Geological mapwork from models 3: valley with horizontal floor

Draw and make your own 3D model of the geology of a valley with a horizontal floor

A valley with a horizontal floor looks like this:

The Bloody Bridge River valley, Northern Ireland.

Cut out and fold the flat-bottomed valley model.

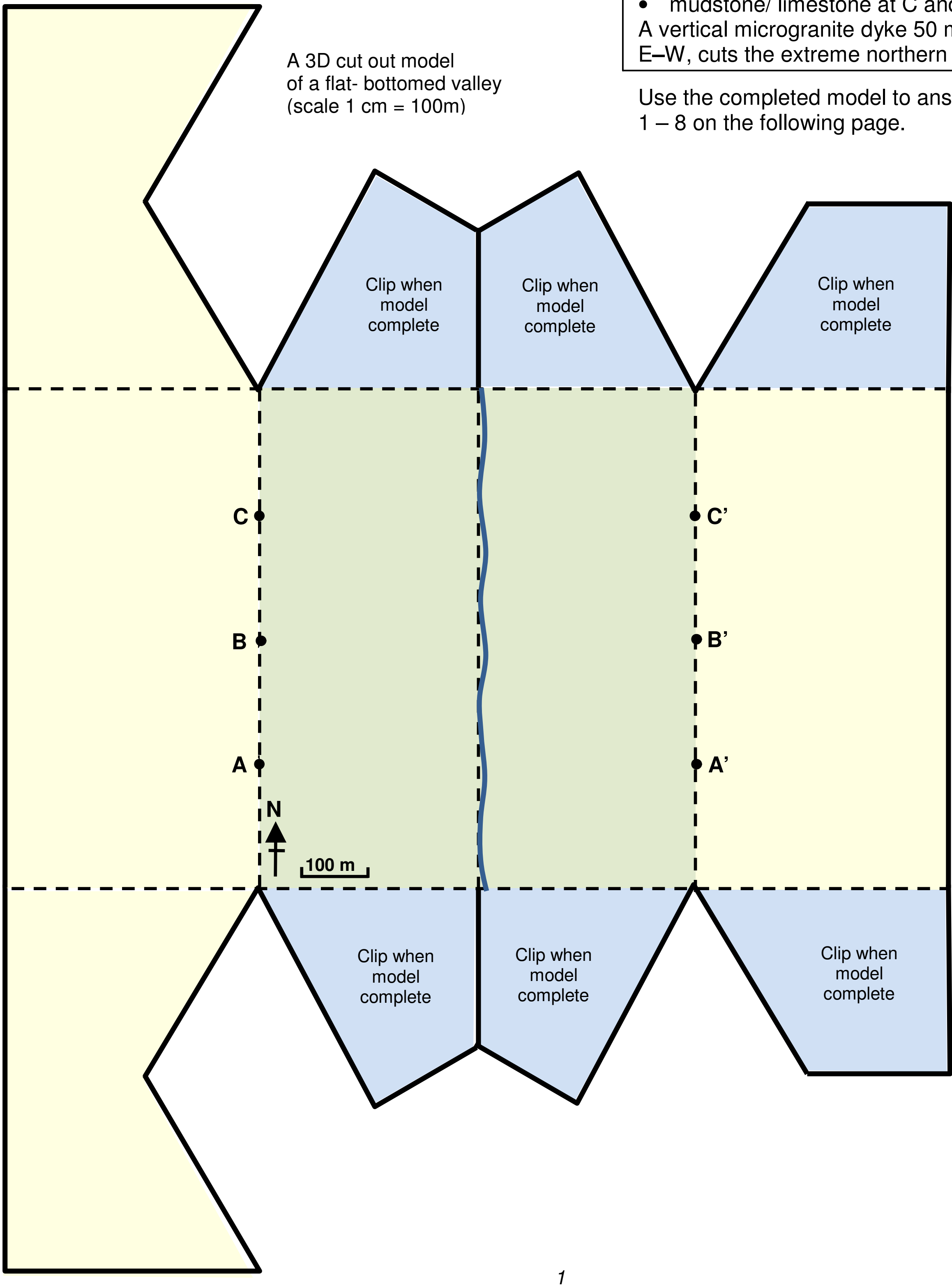
Add the following geology to the model using the shading or colours and the symbols in the key. Then paper-clip it together to show the 3D geology.

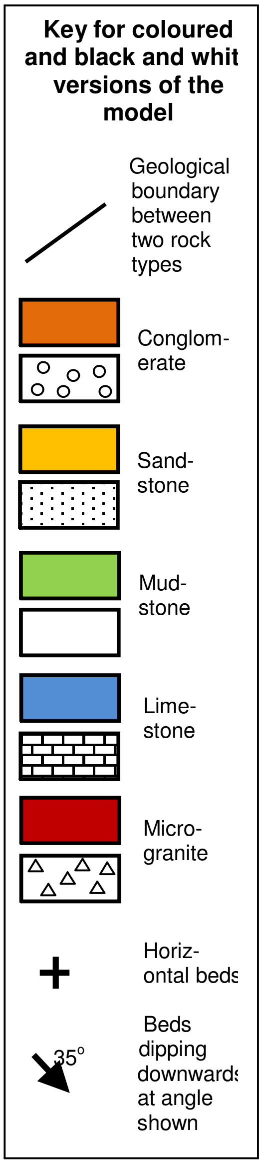
The solid geology is made of formations of conglomerate, sandstone, mudstone and limestone all dipping at 30°S and striking E–W. The boundaries outcrop at the tops of the valley sides;
- conglomerate/ sandstone at A and A';
- sandstone/ mudstone at B and B';
- mudstone/ limestone at C and C'.

A vertical microgranite dyke 50 m wide, striking E–W, cuts the extreme northern end of the valley.

Use the completed model to answer questions 1 – 8 on the following page.

A 3D cut out model of a flat- bottomed valley (scale 1 cm = 100m)





Model questions

1. If there were rock exposures on the valley sides, draw on model the map symbol that would be used to show the dip of the beds in those locations.
2. Draw a geological map of the area at the same scale.
3. Draw a vertical cross section E–W across the centre of the valley.
4. Measure the vertical thickness of the sandstone, as measured in a vertical borehole.
5. Measure the true thickness of the sandstone, at right angles to its boundaries.
6. Based on 3. and 4., say how the dip of the formations affects the vertical (apparent) thickness of the formations.
7. Tabulate the sequence of geological events of the area (its geological history) beginning with the first event at the bottom of your table.
8. Write the following sentence correctly, 'In a valley, the outcrop of a geological boundary or bed normally Vs in the *opposite direction to* / *in the direction of* the dip of the beds.'

The back up

Title: Geological mapwork from models 3: valley with horizontal floor

Subtitle: Draw and make your own 3D geological model of the geology of a valley with a horizontal floor.

Topic: Part of a series introducing simple geological mapwork – through 3D models. A table of the progression and spiralling of spatial thinking skills involved through the series is given on the final page.

Age range of pupils: 14 – 19 years

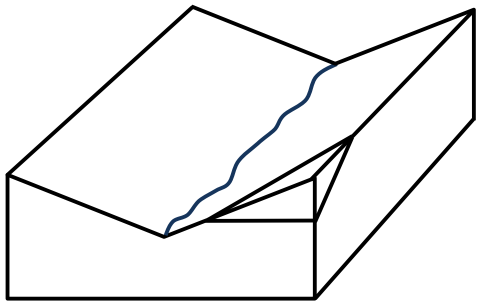
Time needed to complete activity: 40 mins

Pupil learning outcomes: Pupils can:

- add geological data to a 3D block model of a flat-bottomed valley;
- link up the data with geological boundaries,
- interpret these into a 3D picture of the geology.

Context:
Pupils are shown a photograph of a flat-bottomed valley and then are asked to cut out a 3D paper model of the landform. They then plot the geology onto the model from the description given.

This exercise challenges three dimensional/ spatial thinking, since the map can only be completed by students realising that the limestone/ mudstone boundary appears horizontal on the southern cross section and so cuts the valley sides. The boundaries can then be joined by a straight line on the surface of the model, as shown below:



All the other sedimentary boundaries on the surface are then drawn parallel to these lines.

The questions show that:
The vertical (apparent) thickness of dipping formations is always greater than the true thickness.
In a valley, the outcrop of a geological boundary Vs *in the direction of dip* of the beds (providing the beds dip at a steeper angle than the valley floor).

Following up the activity:
Pupils could be asked to turn the model inside out and then complete the model from a different geological description of the area.

Underlying principles:

- The three dimensional geological structure of an area can be plotted on block diagrams.
- Additional principles are given above; these could be added to a developing list of 'mapwork rules'

Thinking skill development:
The drawing of geology onto three dimensional models involves spatial thinking skills. The more complex the geology becomes, the more spatial interpretation is needed, including interpolation and extrapolation skills.

Resource list:

- a print-off of the page containing the block diagram cut-out, per pupil
- scissors (if these are not available, place a ruler flat along the edge to be cut, and tear the paper along the ruler)
- paper clips, four per model
- drawing materials, including pencil, eraser, ruler, protractor and pencil crayons

Useful links:
Higher level mapwork exercises with online tutorials are available for free download from the Open University: http://podcast.open.ac.uk/oulearn/science/podcast-s260_mapwork#

Source: This is the sixth of a series of simple introductory geological map exercises developed by Joe Crossley and Joe Whitehead. Part II of this series of exercises (from which this exercise comes) was published in '*Geology Teaching*' the journal of the Association of Teachers of Geology in 1980 (Volume 5, No. 1, pages 15 – 19).

The progression and spiralling of spatial thinking skills shown by the Earthlearningidea 'Geological mapwork from scratch' exercises and the 'Geological mapwork from models' exercises

Exercise		Topographic surface	Geological surfaces	Strategies and skills
Mapwork from scratch 1: a conical hill		Conical hill	Flat and horizontal	• Plot and draw simple topographic cross sections • Add geological boundary intersections and join with straight, horizontal lines
Mapwork from scratch 2: valley with simple geology		Sloping valley	Flat and horizontal	• Plot and draw simple topographic cross sections • Add geological boundary intersections and join with straight, horizontal lines • Sketch geology onto a 3D block diagram
Mapwork from scratch 3: valley with dipping geology		Sloping valley	Dipping surfaces	• Draw true dip on a cross section using a protractor • Add geological boundary intersections and join with straight lines • Appreciate that apparent dip is always less than true dip • Appreciate that, in valleys, geological boundaries usually 'V' in the direction of dip. • Sketch geology onto a 3D block diagram • Begin to compile a list of mapwork rules
Mapwork from models 1	Plain version 1	Flat	Flat and horizontal	• Add geological boundary data to cross sections and join with straight, horizontal lines
	Plain version 2	Flat	Dipping surfaces; vertical feature	• Add geological boundary data to cross sections and join with straight lines • Use boundaries on the cross sections which intersect the topographic surface to draw a boundary on the surface • Add a vertical feature (dyke)
Mapwork from models 2	Cuesta version 1	Asymmetrical ridge	Flat and horizontal	• Add geological boundary data to cross sections to construct straight, horizontal lines
	Cuesta version 2	Asymmetrical ridge	Dipping surfaces; vertical feature	• Draw true dip on a cross section using a protractor • Add parallel geological boundaries • Add a vertical feature (fault) that moves a geological boundary • Appreciate the link between tough and weak geological formations and topography
Mapwork from models 3: valley with horizontal floor		Valley with horizontal floor	Dipping surfaces; vertical feature	• Draw true dip on a cross section using a protractor • Add parallel geological boundaries • Use boundaries on the cross sections which intersect the topographic surface to draw in boundaries on the surface • Construct parallel boundaries on the surface • Appreciate that, in valleys, geological boundaries usually 'V' in the direction of dip • Appreciate that apparent thickness is always greater than true thickness • Add a vertical feature (dyke)
Mapwork from models 4	Ridge/ valley with sloping floor version 1	Ridge/ valley with sloping floor	Dipping surfaces	• Add geological boundary data to cross sections to construct straight lines • Add parallel geological boundaries • Appreciate the link between tough and weak geological formations and topography • Interpolate approximate true dip from apparent dip
	Ridge/ valley with sloping floor version 2	Ridge/ valley with sloping floor	Dipping surfaces	• Draw true dip on a cross section using a protractor • Add parallel geological boundaries to cross sections • Use boundaries on the cross sections which intersect the topographic surface to draw in boundaries on the surface • Construct parallel boundaries on the surface • Appreciate that, in valleys, geological boundaries usually 'V' in the direction of dip and the opposite is true of ridges
Mapwork from models 5: plain; cuesta; valley with horizontal floor; ridge/ valley with sloping floor		All the model landforms above	Surfaces folded into open folds	The strategies and skills described in the box above and, in addition: • Identify folds with equally dipping limbs, and those with limbs dipping at different angles • Appreciate inverted topography • Draw fold axes and fold axial planes • Draw an unconformity and a pluton with a metamorphic aureole
Mapwork from models 6: plain with faulted rocks 1		Flat	Normal and tear dip faults; dipping bedding	• Draw the effects of a normal and a tear dip fault on cross sections • Use these to explain how different types of fault can have similar effects on outcrop patterns of dipping beds (but different effects of vertical features)
Mapwork from models 7: plain with faulted rocks 2		Flat	Normal and reverse strike faults; dipping bedding	• Draw the effects of normal and reverse strike faults on cross sections • Use these to explain how different types of fault can have similar effects on outcrop patterns
Mapwork from models 8: plain with faulted rocks 3		Flat	Normal, reverse, thrust and strike-slip faults at 45° to the strike; dipping bedding	• Draw the effects of different sorts of faults on cross sections • Use this to explain how different types of fault can have similar effects on outcrop patterns
DIY dip and strike model		Dipping surface	Dipping bed	• Measuring dip, strike and apparent dip on a model dipping surface, using a DIY clinometer if no other clinometer is available
Geological mapwork: Surface geology and the geological map		Not given, assumed fairly flat	Relatively complex	• Match surface geological features to places on a geological map where they might be found.