Questions for any rock face 8: faults
What questions about faults might be asked at any rock exposure?

The ELI* series of 'Questions for any rock face' helps teachers to plan investigative fieldwork at any rock exposure**. In each case some possible questions are given, with some likely answers, to help you to decide whether the questions might work well at your site, or whether they would be asked better elsewhere. Answering the questions will provide basic understanding of the evidence preserved in rocks of the processes that formed them.

Faults
Take your pupils to sites where clear faulting can be seen, preferably where beds can be matched up on either side of the fault, and ask these questions:

Possible questions	Possible answers
How can you tell that this fracture is a fault? (Faults are fractures where the rocks on either side have moved)	Layers or rocks do not match up across the fault
What types of forces might have caused this fault, squeezing, pull-apart or sliding forces? 1) Faults caused when rocks are squeezed (compressed) have one rock slice forced over another and usually slope downwards at less than 60° 2) Faults caused by pull-apart forces (tension) are usually steeper than 60°, where one block of rock has slid downwards 3) Faults caused by sliding are usually vertical – and are more clearly seen by looking down on horizontal rock surfaces rather than in vertical rock faces	If a rock sequence can be matched up across a fault, the type of fault can usually be confirmed 1) Compressional forces (squeezing) cause reverse faults where one slice of rocks has been forced over another 2) Tensional (pull apart) forces cause steep faults (called normal faults) where one block slides down, adjacent to the other 3) Shearing (sliding past) forces usually produce vertical tear faults
How can some rocks be both faulted and folded?	At relatively high temperatures and pressures, rocks tend to behave plastically and bend, whilst at lower temperatures they have brittle behaviour and fracture
What might have caused the squeezing, pull apart or sliding forces that fault rocks?	• Most faulting is related to the movement of tectonic plates, although there may be local causes as well • Plate collision causes reverse faults (and often folding too) • Plate divergence produces normal faults, as blocks fracture and slide up or down relative to one another • Plate sliding at conservative margins (like the San Andreas fault) causes tear faulting

← Normal fault – caused by pull-apart (tensional) forces →
A normal fault faulting a coal seam, Skelmersdale, UK. *(Peter Kennett).*

→ Reverse fault – caused by compressional (squeezing) forces ←
A reverse fault in the Borrowdale Volcanic Group rocks, Lake District, UK. *(Peter Kennett).*

* ELI = Earthlearningidea
** An exposure is where rocks can be seen at the Earth's surface, exposed by natural or artificial means; anywhere where a rock reaches the surface, even if it is covered by soil, etc. is an outcrop, so an exposure is also part of an outcrop.

The back up

Title: Questions for any rock face 8: faults

Subtitle: What questions about faults might be asked at any rock exposure?

Topic: Questions to help pupils to understand faults seen in field exposures, and the forces that caused them.

Age range of pupils: 9-16 years

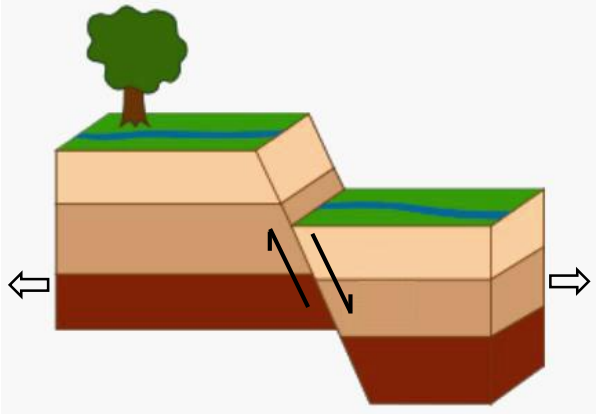
Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:

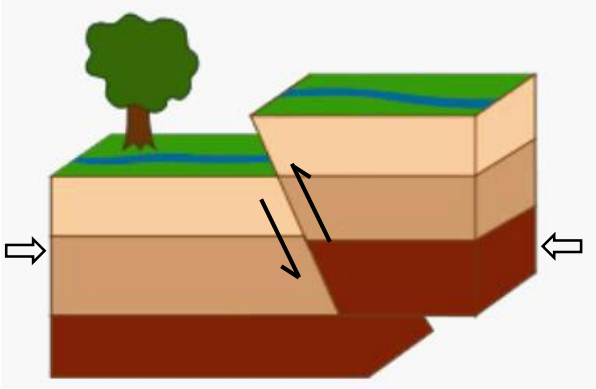
- describe the differences between faults and other kinds of fracture;
- distinguish between normal and reverse faults in the field;
- explain how the type of faulting is linked to compressional, tensional or shear forces.

Context:
Pupils are shown faults in the field, preferably where the beds can be matched up on either side of the fault. The questions lead them to interpret the faults as normal (most common), reverse (less common) or tear faults (uncommon and difficult to see in rock faces in the field – more likely to be visible when looking down on horizontal surfaces). Low angle reverse faults (usually less than 10^{o} dip) are called thrust faults. Faults caused by 'sliding-past' shearing forces can be called tear, wrench or strike-slip faults.

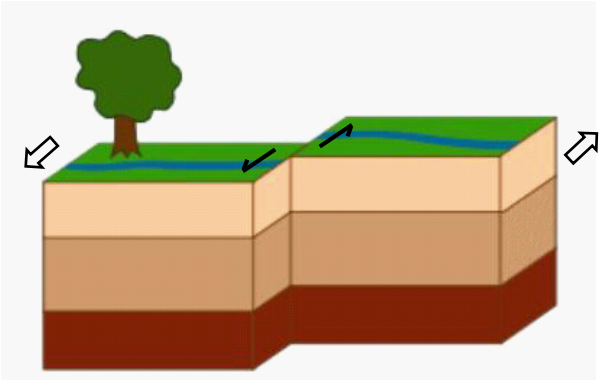
The three different fault types are:



Normal fault – caused by pull-apart (tensional) forces



Reverse fault – caused by compressional (squeezing) forces



Tear fault – caused by sliding past (shearing) forces

These modified images are in the public domain because they contain materials that originally came from the United States Geological Survey.

Remember to carry out a risk assessment before taking anybody to any rock exposure

Following up the activity:
Continue with other 'Questions for any rock face' Earthlearningideas

Underlying principles:

- Faults are fractures where the rocks on either side have moved.
- Normal faults are caused by tension, causing one block to slide down past another, usually at angles of more than 60^{o}.
- Reverse faults are caused by compression, causing one block to slide up over another, usually at angles of less than 60^{o}.
- Low angle reverse faults (usually less than 10^{o} to the horizontal) are called thrust faults.
- Shearing action, causing one block of rock to slide horizontally past another, produces shear faults that are usually vertical; these are also called tear, wrench or strike-slip faults. The movement shown in the diagram is that which may be observed on the ground. Shearing action may be produced by horizontal forces, both compressional and tensional, over a wide range of angles. The forces shown on the diagram above represent the *resultant* of these forces.

Thinking skill development:
Pupils have to construct a pattern of the different fault types linked to the different forces producing them, and then bridge this understanding to their observations in the field. Situations where the answers are not clear cause cognitive conflict.

Resource list:

- the resources needed for pupil fieldwork listed in the Earthlearningidea activity '*Planning for fieldwork: Preparing your pupils before setting out to "ask questions for any rock face"*'

Useful links:
The Geological Society of London has produced an excellent animation of faulting at:
http://www.geolsoc.org.uk/ks3/gsl/education/resources/rockcycle/page3573.html
Another useful faulting animation is at:
http://www.iris.edu/hq/programs/education_and_outreach/animations/2

Source: Devised by Chris King of the Earthlearningidea Team.

The 'Questions for any rock face' series of Earthlearningideas and the sites where they may be applicable

'Questions for any rock face' Earthlearningidea	Site
Planning for fieldwork	Preparation in school beforehand
1: weathering	Any exposure (cliff, coastal exposure, quarry, cutting) or weathered constructions (wall, gravestone, monument)
2: erosion	Any exposure and many walls
3: soil	Some exposures have a useful soil profile at the top (but many do not)
4: rock group (igneous or sedimentary)	Any exposure of igneous or sedimentary rock or both; also applicable to sedimentary and igneous building stones, gravestones or monuments
5: sedimentary grains	Any exposure of sedimentary rock and also building stones, gravestones or monuments
6: fossils	Any exposure containing readily found and obvious fossils, including some building stones, gravestones or monuments
7: tilted or folded rocks	Any exposure of clearly tilted or folded rocks
8: faults	An exposure where rocks are clearly faulted, preferably where beds can be matched up on either side of the fault
9: metamorphism	An exposure where metamorphic features are clearly visible and preferably, where there is also evidence of the former rock type
10: sequencing	An exposure where a sequence of geological events can be relatively dated using 'Stratigraphic Principles'
11. tectonic plates	An exposure of sedimentary rocks containing evidence of deposition in different climates and altitude/depths from today, with further evidence of plate margin processes
12. quarry/ cutting potential	An exposure in any quarry or cutting
13: quarry economics	An abandoned (or working) quarry
14: recording	Any exposure