Funded by Defra's Aggregates Levy Sustainability Fund, administered by English Nature.

Many ideas involved in this Earth-Science On-Site excursion will revise ideas from Key Stage 3 work. In addition, the following concepts should be part of the preparation.

INTRODUCTORY WORK.
In addition to the knowledge and understanding of geological processes gained in KS3, the necessary Physics studied at KS3 of the response of materials to deforming forces needs to be revised and slightly extended. These should form the basis of the preparatory lesson in school within a week prior to the field visit.

1: The Response Of Materials To Bending Forces *Time: about 15 minutes*
In KS3, pupils are likely to have investigated the behaviour of springs and rubber bands when they are stretched. Under lower stresses, both show a linear relationship (known as **Hooke's law**) between force (load) and extension. This is called elastic deformation. However as the stress increases, the behaviour of the two materials begins to differ; neither obeys Hooke's law any more, but the spring becomes permanently deformed, while the elastic band becomes much more difficult to stretch further, and eventually snaps.

However, it is unlikely that pupils will have investigated behaviour of materials under **bending** forces. For the purpose of this preparatory lesson, a few quick qualitative demonstrations should be enough to achieve the following **learning objectives**:

- know that under low bending forces, a strip of material will exhibit **elastic deformation;**
- know that under higher bending forces, a strip of material will exhibit **plastic deformation,** becoming permanently bent;
- know that under very high bending forces, a strip of material may snap, suffering **brittle fracture;**
- know that some materials deform in these ways more readily than others.

For quick demonstrations the teacher will need to 'sacrifice' e.g. a few (old) wooden rulers (or wooden skewers), a few (old) plastic rulers (or similar plastic strips which do eventually show brittle fracture) and a few metal (steel) rulers (or similar metal strips which can be bent by hand). If a variety of metals in strip form such as copper, zinc, aluminium, are available for comparative purposes, so much the better. A steel wire coat hanger could be used to show brittle fracture after 'working' in the plastic stage.

Finally leave the class with the (unanswered) question: is it possible to bend rocks in this way? (The answer is "yes", but only when the rocks are in a plastic condition. This usually occurs when they are buried very deeply in the crust where temperatures are much higher than at the surface.)

2: That Folds Are Formed Gradually, Under Compressive Stresses. *Time about 20 minutes*
This activity is taken from the Earth Science Education Unit (ESEU) workshop "The Dynamic Rock Cycle". Visit the ESEU website at http://www.earthscienceeducation.com for free materials relating to the teaching ideas of The Dynamic Rock Cycle. Contact eseu@keele.ac.uk for details of their facilitator scheme for science department In-Service Training, funded by UK Offshore Operators Association (UKOOA).

Make Your own Folds.
Learning Objectives: pupils should understand:

1) Folds are caused by compression of rocks;
2) Folds are three dimensional, and form with their axes at right angles to the major stress;
3) Folds are evidence of ancient stress pattern in the Earth's crust.

Equipment: a box with transparent sides (a chocolate box, or component drawer.) a spatula or desert spoon, a tray (to catch spilt sand) a cardboard paddle to fit snugly across the box, 500g of dry fine sand, 25g of flour, a photograph of folded rocks, digital camera (optional).

Teachers may want to do this as a demonstration, or, with multiple kits available teachers may want pupils to complete the exercise in small groups and discuss it afterwards to draw out the learning points.

Procedure: Place the cardboard paddle vertically at one end of the transparent box. The build up several layers of sand and flour, but DO NOT fill the box more than half full. (It is useful to place the flour layer ONLY against the front face of the box, thus using less flour, and making the sand re-useable a second and third time.) (See **Figure 1**)

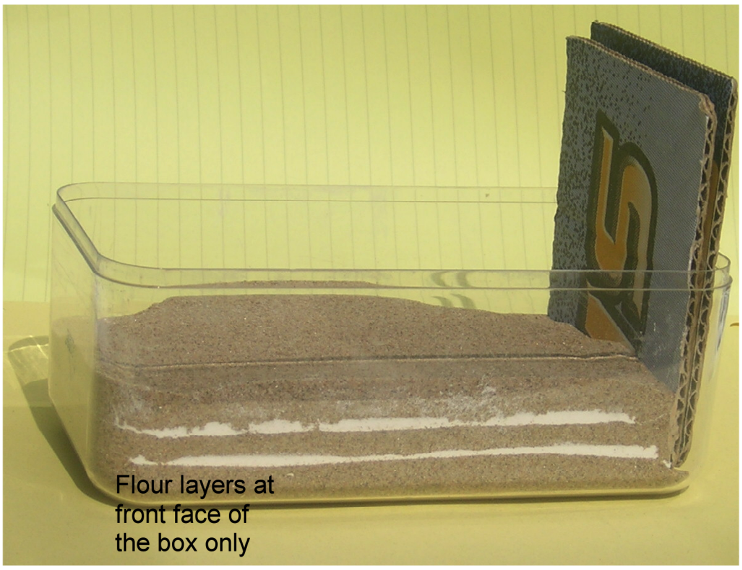

Figure 1 Making Folds in Sand

Very carefully, push the vertical paddle across the box, so that it begins to compress the layers. When you notice the layers beginning to bend, stop pushing. Hold the paddle upright and take a digital photograph, or draw a scaled diagram of the result.

Continue pushing the layers with the paddle until the sand is about to overflow the box. Hold the board upright and again photograph or draw a scaled diagram of the result. It should have features looking something like **Figure 2.**

The Discussion: Describe the folded nature of the layers, bringing out the following points;

- The layers have been compressed into about 40% of their original length.
- In order to do this they have "folded" into upfolds and downfolds.
- That this bending or "folding" happened over a period of time.
- These folds are asymmetrical, i.e. they have a steeply dipping side and a gently dipping side.
- The steep side leans **away from** the main direction of pressure.
- That the view is only of the end (or profile) of the fold, which actually runs all the way across the box, and formed at right angles to the main compression.
- Real folds in real rocks are therefore evidence of ancient compression patterns in the Earth's crust.

Then add arrows to your diagram (or printed digital photograph) to show the directions of the forces which were acting whilst you compressed the layers with the paddle.

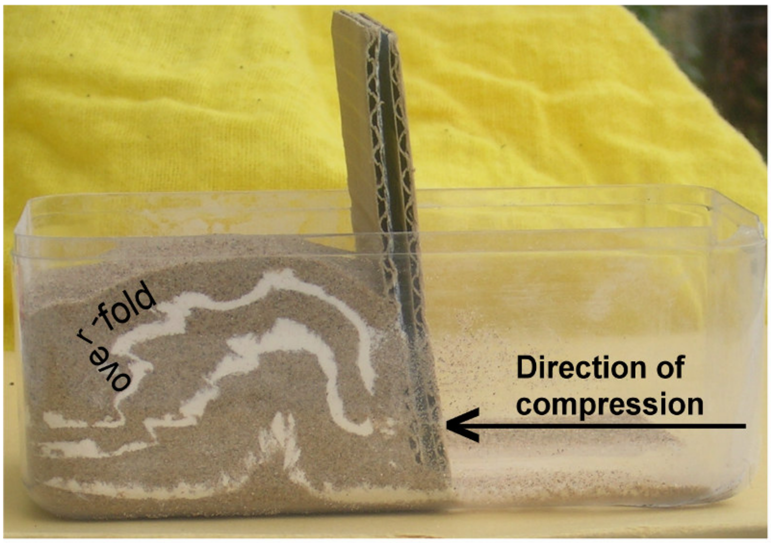

Figure 2 Folds in Layers of Sand and Flour

3. Understanding the Shape of Folds.

Teachers may want to leave “folding” as upfolds and downfolds, but the discussion of the exposures at Dryhill will probably be easier with the following vocabulary introduced during the preparation for the visit.

1) There are two kinds of simple folds, **anticlines** and **synclines.**
2) The line of the tightly curved part of a fold is called the “**axis**”. The relatively straight parts of the folds are called “**limbs**”
3) The limbs of a syncline dip towards the axis: The limbs of an anticline dip away from the axis.
4) The axis forms at right angles to the compression that produces the folding.

PUPIL FOLLOW-UP ACTIVITY Pupil Name: ……………………………………..

Put the letters for the following statements about the events affecting the rocks at Dryhill into the right order in the table below. The oldest (or first) at the bottom, next to number 1, and the youngest (or last) at the top, next to number 8.

Give your reasons explaining why you put each statement in its place.

A. Protection of the Site By Kent County Council
B. Quarrying of Ragstone for roadstone and building
C. Beginning of weathering and erosion continuing to present day
D. Folding and faulting and uplift when the Alps were formed
E. Deposition of the Chalk in a marine area
F. Weathering of rocks to form sand grains during the Cretaceous
G. Transport by rivers into the Cretaceous sea and deposition
H. Deposition of the Beds at Dryhill in a marine area

TIME SEQUENCE OF EVENTS AT DRYHILL NATURE RESERVE

Youngest Event	Reason for placing it here in the sequence
8	
7	
6	
5	
4	
3	
2	
1	
Oldest Event	

TEACHERS' NOTE:

The sequence is deduced in the following way

1) The rocks at Dryhill are part of a Rock Cycle, and deposition is preceded by weathering and transportation of the particles to make up the new rocks. [F,G then H]

2) T**he Principle of Superposition:** the lowest beds are deposited first of all (sandstones and limestones) and the ones on top (Chalk) are deposited later. [then E]

3) **The Principle of Cross-Cutting Relationships** means the folding of the bedding planes come after the deposition. [then D]

4) The erosion of the surface also **cuts across** the bedding planes, and so must come after their formation (then C). (NOTE: "Present day weathering", although continuing today, began after the uplift of the rocks a few million years ago. The term separates this weathering from the weathering episodes of hundreds of millions of years ago)

5) Historically we can see that the quarrying has now stopped, so the protection came after the quarrying. (B; then A)

The sequence is:

YOUNGEST EVENT
A After quarrying in recent years, the site was protected.
B Historical evidence tells us the Romans quarried these rocks about 2000 years ago.
C Present day weathering and erosion can be seen to be happening, and has been going on since uplift, well before Roman times.
D The beds were folded and uplifted in order to be exposed to weathering at the Earth's surface.
E The Chalk is younger as it lies on top of the beds at Dryhill.
H The sandstones and limestones were deposited in layers.
G They then had to be transported, most probably by rivers.
F The sand for the beds at Dryhill had to be weathered from an earlier rock first.
OLDEST EVENT