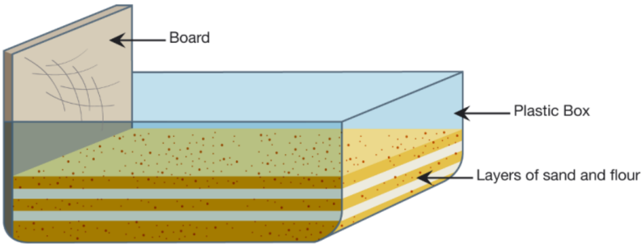
ACTIVITY 8: Deformation
- make your own folds and faults

(seconds [faulting] to millions of years [folding, faulting, metamorphism during mountain building])

Activity:

This activity shows how folded and faulted rocks can provide evidence of the size and direction of the forces which produced the deformation.

When forces are applied to solid materials they may bend or break. When sands or sandstones bend, folds are produced; when they break, faults are formed.



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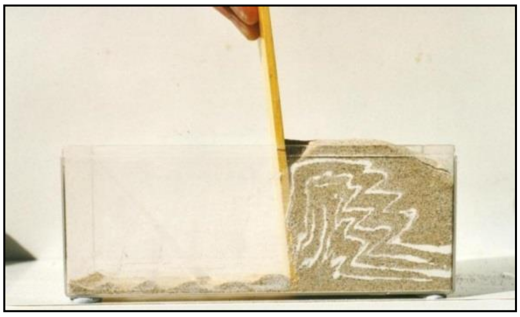
Find out what types of folds and faults are produced by compression by following these instructions.

- Place the board vertically inside one end of the box.
- Build up several thin layers of flour and sand. Do not fill it more than half-full. (Only thin layers of flour are needed, sprinkled along the front of the box alone, in order to save flour and to allow the materials to be reused several times.)
- Very carefully, push the vertical board across the box, so that it begins to compress the layers.
- When you notice the layers beginning to bend, stop pushing the board.
- Hold the board upright and draw a scaled diagram of the result.
- Continue pushing the layers with the board until the sand is about to overflow the box.
- Hold the board upright and draw a scaled diagram of the result.
- Then add arrows to your diagram to show the directions of the forces which were acting whilst you compressed the layers with the board.
- Are the layers still horizontal, or are they folded?
- Did one set of layers slide over the rest? If you have been careful, you will have produced a fault in which layers of rock are pushed up and over other layers. These types of faults are often nearly horizontal.
- How could you use the same apparatus to find out what happens when sands and sandstones are stretched (put under tension)?
- Be ready to tell the rest of the group about the activity and your results.



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Pupil learning outcomes:

- Rocks experience enormous pushing and pulling forces because continents move around, jostling each other.
- These forces can bend (fold) rocks or snap them along a fault, or both.

Further Notes:

Rock deformation

Rocks frequently become fractured during their history, but school laboratory investigations on real rocks are difficult to carry out with any finesse. The activity described uses layers of fine sand and flour which behave like layers of rock.

Pupils should appreciate that faulted rocks at the Earth's surface contain clues about the ancient pressures which deformed them.

The near-horizontal faults produced by compressional pressures are called thrust faults (more steeply inclined faults are produced by tensional stresses and these can be formed in the same transparent box as in Activity 8, by putting the vertical board in the centre of the box, filling one side with sand and flour as before and moving the board gently away).

Large scale pressures acting within the lithosphere are caused by plate tectonic movements. Where plates are converging, the compressional stresses produce near horizontal thrust faulting. Where plates diverge, the tensional stresses produce steeper faults, called normal faults.

Pupil practical or teacher demonstration:
Pupil practical.

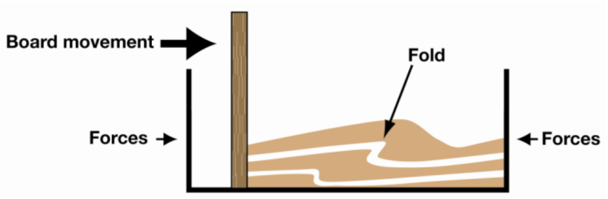
Time needed to complete the activity:
10 minutes.

Preparation and set-up time:
10 minutes.

Resources:
Per pupil / pair / small group:

- Empty clear plastic box (e.g. Ferrero-Rocher chocolate box - not the 'tray' variety)
- About 500g of dry sand
- About 25g of flour
- Spatula or dessert spoon
- Eraser or similar flat object (for tamping down the sand/flour)
- Piece of board or plastic to snugly fit into the box
- Tray for tipping out sand

Some diagrams of what might be expected are shown below.



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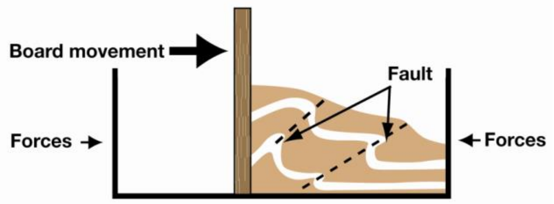
This is a sideways view of a squeeze-box after the sliding board has been moved a short distance to the right.



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This is a sideways view of a squeeze-box after the sliding board has been moved a short distance to the right.

Ideas for leading into the activity:
Show the photograph of some rocks which have been folded or faulted. Explore how everyday things get folded or broken.

Demonstrate with the bars of toffee if available how forces can bend or snap things. Try to show that you are effectively using pushing forces from the sides – a kind of squeezing.

Ask pupils to apply forces to either side of a piece of paper to show folding. We are focusing on the idea of pushing forces being applied towards each other (i.e. compression).

Ask if they can fold a lump of rock by pushing from the sides. Why can't they do it?
Not strong enough; the rock is too brittle.

Explain that, several kilometres deep in the crust, the rock is hot - but not hot enough to melt. Like the warm toffee, rock in this state becomes more "bendy" and can be folded before it breaks. Folded rocks like the ones in the pictures tell us that, at some time in the past, they have been a few kilometres below the surface and have been slowly squeezed by sideways pressures.

Explain that we are going to simulate folds and faults using sand and flour as our 'rocks' because we only have tiny forces available to us in the classroom.

Concluding discussion:
Display again the picture of the folded rock. Does it look like what is in the squeeze boxes? Some diagrams of what might be expected are shown below.

Further notes:

How can rocks be folded?

Continents are moved slowly across the surface of the globe by plate tectonic forces. When continents meet each other, enormous forces are produced, even though they are moving very slowly. These forces can be "pushing" or "pulling" forces. They can slowly fold solid rock if it is warm enough. To be warm enough, it must be deep in the crust - several kilometres down, but not far enough to be melted. It is a bit like toffee. If you try to bend it, it will snap if it is cold or bend (fold) if it is warmer. This is a useful demonstration or experiment in its own right, with lots of potential for fair testing and recording results using different variables.

What happens when rocks don't fold?

If the pressure is applied too quickly, or is too great, or the rock isn't warm enough, then the rock will not fold but will break like any other brittle solid. The line of the break is called a fault. The pressure is still on the two sides of the fault so the bits of rock usually start sliding slowly past each other. The initial movement – the break – causes shockwaves in the surrounding rocks and creates an earthquake.

What's the difference between deformed rocks and metamorphic rocks?

Where heat and pressure cause the rock itself to change, it changes to a metamorphic rock. Where the rock stays the same but its bulk is bent (folded) or snapped (faulted) then this is deformation. Often they occur together.

'Folded rocks' Isle of Arran, Strathclyde and Ayrshire Area © Lorne Gill/SNH

Folded layer in a Shetland boulder © Peter Craig

'Recumbent fold', Crackington © Peter Kennett

A normal fault in Precambrian rocks near Manila, Utah © Bruce Molnia, image courtesy Earth Science World Image Bank (www.earthscienceworld.org/images)

Aerial view of the San Andreas Fault © U.S. Geological Survey/photo by Scott Haefner

Aerial view of rock strata offset by fault line, **Southern Nevada** © Marli Bryant Miller, marlimillerphoto.com

The science of simulation, again
Once again, we are talking about time scales and spatial scales and forces that can't be brought into the classroom or the laboratory. So our scientific way of investigating how these forces affect rock is simulation. The simulation in this activity is designed to investigate pushing (compressional) forces. It is useful for pupils to understand why science sometimes needs to use a simulation. There is no choice. It is real science, not just a way of demonstrating for teaching purposes.

The imaginative leaps, again
In this activity the teacher is again faced with the challenge of helping pupils over imaginative leaps. The activity needs to be thought of as taking millions of years. It needs to be considered in the context of solid rock, not sand and flour. And it needs to be thought of as often happening over areas of hundreds or thousands of kilometres. The geological map and pictures of deformed rock will help. But both the picture and the map are abstract things. They are also snapshots in time – you don't 'see' forces in either. There is a challenge to help pupils to understand what the simulation is showing before its usefulness as a teaching aid can be realised.

The results
The near-horizontal faults produced by compressional pressures are called thrust faults, meanwhile the whole deformational effect is of a series of chevron folds.

Angular fold within thinly-bedded sedimentary rocks, Arkansas Novaculite
© Earth Sciences Department,
University of Arkansas at Little Rock

Using the box to simulate the effects of tensional forces
More steeply inclined faults are produced by tensional stresses and these can be formed in the same transparent box, by putting the vertical board in the centre of the box, filling one side with sand and flour as before and moving the board gently away.

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A steeply-inclined normal fault
– formed by tensional forces pulling apart the rock mass, allowing the rocks on the right to slide downwards. Orgreave opencast site, South Yorkshire.
© Peter Kennett, ESEU

Source of activity:
This activity is based on the Earth Science Teachers' Association's (1991) 'Earth's Surface Features' in 'The Science of the Earth 11-14' series, published by Geo Supplies, Sheffield.