Structural Geology

Folding

Folding pieces of felt — A P 10 min

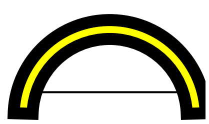
Provide students with 3 pieces of felt of different colours each 10cm by 60cm. Each colour represents a different type of strata.
The felt pieces are laid out flat with the pieces on top of each other and then the students push the ends together to show how compression causes folds. The students draw and label the folds they have made using technical terms.

Folds using arms for anticlines — G

The teacher draws the shape on the board and then uses his arms to emulate it. The students must do the same and say the term. So for anticline arch your arms in front of you and join your hands. Rounded, sharp, asymmetric, overturned and recumbent anticlines can be shown easily. Synclines can be done but are less satisfactory.

Anticlines and synclines — T

Students often get them muddled. A is for arch and anticline. S is for saucer and syncline.

 nticline

Making folds — A I 3 min

Having been shown a simple anticline and syncline students are given a piece of paper and must make it into a many different varieties of fold as they can. They should come up with different attitudes, shapes, tightness and plunge.
Or they can draw the varieties they think of.

Making folds — A P 2 min per fold

To reinforce the names and descriptions of folds, e.g. anticline, syncline, monocline and upright, asymmetric, overturned and recumbent.

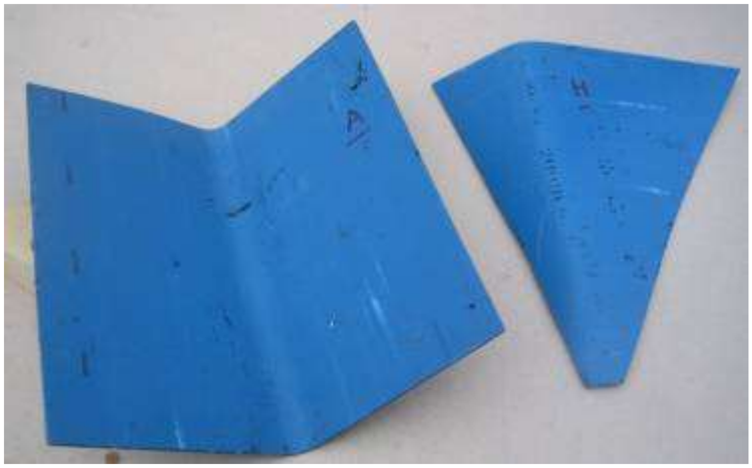
Students fold pieces of electrical cable (30 amp cable is best) into the shape being described by the teacher or drawn on the board. Thin lead sheet (5cm by 20cm) is even better because it stands up on the desk.

Demonstrating fold attitude, shape and tightness ***D***

A pile of A4 paper 3cm thick made of several colours representing the strata is good for demonstrating upright, asymmetric, overturned and recumbent folds and for tightness and shape of folds.

Shapes of folds I ***A I 1 min for each fold***

This activity tests students on the use of technical terms used to describe folds. Various fold shapes including plunging folds are made from sheets of plastic about 30cm by 30cm. The plastic can be bent over a low heat and can be cut with a hot wire or knife. Polystryrene ceiling tiles are easiest to fold but less durable than plastic sheet. Or use pieces of ready folded plywood e.g. Pendock pipe boxing.



Plunging folds and axial plane *D*

Open a thin A4 size book with a stiff cover (an old attendance register is ideal) and hold as an anticline and tilt to show the meaning of plunge. Allow a single page to hang vertically to show the axial plane.

Making folds *A G 1 min per fold*

To revise the names and descriptions of folds students are supplied with pieces of thick electric cable 40cm long. The teacher calls out a fold shape then the students make the fold shape in the cable as quickly as possible. Alternatively students take it in turn to call out fold shape for every one else to make.

Photos of folds *A I F 10 min*

To revise or test students knowledge of the terms used to describe folds they are given 12 or so numbered postcard sized photos of a variety of folds. Students describe each fold using technical terms.

Painted wooden blocks *A P F 3 min each*

Wooden blocks 15cm by 10cm by 7cm are painted with fold patterns and with a north sign on top. Students describe the folds including the orientation of the fold axis and the dip and dip direction of the limbs. Click F for the best way of painting blocks. See also the Outcrop patterns section of this website.

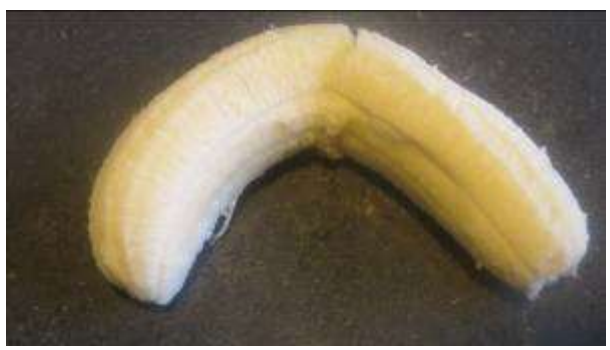
Refolded folds *D*

To demonstrate the shape of refolded folds use polystryrene ceiling tiles (or paper) folded and then refolded either with the fold axis in the same

orientation or at an angle to the original orientation. Ask students to show how these shapes might form using a piece of paper.

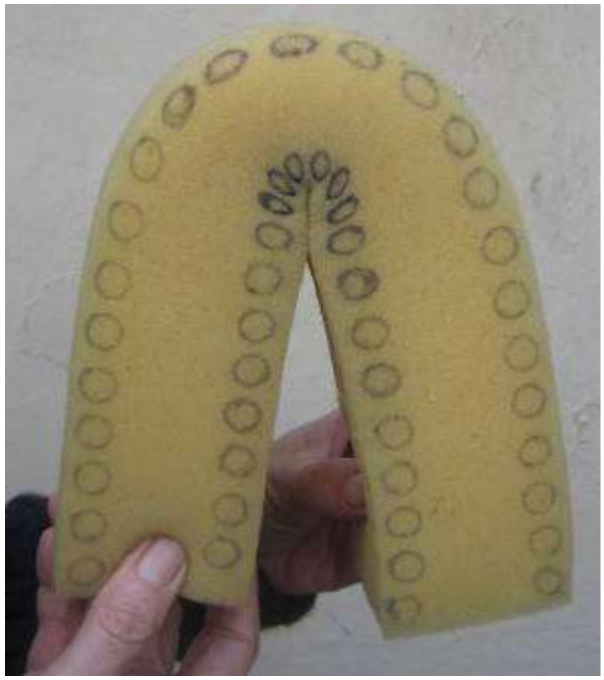
Banana bending ***A P 3min***

Take a peeled banana. Hold the ends and push gently together and bend to increase the curvature. Tension gash or gashes will appear on the outside and compression crumpling on the inside.



The effects of tension and compression in a fold ***D or P 10 min***

Use a piece of sponge 40cm by 6.5cm by 6.5cm with a grid marked on the long edge. Students should bend the sponge and then draw it. On the other long edge mark two rows of circles 1cm in diameter. Students bend the sponge to see some of the circles become ellipses. They the draw and explain the shape of the ellipses.



Effects of compression and tension in a fold D
Alternatively use a piece of plasticine 10cm by 5cm by 2cm. Mark the top, and bottom with a row of circles by pressing a pen top into the plasticine.
Mark the long edge with two rows of circles. Bend the plasticine and note the changes in shape of the circles.

The effect of compression on the inside of a fold D or A P 5 min
Bend a piece of thick rubber 2cm thick 25cm by 5cm (a slice cut from a flip flop sandal works well) or a 3cm thick pile of A4 paper gripped tightly at each end. Crumpling occurs on the inside of the fold.

Formation of tension gashes A P 2 min

Supply students with rubbers 6cm by 2cm by 1cm with slits cut 5mm deep every 5mm along the long edges. When the rubbers are bent slightly gaps open up on the outside of the fold. (The rubbers should only be slightly bent otherwise they break)

Slip between beds during folding A P 3 min

To show the amount and direction of slip and the cause of slickensides provide students with two pieces of rubber 20cm by 5cm by 0.5cm. Students place the pieces together and then bend them and note the direction of slip on each side of the hinge and that it increases with the tightness of the fold.

Slip between beds during concentric folding E P F 105 min

To determine which factors control the amount of slip during concentric folding. Three separate activities totalling 105 minutes.

Drag folds *D*

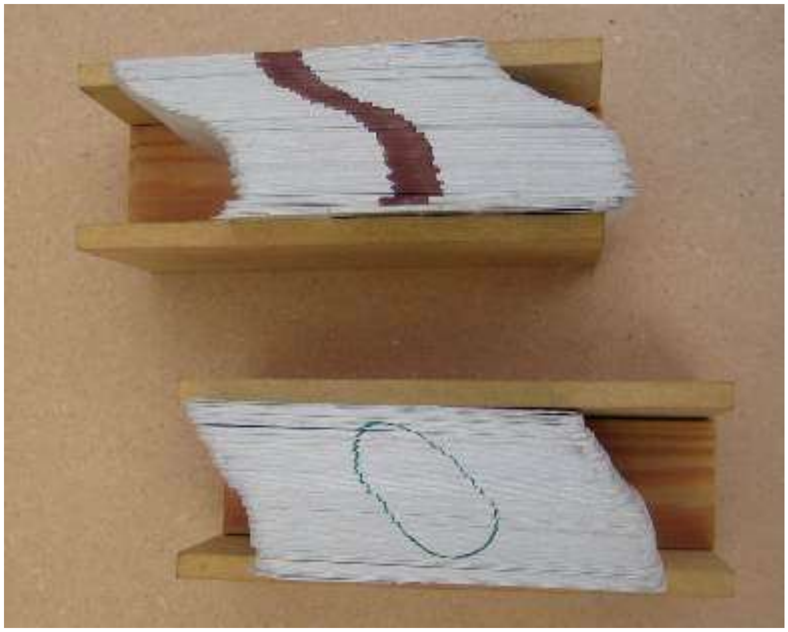
To show the formation of S and Z drag folds and their relationship to anticlines and synclines take two pieces of foam rubber 50cm by 25cm by 2cm. A piece of brightly coloured paper the same size is glued to both pieces in the middle, to the upper sponge at the outside 8cm on both sides, It is glued to the lower sponge between 12cm and 17cm from both short edges. Mark top for anticline on one side and top for syncline on the other otherwise the paper gets torn. Bend the foam rubber and the drag folds appear.

Using drag folds to work out the types of folds *Pa I 5 min*

Students are given a diagram of isoclinal folds with no hinges shown but several drag folds on the limbs. They must work out the position of the anticlines and synclines.

Similar folding *D or P 5 min*

To show the formation of folds by slip along cleavage planes and to show thinning on the limbs students are supplied with a box containing two packs of playing cards. A 1cm thick bed is marked on the edge of the cards. The centre of the cards is pushed to make a fold. The thinning on the limbs can then be observed.



Deformation of oolites during similar folding *D or P 5 min*

As above but with a circle drawn on the cards. Keep the cards in value and suite order so that if they are dropped they can be replaced in the correct order. Students press the cards into a diamond shape and the circle becomes and ellipse.

Wavelength and amplitude *E P 10 min or 1 hour F*

Students fold a piece of A4 paper into a zigzag pattern with each limb being about 3cm. They should then note how the wavelength and amplitude change as compression takes place. A more detailed version with measurements can be done as an experiment.

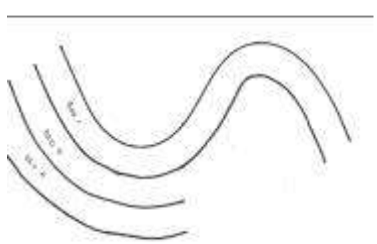
Crustal Shortening *A P 5 min*

Students lay felt strips, 10cm by 60cm, on top of each other on the desk and measure the length l_1. They now fold it by pushing the ends together and measure its new length l_2. They then must calculate the crustal shortening as a percentage: $(l_1-l_2)\ x100/l_1$.

Fold wavelength and bed thickness E P F 40 min
This activity is to show the relationship between fold wavelength and bed thickness using rubber sheets and sponge rubber. The sheets are compressed and the fold wavelength measured.

Bedding and ease of folding D or P 2 min
To show how easy it is to bend beds if they are thinly bedded and how much more difficult if they are thickly bedded hold a pile of A4 paper 3cm thick paper lightly at each end and bend it. Now grip the paper or very thin card very tightly at each end and try to bend it again. If the sheets are allowed to slip then folding is easy.

Tightness of folding in concentric folds Pa I F 3min
Students are given a diagram of a fold and must draw other beds inside an anticline keeping the strata the same thickness. They find it is impossible.



Incompetent layer between concentric strata D or A P 1 min
Students are given two A4 sheets each with an identical drawing of a syncline and anticline. They are overlain but with one fold just below the other. They are then held up to the light. The strata in the gap between

the two folds is always thinner on the limbs and thicker at the hinges. This can also be shown with acetates on an overhead projector.

Concentric folds do not stack **D**

To show that there is always a gap between concentrically folded beds take two curved objects with the same curvature and the same thickness and place them together. The photo shows shelf brackets from Ikea.

Radius of folds in concentric and similar folding **D**

To show that the folds in beds above each other must increase in radius if the beds are to remain constant in thickness (concentric folding) but folds of the same shape and size can stack if there is variation in bed thickness (similar folds). Place two pieces of hardboard with same curvature and same width together. There is a gap. Now place two pieces with the same curvature but thinning on the limbs together, there is no gap.

Competent and incompetent beds. **D**

Two pieces of rubber 50cm by 10cm are glued on to both sides of a piece of sponge 10cm by 5cm by 50cm. When the rubber and sponge are folded *the rubber (competent) remains the same thickness but the sponge (incompetent) changes thickness.*

Thinning of incompetent beds D

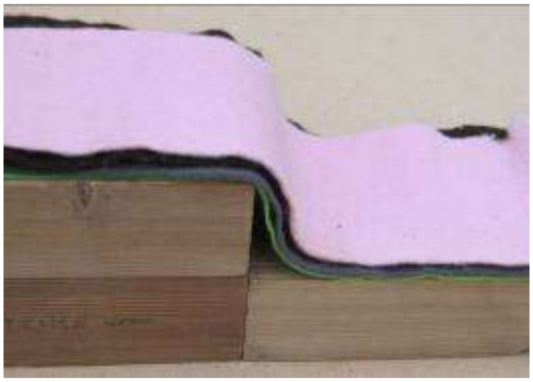
Two strips of rubber 50cm by 1cm by 5mm are held 1cm apart at either end
with wooden strips. The rubber represents the competent beds and the air between the incompetent bed. Place on a table with the lip on the table edge and slowly move the ends towards one another. A fold will develop and the gap between the rubber strips narrows on the limbs. The right hand photo shows one end piece upside down.

Gravity Folding D

Lay a silk or nylon square at least 100cm by 20cm such as a scarf out flat on a piece of wood. Lift up one end of the wood. You will need a tilt of 40^o or so before it will slip unlike the rocks which can slip with an angle of only a few degrees.

Formation of monoclines by faulting of basement D

Strips of felt are laid on top of two blocks of wood or books. Raise one of the blocks by about 5cm to simulate normal faulting. The felt will now form a monocline. This can also be done with wedge shaped blocks to show a monocline forming from thrust faulting.




Formation of folds by wrench faulting in the basement D

Place two blocks of wood 10cm by 20cm by 3cm side by side with a piece of cotton or better a piece of Jersey cloth 20cm by 20cm laid on top. Glue the outer edges only to the wood. Move the blocks sideways past each other and folds will develop in the cotton.

Anticlines and antiforms A P 15 min

To show students the difference between anticlines, and antiforms and synclines and synforms use felt strips 10cm by 60cm of different colours. It is best if all students have the same three colours placed in the same order.

Students lay out the felt flat on the desk and then compress it so that there are recumbent folds. With luck some parts of the upside down limbs will have subsidiary antiforms which are synclines and synforms which are anticlines. They should sketch and label the all the folds made by the felt as anticline and synform or anticline and antiform etc.

Flow folding ***A P 5min***

Students are provided with two different coloured sheets of soft plasticine 7cm by 7cm by 1mm. They place onetop of the other and then fold them into an s shape and then old again with the fold axis at right angles to the first. Then they squash the plasticine and much as they can in a variety of directions, the result should be very disorganised folds.