Talkin Tarn and surrounding area, Cumbria

- **Science and geology**
  Forest Head: Bendy Rocks

- **Geography and Landscape**
  Landscape and recreation pressure at Talkin Tarn
  River features and processes on the River Gelt

- **Signposting of places of interest and information at Talkin Tarn and the surrounding area**

Science and Geology

ORGANISATIONAL DETAILS

Aim of field work

1. To consider the geological evidence from the quarry in using the sedimentary rocks and evidence contained within in a plate tectonics context
2. To recognise folding in rocks and how this was produced by compressional tectonics
3. To appreciate the landscape and how this is created by the underlying geology.

Target Group

Key Stage 4 geology, science and geography. However, the exercise could be easily adapted for key stage 3.

Location

Forest Head Old Quarry, Cumbria.

Practical Details

This fieldwork half day is based at Forest Head Old Quarry, Cumbria. It will start from the main entrance to the quarry and will involve a short walk of approximately 300-400 m each way to complete all the stops (allow 3 hours). The walk will take in various geological stops and will involve in-depth scientific reasoning about evidence for plate tectonics from the rocks. If travelling by coach it is advised for the coach to drop you off and collect you from the entrance to the quarry. No toilet facilities available at the quarry. The nearest facilities are at Talkin Tarn Visitor Centre.

Materials Required

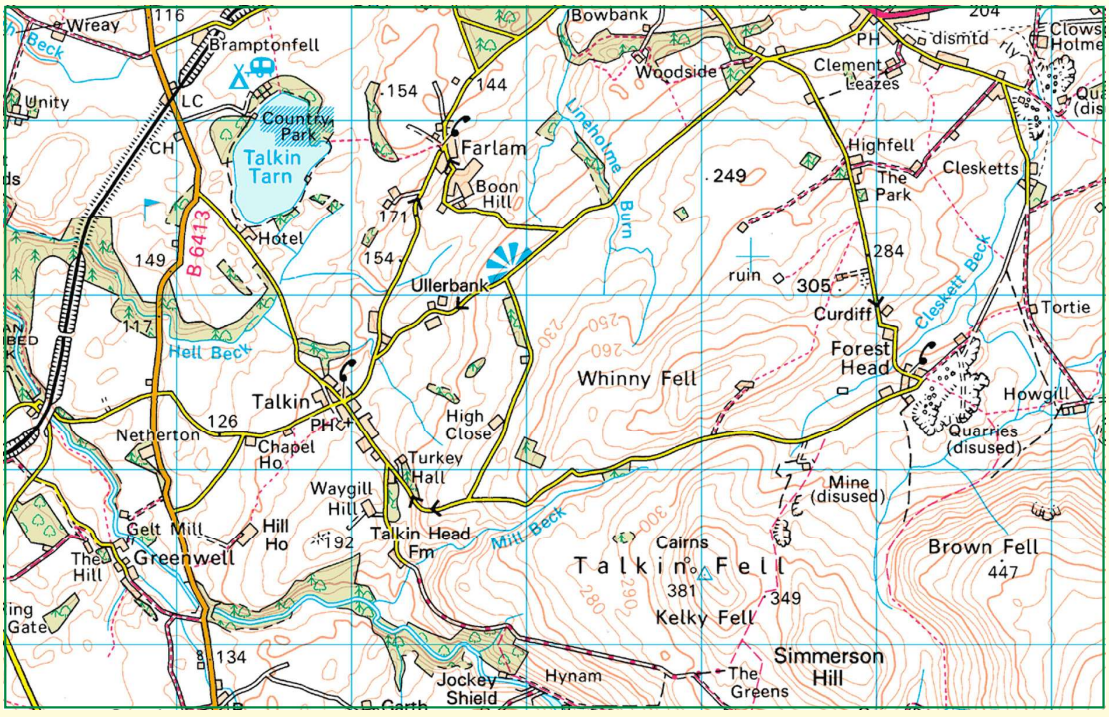
- Student work sheet and map of Bendy Rocks!
- Grain size cards (available from the Geopark Rock Boxes)
- Hand lenses (available from the Geopark Rock Boxes)
- Use of rock and mineral dials

Safety Issues:

- This part of Cumbria can experience bad weather and like much of the North Pennines is an exposed area. Staff and students should be prepared for extreme weather conditions and all need to wear suitable warm clothing and footwear.
- In some places old mine workings are present that may be unstable. Do not attempt to enter any of these old workings and only keep to the designated paths
- The quarry is now disused but extreme caution should be taken at all times close to rock faces
- Hard hats MUST be worn at all times while in the quarry
- Refer to the Hazard Identification Sheet.

Forest Head: Bendy Rocks

Fieldwork Outline - Teacher Resource Sheet



HAZARDS IDENTIFICATION SHEET

The following notes will help teachers conduct their own risk assessments. This is not a risk assessment and teachers should follow guidelines from the Department of Children, Schools and Families.

Hazard Identified	Risk and to whom	Control measures
Vehicles in the car park	Caution needed when getting off the coach or minibus in the car park, and crossing any roads. All students and staff.	Supervise students getting off the coach or minibus and gather in a safe place.
Uneven paths	Paths are uneven and may be slippery in wet weather. Students may slip and fall. All students and staff.	Warn about conditions.
Disused quarry workings	The activity is based in a disused quarry with parts that may be unstable. All students and staff.	Warn all about NOT getting too close to old quarry faces and to keep to the designated paths at all times.
Steeps drops at quarry edge	Some parts of the quarry have steep drops down to lower levels. All students and staff.	Keep away from the edge and warn all students of risks.
Cliff faces of quarry	Loose and material that could fall from cliff faces. All students and staff.	To wear hard hats at ALL times while in quarry.

Plan of activities

- All the activites are based in Forest Head Quarry, near Hallbankgate, Cumbria.
- Follow track from Forest Head into the quarry and walk to far southern side of quarry. This provides the best section for observation *(Approx. 15 minutes walk)*.
- At Stop 1 complete the questions in the field using Pupil Resource Sheet *(45 minutes to 1 hour)*.
- Move to the centre of the quarry in a northerly direction where rock faces exhibit some gentle folds in the sedimentary strata *(10 minutes)*. This is where Stop2, 3 and 4 can be conducted *(1.5 - 2 hours)*.

BACKGROUND INFORMATION

Old Quarry Forrest Head: Bendy Rocks!

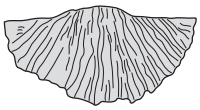
Tropical Limestones

The landscape of Talkin Tarn has been influenced by both physical and human processes The table below provides information about each stop on the circular walk around the tarn and pupils can record the information on Pupil Resource Sheet 2.

Between 350 and 290 million years ago the landmass that was to become the UK was positioned at the Equator. The North Pennines, during this geological time period known as the Carboniferous was periodically covered by large rainforests, vast river deltas and warm tropical seas that hosted an abundant fauna. The Carboniferous is named after the presence of coal (carbon) within much of the coal succession worldwide. Coal can be sen in the some of the sections at Forest Head Quarry and the quarry sections are very important for understanding the evolution of the North Pennines.

During the early part of the Carboniferous period, much of the area was submerged beneath warm tropical seas, where marine animals including, corals, sponges and crinoids (sea lilies) and molluscs flourished. Their remains are now found preserved in the limestones. Periodically large deltas built out into the sea where the sand, silt and mud settled out on the sea floor, burying the marine life and eventually hardening into sandstone, siltstone and mudstone. Over millions of years this pattern of limestone formation, followed by muds and sands of deltas produced regular and repeating cycles. These repeating cycles are not well illustrated at Forest Head Quarry but the sections do provide wonderful examples of grey carboniferous fossiliferous limestone. The limestones are grey in colour due to mixing with muds and silts washed off the nearby landmasses.

The Carboniferous is an interesting geological period for understanding plate tectonics and is marked by the progressive formation of the supercontinent Pangea. This was the only time in Earth's history when all the tectonic plates were fused together as one giant supercontinent. The Carboniferous age rocks of the North Pennines contain many fossils that clearly demonstrate the plates have moved over the last 350 million years. For example colonial corals are only found today in tropical and subtropical seas. Furthermore, thick limestone deposits only form today in warm tropical seas. These occurrences and many other geological criteria will be used as part of this activity to further consider plate tectonics.



A Carboniferous brachiopod

A solitary Carboniferous *Dibunophyllum*

A colonial Carboniferous *Lithostrotion*

Crinoid stems

Bendy rocks

Perhaps the most obvious feature of the limestone layers in the quarry is the way they have been buckled, crumpled and folded. Folding is a term used in geology when one or a stack of originally flat and planar surfaces, such as sedimentary beds are bent or curved as a result of plastic (i.e. permanent) deformation. Folds are a deformational response (strain) to a compressive stress that is applied to a section of rock. These compressive stresses push on the rock. Because the rock is not able to deform like an ideal fluid in response to the stress by shortening and becoming thicker, it instead buckles, and forms folds. (These folds still, in essence, shorten the rock unit while making it thicker.) The plane of symmetry of the fold forms perpendicular to the greatest compressive stress. This can easily be replicated by looking at how a stack of paper responds to compressional stress applied by one's hands as one pushes on the edges of the stack.

Understanding the relationship between the stress regime in which a fold forms and what structures one would expect is important in geology. Using these relationships, geologists are able to use the observed fold geometries to understand the physical forces that made them.

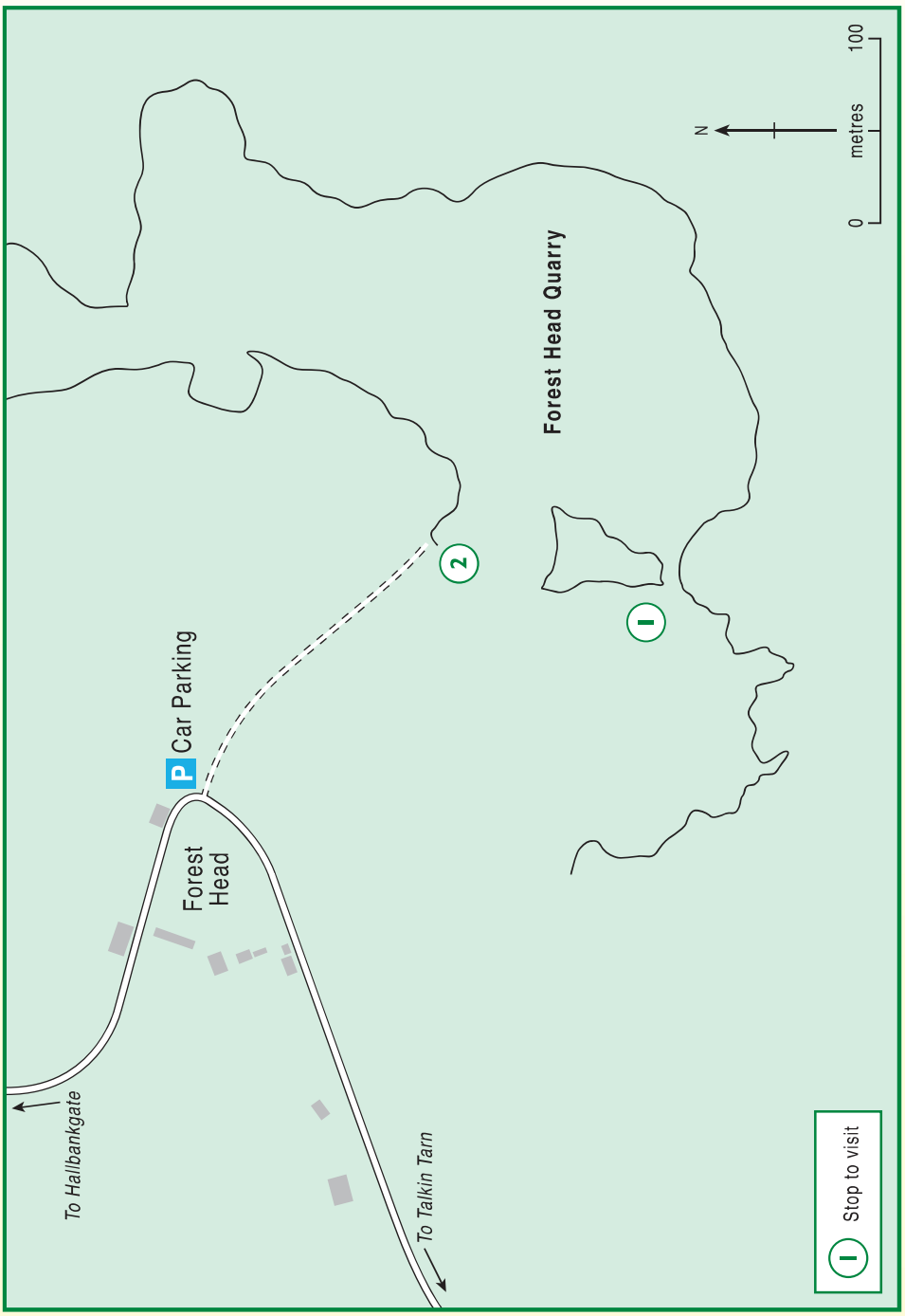
2. *The future of Talkin Tarn*

Talkin Tarn is now owned and managed by Carlisle City Council who have spent more than £1 million on improvements including new educational facilities, new toilets, a play area, better access for disabled people, improvements to the tea room, with lift access and improved car parking. In the coming years the council wish to develop a management plan for the whole site incorporating the views of user groups. Carry out a survey of people using Talkin Tarn Country Park. Pupil Resource Sheet 2 provides a questionnaire that looks at the views of visitors to the park to find out what they like/dislike and the improvements they would like to see. Pupils could add additional questions to the survey.

Forest Head: Bendy Rocks

Student Information Sheet 1

MAP OF GEOLOGICAL ACTIVITY





Forest Head: Bendy Rocks

Student Resource Sheet 2

BENDY ROCKS!

Hard Hats are essential to wear at all times!

Aims of exercise

i. To recognise geological evidence from rocks and how this can used to understand plate tectonics
ii. To understand how rocks can be crumpled and folded
iii. To appreciate the landscape, how this is created by the underlying geology and can be used for economic purposes.

What do you need: a pencil, a hand lens and about 3 hours of time

Where do you go: Follow the map on this handout and answer the questions with each of the geological stops (1 to 4).

STOP 1 THE ROCKS

Choose any rock face in the quarry. Look at the rocks by first standing back and identifying the different layers (geologists call these beds) and then move closer to look at the rock in detail using a hand lens.

Now answer the following questions:

Would the oldest rocks be at the top or bottom of the cliff section? Explain your answer.

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……

Some of the rocks in the cliff section are harder than others –why?

……

……

……

Use the Rock dial to identify the rock types in the quarry.

What types of rock are found in the quarry?

1) …… 2) ……

What sort of climate do you think these rocks were deposited in?

……

……

You may have recognised some fossils in the grey hard rocks. If so, well done as you have made some excellent observations.

Draw at least one fossil you find in the rocks and use the fossil identification sheet to recognise some others.

Sketch of a fossil found inforest Head Quarry. Limestones are full of fossils but not always obvious. Remember to include a scale on your sketch to show the size of the fossil.

Discuss in small groups what ancient environment you think the fossils you have found use to live in? Give your reasons.

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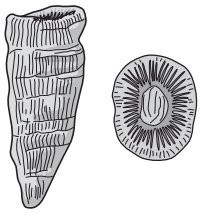
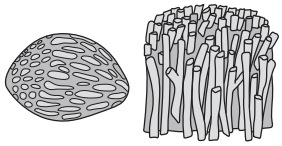
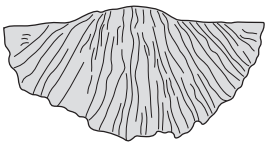
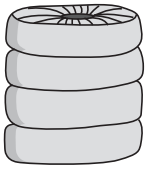
FOSSIL IDENTIFICATION SHEET

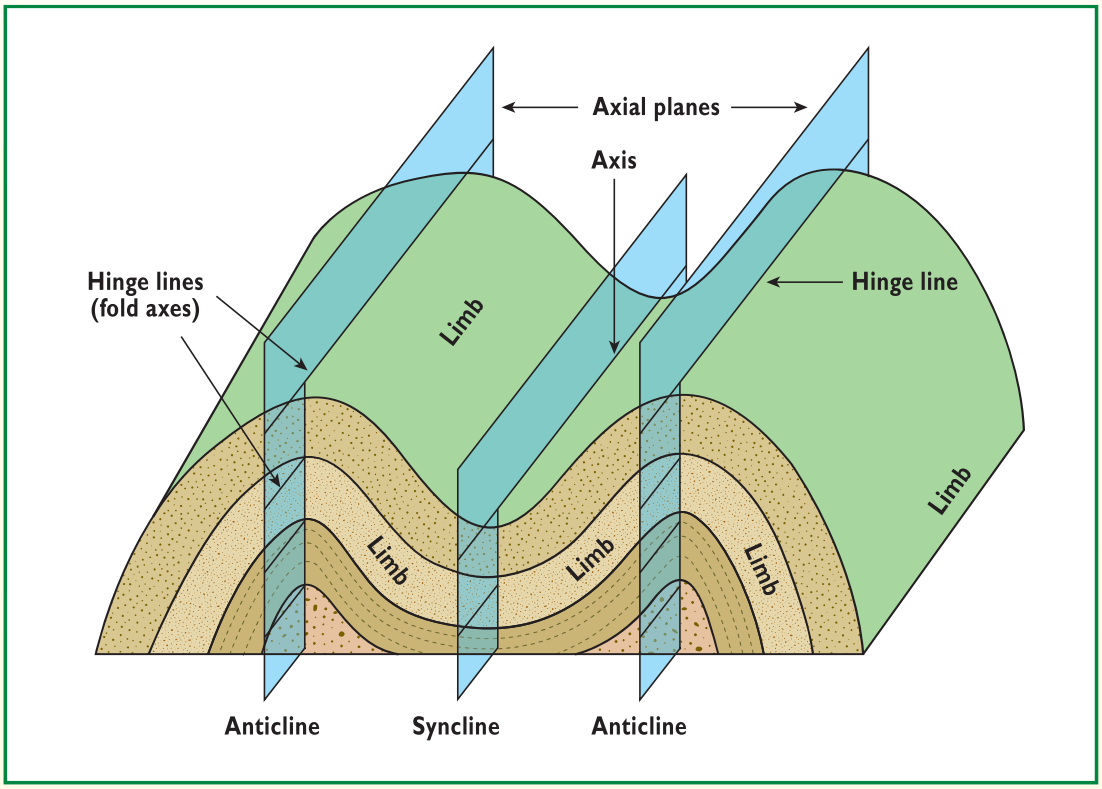
Fossils found in Limestones

Type of fossil	Name	Description	Sketch	Found
Coral - Solitary	*Dibunophyllum*	Corals live on own		
Coral - Colonial	*Lithostrotion*	Corals live together		
Brachiopods	*Gigantoproductus*	Two shells of different sizes		
Crinoids	*Crinoid ossicles and stems*	Fossilised 'Sea Lillies'. Ossicles are disc shaped segments that make up stalks		

STOP 2 BENDY ROCKS!

Perhaps the most obvious feature of the sedimentary limestone layers in the quarry is the way they have been bent, buckled, crumpled and folded. Folding is a term used in geology when one or a stack of originally flat and planar surfaces, such as sedimentary beds are bent or curved as a result of plastic (i.e. permanent) deformation. Folds are a deformational response (strain) to a compressive stress that is applied to a section of rock.

Study the sketch below of geological terms used to describe folding in rocks. Use these terms to label the photography in the quarry. Using arrows indicate the main compression directions to form the fold.



STOP 3 PLATE TECTONICS

In 1962, Harry Hess (1906-1969) proposed the theory of plate tectonics. The theory suggested that the surface of the Earth was covered in tectonic plates which move around slowly, driven by convection currents derived from the Earth's mantle.

Geologists have been continuing to study the Earth. The details of this theory have been fine tuned and modified since Hess first proposed it to take account of new scientific evidence. Plate tectonics is the currently accepted theory that explains how the Earth works.

However we do not need to study the whole earth to understand the theory of plate tectonics. Many observations you have already made in this quarry help to understand how plates move around the Earth's surface.

STOP 2

Folded sedimentary strata, Forest Head Quarry

Are there any clues that can be deduced from the rocks that this place had a very different climate in the past?

	Geological observation	Scientific reasoning
1		
2		
3		

What might have caused the change in climate between the Carboniferous and now?

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Are there any clues that show the rocks in the quarry were once affected by compressional forces?

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During the Carboniferous the plates were progressively getting closer together and would eventually join to form the supercontinent Pangaea in the Permian. This occurred from about 350 to 260 million years ago.

What geological evidence would you look for to support the existence of Panagaea?

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Pangea supercontinent

How would all the plates being together influence the global climate?

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STOP 4 Quarry potential

The rocks were once quarried but it is now abandoned.

Based on your own observations of the limestone in the quarry what do you think it was used for?

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You have been asked as a consultant geologist to offer advice to the local council who are considering in using the quarry to dispose household waste material.

You need to consider the potential geological problems with the site and how these may be over come.

Write your geological comments in the table below:

Geological problems with the site	Solution to problems with the site



Forest Head: Bendy Rocks

Follow-up Activity 1

WAVELENGTH

Purpose

To work out the relationship between wavelength, amplitude, dip of limbs and crustal shortening

Instructions

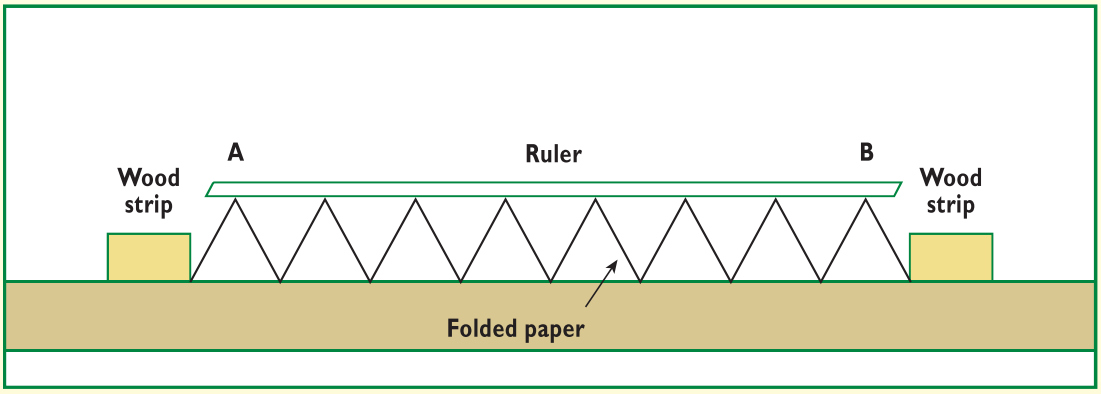
1 Set out a table with the following headings:

Limb length	Original length	No. of synclines	New length	Amplitude	Dip angle	Wave-length	Crustal shortening

2 Stretch the piece of paper out flat and measure the length from A to B.

1	2	3	4	5	6	7	8	9	10

3 Stretch out the folded paper at the edge of the desk so that the wavelength is large. Place a piece of wood at each end and a ruler on top to make sure all crests are the same height and same spacing.
To be drawn in colour



4 Count the number of synclines.

5 Measure the length from first crest to last crest and record it.

6 Measure the dip of the limbs

7 Measure the amplitude using the small ruler.

8 Repeat instructions 3 to 6 three more times with shorter lengths between crests.

9 Calculate the wavelengths.

10 Calculate the crustal shortening as a percentage:

$$\frac{\text{Original length} - \text{new length} \times 100}{\text{Original length}}$$

11 Plot wavelength and amplitude against crustal shortening.

12 Draw your conclusions.

13 Calculate the crustal shortening, wavelength and amplitude of the folds on the photo.

TEACHER SECTION

Requirements
A3 piece of paper cut lengthways into strips about 10cm wide. One strip folded very carefully every 2cm, one every 3cm and the last every 4cm. Alternatively get strips of sticky labels of different sizes, these fold very easily and actually work better. There should be an odd number of folds.

Two 30cm rulers, one which has no space between zero and the end (the end can be cut off with a fine toothed saw or use a metal ruler).

Small protractor or better a clinometer.

Two small weights to hold paper at set distances; anything will do but pieces of wood 10cm by 3cm by 2cm are ideal except for the 2cm limbs when coins or thinner wood are needed.
Photo of highly folded strata (e.g. BGS memoir 307 p43)

Notes
It is more difficult to get an even spread with steeper limbs and probably less likely to occur in nature. Students need only do one strip, different pairs of students could do different limb lengths and compare results

Results
Wavelength decreases and amplitude and dip increase with increasing crustal shortening

Time
60 minutes for all three strips

Forest Head: Bendy Rocks

Follow-up Activity 2

DEFORMATION - FOLDING AND / OR FAULTING

Purpose

To show how folded and faulted rocks at outcrop can provide evidence of the size and direction of the forces which produced the deformation.

Notes: The apparatus and materials required are: transparent plastic box (e.g. chocolate box or component drawer); spatula or dessertspoon; tray; a piece of board to fit snugly into the box; 500g of dry fine sand; 25g of flour; a photograph of faulted rocks (optional).

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.

Development of knowledge and understanding:

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, call normal faults.

Activity: Make your own folds and faults

Learning objective: To simulate the movements which produce faulting in rock structures.

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

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

1. Place the board vertically inside one end of the box.
2. Build up several thin layers of flour and sand. Do not fill it more than half-full. Spread the flour along the front of the box only.
3. 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.
4. 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.
5. Then add arrows to your diagram to show the directions of the forces which were acting whilst you compressed the layers with the board.
6. Are the layers still horizontal, or are they folded?
7. 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.
8. How could you use the same apparatus to find out what happens when sands and sandstones are stretched (put under tension)?