Geological mapwork from scratch 3: valley with dipping geology
Draw your own cross sections and 3D geological model

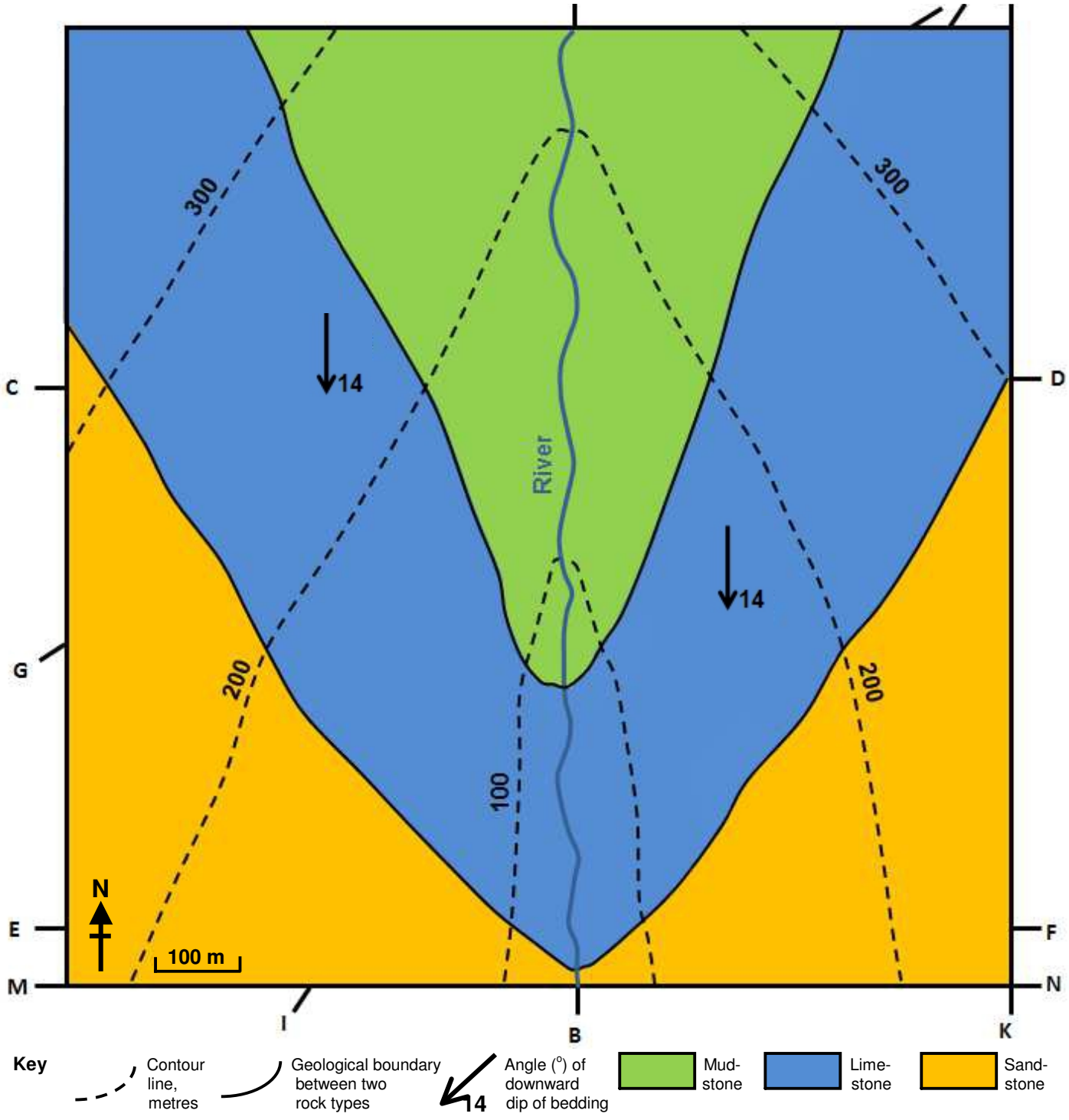
A valley with a river looks like this:

The straight glen of the Allt Mhuic from its headwaters on Carn Dubh, Scotland.

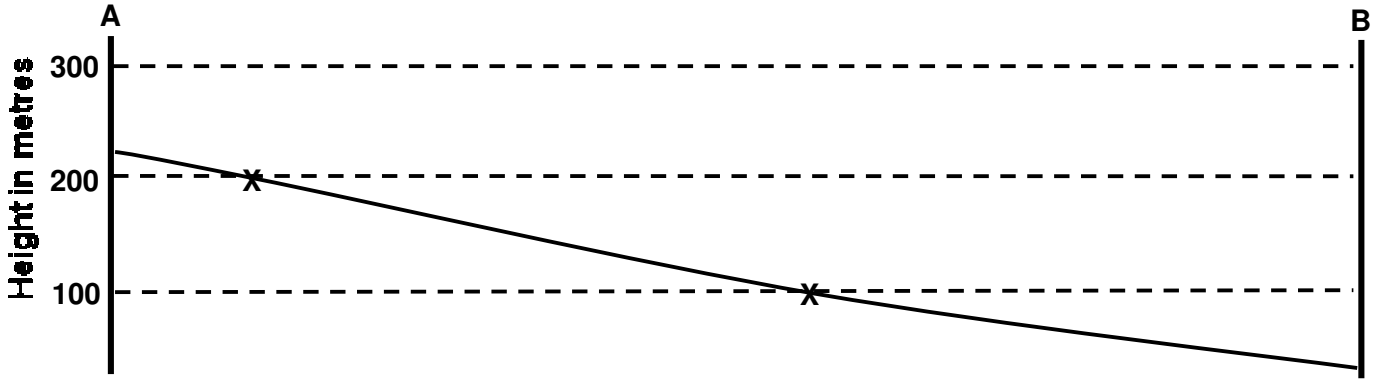
For the map of a valley below, with dipping geology, draw geological cross sections, A –B, C–D, E–F, G–H, I–J, K–L and M–N. using the cross section profiles on the following pages.

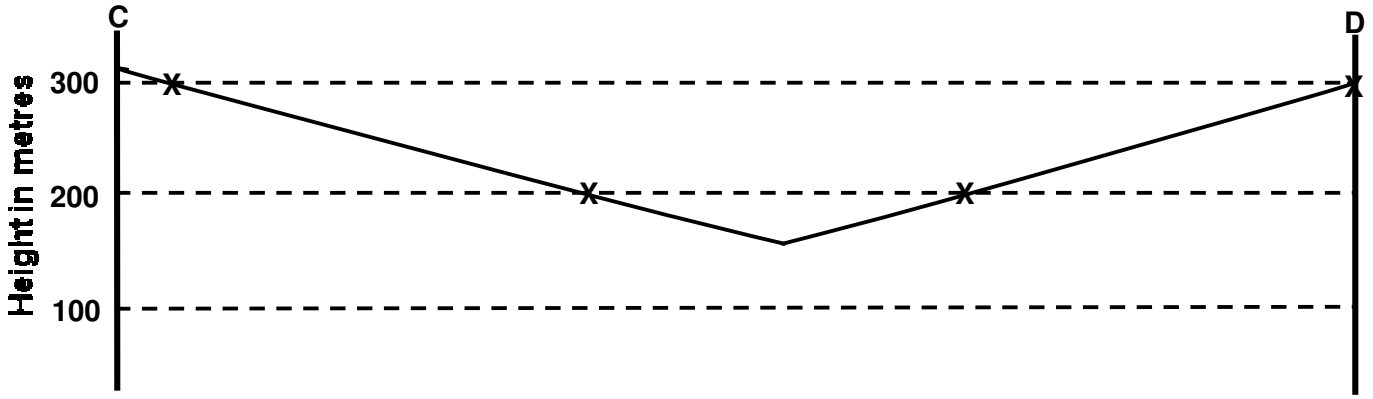
Then use cross sections K–L and M–N and the map to sketch the geology onto the 3D block diagram – to show the 3D geology of the area.

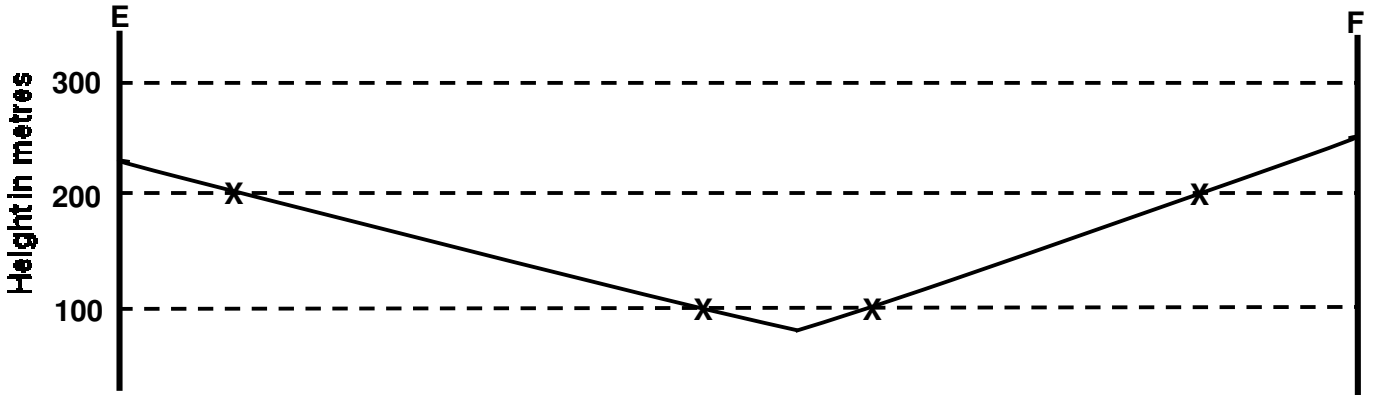
Map of a valley with a river and dipping geology (a black and white version for non-colour printers, is given at the end)

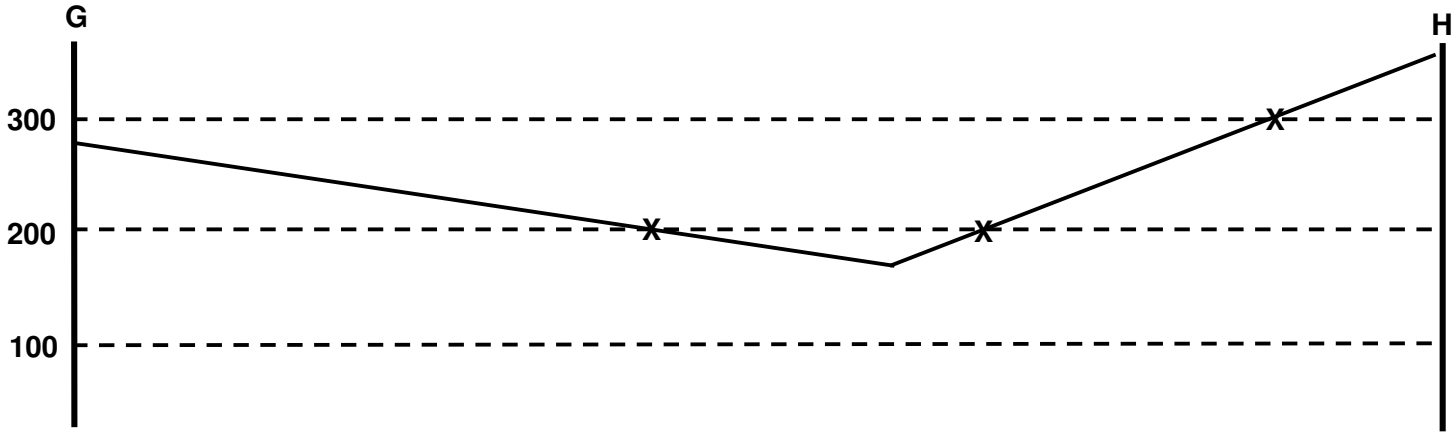


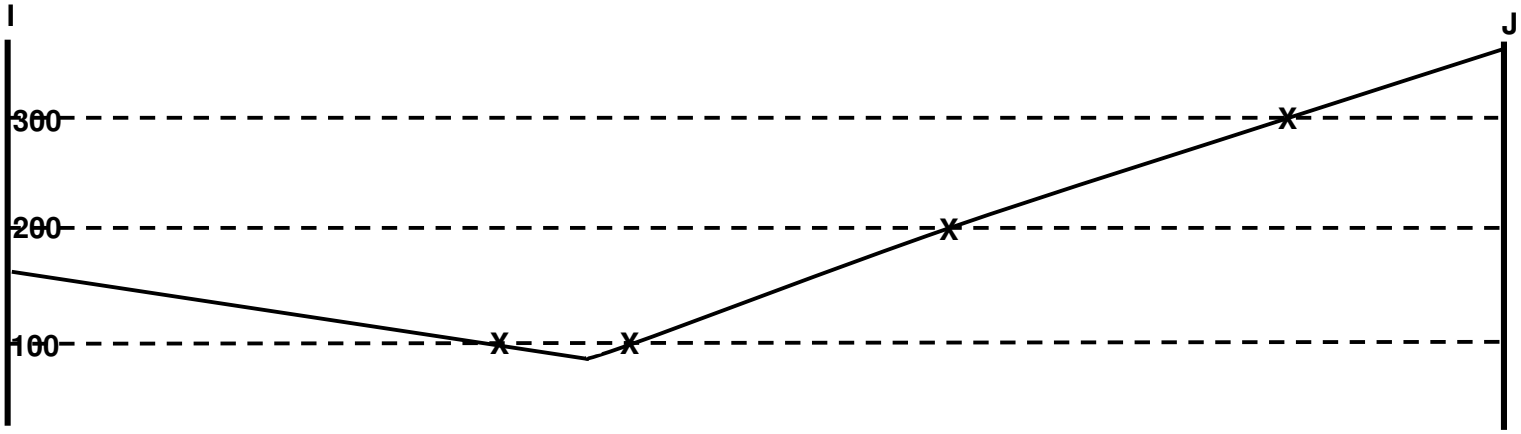
Topographic profiles (horizontal scale equals vertical scale)

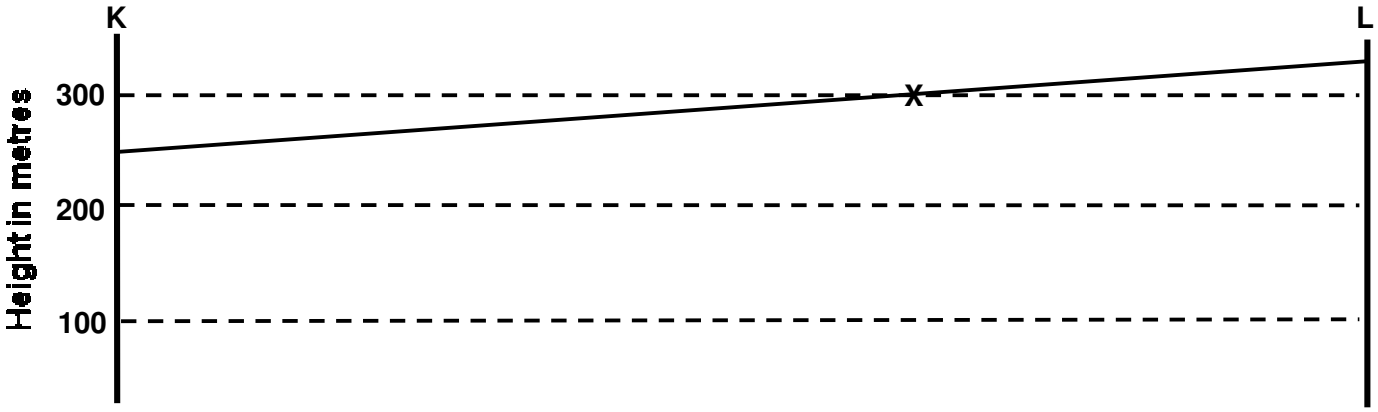


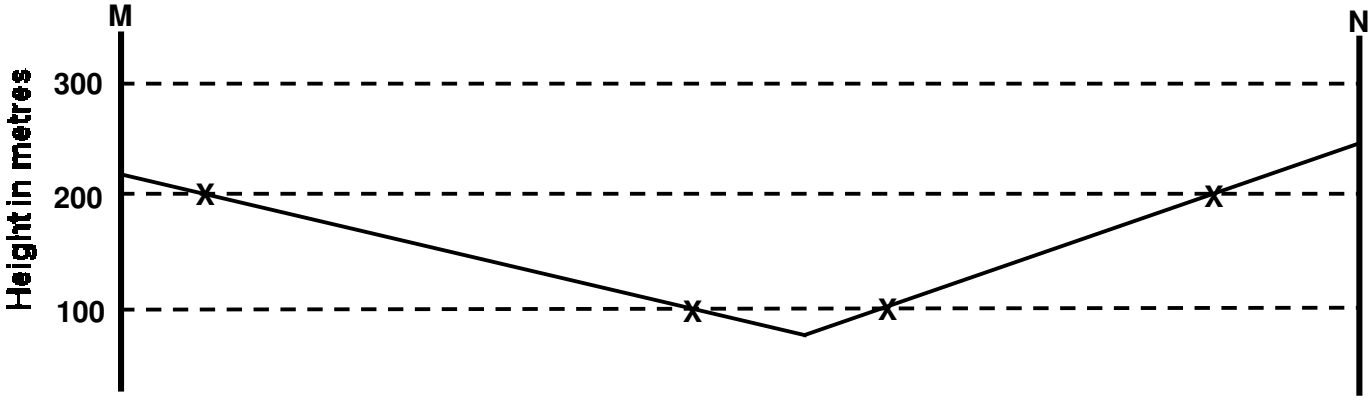


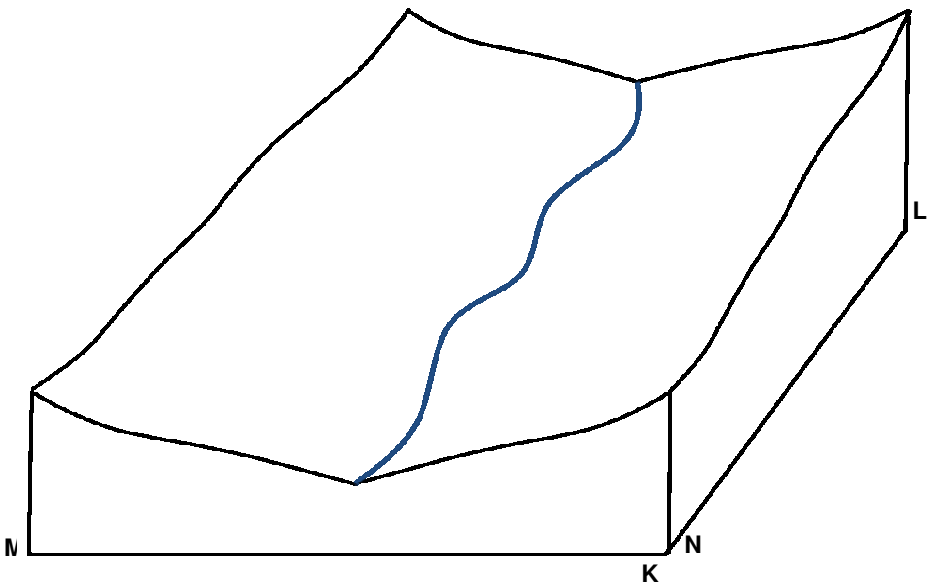












3D block diagram of the map area

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The back up

Title: Geological mapwork from scratch 3: valley with dipping geology.

Subtitle: Draw your own cross sections and 3D geological model.

Topic: Part of a series introducing simple geological mapwork. 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 boundaries to topographical profiles to produce cross sections of geological maps;
- sketch geology onto 3D block diagrams;
- begin constructing a set of mapwork rules;
- use the exercise to understand three dimensional topography and how it interacts with three dimensional geology.

Context:
Pupils are shown a photograph of a straight valley. They are given a simple geological map of such a landform, with beds dipping southward at 14°. They are asked add the geology to topographical cross sections of the valley to produce geological cross sections.

A–B is drawn by realising it is a true dip section, and so the angle of dip of the boundaries is shown by the dip arrow on the map (14°), so that they should be drawn using a protractor.

C–D is a section at right angles to the dip direction (and so parallel to the strike), so that the apparent dip of the boundaries will be 0° and they will appear horizontal; they can be drawn as on previous mapwork exercises, by marking the geological boundaries on the cross section, and joining them with straight lines.

E–F requires the same thinking, but also realisation that the thickness of the limestone is obtained from the previous section.

G–H and I–J can also be constructed using intersections of the geological boundaries with the contours, and illustrate how apparent dip reduces as the sections become more parallel with the strike.

K–L and M–N are quick to draw, using principles established previously, but then allow geology to be sketched in on the 3D block model diagram, using the map as well.

Both map and block diagram show how outcrops in a valley 'V' in the direction of dip of the beds.

The map has been constructed using structure contours to ensure that the topographical contours and geological boundaries are correctly drawn – thus pupils need an accurate version of the map to work on.

Further simple mapwork exercises can be developed using this approach, for example by :
- having geology dipping north at perhaps 45°;
- using a spur as a base map, instead of a valley;
- using a map of a series of spurs and valleys.

Following up the activity:
Pupils could be asked to begin to compile a simple set of mapwork rules, as follows:
- horizontal boundaries follow the contours;
- vertical boundaries cut the contours as straight lines;
- in cross sections drawn parallel to the dip of the geology, the angle of dip of the boundaries can be drawn with a protractor, providing the horizontal and vertical scales of the cross section are the same;
- when a cross section is drawn at right angles to the dip (parallel to the strike) the beds appear horizontal (have an apparent dip of 0°);
- apparent dip is always less than true dip;
- in a valley, the boundaries 'V' in the direction of dip of the beds (providing the dip of the beds is steeper than the valley floor).

Underlying principles:
- Geological boundaries can be added to topographical cross sections and block diagrams, to show the three dimensional geological structure.
- An understanding of simple three dimensional geology allows a set of mapwork rules to be developed, as above.
- Pupils who have difficulty in visualising three dimensional geology can draw correct cross sections by applying these rules.

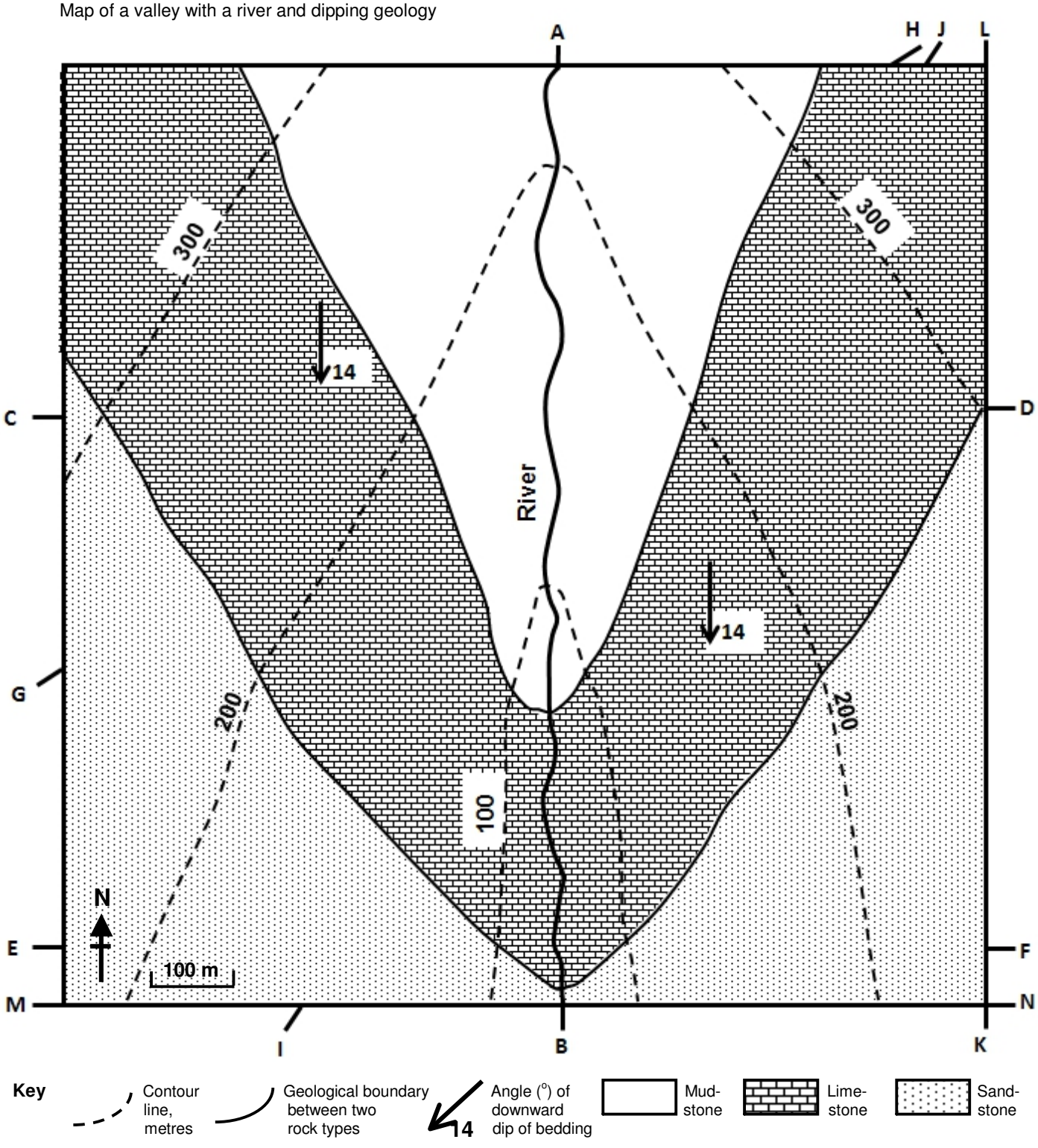
Thinking skill development:
The drawing of topographical and geological cross sections involves spatial thinking skills. The more complex the cross sections become, the more spatial interpretation is needed, including interpolation and extrapolation skills.

Resource list:
- a print off of the map and blank topographic profiles, per pupil
- 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 third of a series of simple introductory geological map exercises developed by Joe Crossley and Joe Whitehead. Part I of these series of exercises (from which this exercise comes) was published in '*Geology Teaching*' the journal of the Association of Teachers of Geology in 1979 (Volume 4, No. 2, pages 56 – 61).

Map of a valley with a river and dipping geology



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^{o} 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.