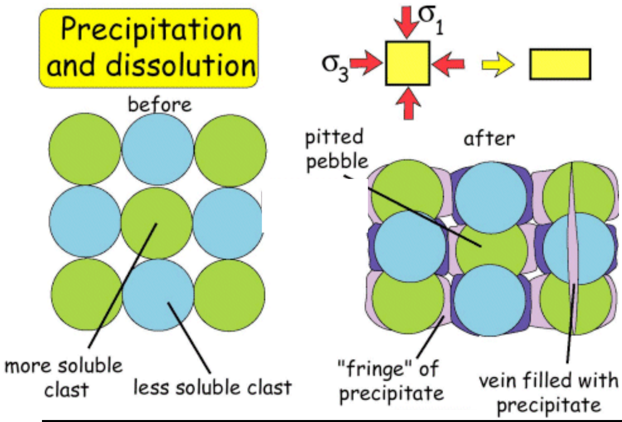
Tension gashes





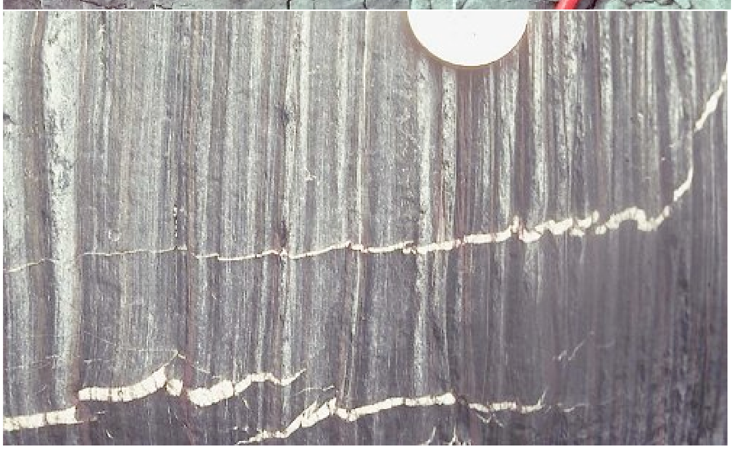


沈殿と溶解



Stilolite

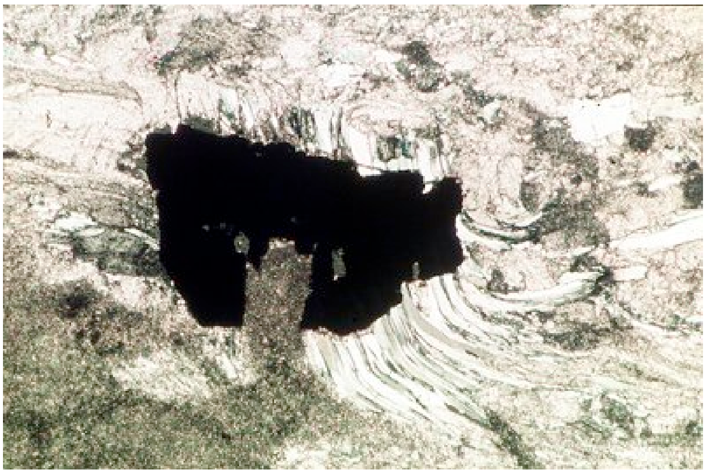
Cleavages



溶解構造

沈殿構造

鉱物脈



fringe