

Burbage Valley Part 1 - An ancient river system

Using field measurements to determine the origins of a sandstone sequence.

The photographs below were taken in the Burbage Valley in the Peak District, a few miles South West of Sheffield. The crags form part of a long linear feature known locally as Burbage Edge. The rocks in the exposure belong to the Namurian Stage of the Carboniferous Period, commonly referred to as the Millstone Grit Series. They consist of coarse gritstones, comprising

angular grains of quartz and feldspar, with occasional layers of small rounded quartz pebbles. In Photo 1, the rocks are strongly cross-bedded, with the planar fore-sets dipping towards the left. They are regarded as having been deposited in huge underwater dunes in an ancient river system. The tectonic dip of the rocks is at a low angle towards the North East.



Photo 1. Part of Burbage Edge looking North East. Climber about 180cm tall



Photo 2. Detail of a high part of the face, looking North East



Photo 3. The lowest part of the face, looking North East

Tell pupils that they are to plan for a field visit to this area. Give them the information quoted above and a copy of each photograph. What observations would pupils make and how would they try to minimise errors? Remind them that the dip direction of foresets in cross-bedding indicates the direction towards which the ancient current was flowing when the sediments were deposited: also that cross-bedding may be used to indicate the “way-up” of the beds. Prompt pupils by asking:

- Are the beds the right way up? (*Yes. In each photograph, especially in Photo 2, there is a very abrupt junction between the foresets and the erosional truncation plane above them.*)
- What equipment would they need to measure the dip of the foresets? (*Compass and clinometer, or the equivalent on a mobile device.*)
- How would they collect and record the data? (*Find the horizontal on the bed (the strike) and mark it in pencil, or with a scratch mark with a*

thumbnail. Measure and record the dip direction and angle of dip from the horizontal).

- How would they avoid getting all their measurements from just one set of beds? (*Work laterally along the Edge to ensure that they are measuring different foresets*).
- Does there appear to be a general foreset dip direction across this section of the Edge? (*There is a clear preference for an apparent dip towards the left, i.e. approximately to the North West*).
- Identify an exception to this in the photographs? (*Photo 3, at the very base of the face, shows an apparently opposite direction*).
- What correction to their compass bearings might pupils need to make before plotting the results? (*Pupils need to be aware of magnetic variation affecting their compasses. However, in this part of England in 2025 Magnetic North is identical with True North*).
- How would they manipulate the measurements or plot them out to show the dominant

directions, without missing potentially important anomalous directions? (*Any attempt at averaging the results would miss important differences. The simplest way of showing each measurement is to plot them on a rose chart – see below*).

- Are any other corrections to the data needed? (*The tectonic dip may need to be taken into account, although in this case study, this is very small*).
- When these sediments were deposited in an ancient river system, the depth of water cannot have been less than the preserved set height. In fact it must have been rather more, otherwise the top of the set would have been disturbed by turbulence. Estimate the minimum depth by using the thickness of the beds from the foot of the climber in Photo 1 to the truncation plane about half his height above his head, shown by arrows. (*At least 2.7m, probably about 3.2m*)

The back up

Title: Burbage Valley Part 1 – An ancient river system

Subtitle: Using field measurements to determine the origins of a sandstone sequence.

Topic: An exercise in planning for a field visit, deciding what measurements to take and raising awareness of possible errors.

Age range of pupils: 16 years and above

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:

- recall techniques used in actual field investigations;
- explain how possible errors might creep in during such work;
- interpret evidence of sedimentary structures from photographs;
- choose the best method for processing their data from the field;
- carry out a simple calculation of former water depth.

Context: This activity could be used as “indoor fieldwork” or as preparation for an actual field visit to similar geological sites.

Following up the activity:

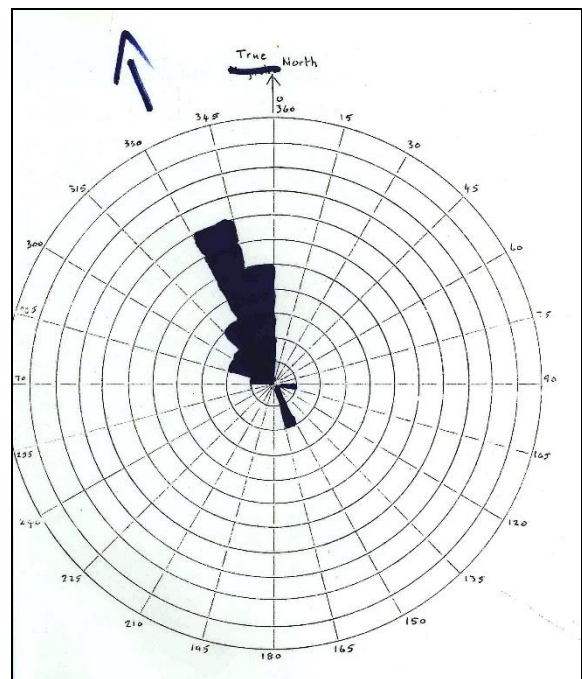


Fig. 1 Rose diagram of foreset dip directions, taken on Burbage Edge by students. N= 23. The thick arrow shows the dominant palaeocurrent direction.

- Ask pupils to interpret the sedimentary environment and possible sources of the sediment using evidence from the rose diagram above, from the photographs and from the information given in the text.
- What extra information would they seek to broaden the investigation beyond Burbage Edge?

(The rose chart indicates a dominant current flowing from the South South East towards the North North West, with an anomalous opposite direction, low down in the face. The angular grains and presence of feldspar suggests rapid erosion, transportation and deposition, before the

feldspar had time to be weathered to soft clay minerals. The large thickness of the foresets suggests a very deep, fast flowing river system. Their uniform direction points to braided rivers, rather than meandering ones. The anomalous foreset directions low down in the face might prompt wider investigation beyond Burbage Edge. Indeed, such work has shown that it is the main face at Burbage which is anomalous. Evidence elsewhere in the South Pennines points to a dominant source of sediment from the North, i.e. from ancient Caledonian land masses which were being eroded at the time.

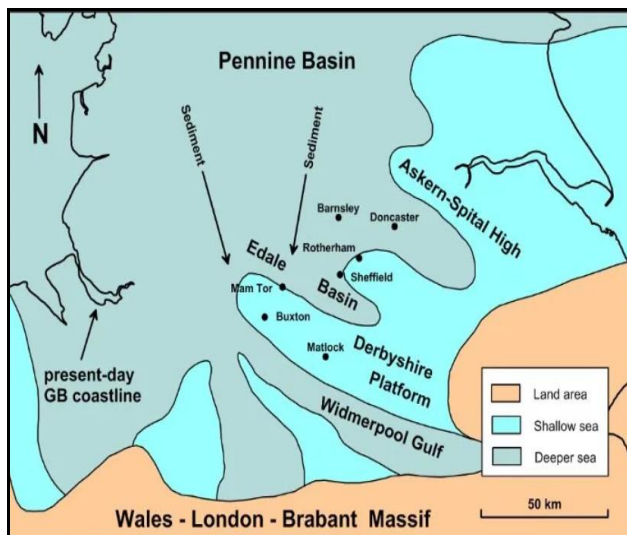


Fig 2. Palaeogeography of the South Pennines during the Namurian. J. Hunter, adapted from Smith et al, 2005 (www.sagt.org.uk)

Underlying principles:

- Dip directions of foresets in cross-bedding indicate palaeocurrent directions.
- Sufficient measurements are needed to establish valid patterns.
- Pupils need to be made aware of possible errors of measurement.

Thinking skill development:

Planning to gather data involves construction, and cognitive conflict may occur when anomalous results are considered. Discussion involves metacognition, and hopefully bridging skills will be learnt if this type of class activity can be put into effect in the field.

Resource list: Enlarged photographs and information from page 1 above.

Useful links:

If pupils need to revise cross-bedding before they start this activity, the following Earthlearningidea activities may be found useful:

- https://www.earthlearningidea.com/PDF/330_Make_own_cross_bedding.pdf
- https://www.earthlearningidea.com/PDF/195_Cross_bedding_2.pdf
- https://www.earthlearningidea.com/PDF/194_Cross_bedding_1.pdf

Source: Written by Peter Kennett of the Earthlearningidea team

© **Earthlearningidea team.** The Earthlearningidea team seeks to produce a teaching idea regularly, at minimal cost, with minimal resources, for teacher educators and teachers of Earth science through school-level geography or science, with an online discussion around every idea in order to develop a global support network. 'Earthlearningidea' has little funding and is produced largely by voluntary effort. Copyright is waived for original material contained in this activity if it is required for use within the laboratory or classroom. Copyright material contained herein from other publishers rests with them. Any organisation wishing to use this material should contact the Earthlearningidea team. Every effort has been made to locate and contact copyright holders of materials included in this activity in order to obtain their permission. Please contact us if, however, you believe your copyright is being infringed: we welcome any information that will help us to update our records. If you have any difficulty with the readability of these documents, please contact the Earthlearningidea team for further help.

