

Questions for any rock face 10: sequencing

What questions about sequencing geological events 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.

Sequencing

Show your pupils how to use geological 'relative dating' methods to work out the sequence of events recorded in a rock exposure, and so to work out the geological history of the area, by asking these questions:

Possible questions	Possible answers
In a layered sequence, which of the layers was formed first? Which last?	The last (youngest layers) are on top (unless major geological upheavals have overturned the whole sequence – very unusual). This is the 'Principle of Superposition of Strata'
Where a feature cuts across another feature, which came first, the feature that cuts through or the feature that is cut?	The feature that is cut is always older than the feature (such as a fracture, fault, dyke or erosion surface) that cuts across it. This is the 'Law of Cross-Cutting Relationships'
If a rock A contains pebbles of another rock B, which came first, rock A or rock B?	The pebbles of B must be older than rock A that contains them. This is the 'Law of Included Fragments'
If a rock is tilted, folded or metamorphosed, which came first, the rock or the tilting/ folding/ metamorphism?	The rock must have been formed before the tilting, folding or metamorphism happened
What is the sequence of geological events at this site using these methods?	Most geological histories begin with the deposition of the oldest rock and end with the erosion that exposed the rock you can see today



'The Principle of Superposition of Strata'. Which of the beds in this folded sandstone sequence is the oldest (it has not been overturned)? Devonian Old Red Sandstone, St. Anne's Head, Pembrokeshire, UK.

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'The Law of Cross-Cutting Relationships'. What was the order of events here: intrusion of the pale cross-cutting dyke: formation of the surrounding rock; removal of overlying rocks by erosion; intrusion of the dark dyke? Precambrian rocks in the Koster Islands, Sweden.

*Thomas Eliasson of Geological Survey of Sweden
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'The Law of Included Fragments'. Which came first, rock A, the surrounding rock, or rock B, the pebbles it contains? Sandy conglomerate, California, USA.

*Earth Science Image Bank h27siz ©
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An overfold showing that the 'Principle of Superposition of Strata' is only a principle, and not a Law – since here the rocks of one of the fold limbs have been overturned. If the oldest rocks here are in the centre of the fold, which is the overturned limb? A recumbent fold, Crackington Haven, Cornwall, 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 10: sequencing.

Subtitle: What questions about sequencing geological events might be asked at any rock exposure?

Topic: Questions helping pupils to sequence events using 'relative dating' methods.

Age range of pupils: 9-16 years

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:

- apply 'relative dating' stratigraphic principles;
- use these principles to work out the geological history of an area.

Context:

Some of the methods used for the relative dating of geological events (putting them in relative order from the oldest to the youngest) have unfortunately long names – but the ideas are simple, as explained in the 'Underlying principles' section below.

When introducing these relative dating methods, it is a good idea to ask the pupils if each one is a '**principle**', which usually applies, but there could be certain unusual circumstances when it doesn't apply, or a '**law**', which always applies, as below:

Method	Principle or law?
Superposition of strata	Principle
Cross-cutting relationships	Law
Included fragments	Law
Deformation after formation	Law

In the photographs:

- St. Anne's Head: the oldest sandstone bed is in the core of the anticline to the right;

- Swedish Precambrian rocks: the order of events was: formation of the surrounding rock; intrusion of the pale cross-cutting dyke; intrusion of the dark dyke; removal of overlying rocks by erosion;
- Californian sandy conglomerate: the pebbles of rock B are older than rock A, in which they are included;
- Crackington Haven fold: the lower fold limb is the overturned one.

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:

- The 'Stratigraphic Principles' used to sequence geological events in 'relative dating' are:
 - 'The Principle of Superposition of Strata' – which states that topmost layer is the youngest and the oldest layer is at the bottom (this is a Principle, and not a Law, since there are circumstances, such as overfolding or reverse faulting, that can cause older rocks to be on top of younger rocks).
 - 'The Law of Cross-Cutting Relationships' – which states that something which cuts something else must be younger – so if a fault cuts a sandstone, the sandstone formed before the fault. This always applies and so is a Law.
 - 'The Law of Included Fragments' – stating that anything clearly included in something else must be older – so an 'inclusion' of rock in a granite must be older than the granite. This always applies and so is a Law.

- A further important fact in the relative dating of rocks, is that rocks cannot be deformed or metamorphosed before the rocks formed in the first place.
- Together, these relative dating methods allow a geological history for an area to be constructed.

Thinking skill development:

The 'Stratigraphic Principles' are patterns that the pupils need to construct mentally before applying them to rock exposures through bridging.

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:

A useful animated rock sequencing exercise can be found at:
<http://sciencelearn.org.nz/Contexts/Dating-the-Past/Sci-Media/Animations-and-Interactives/Relative-rock-layers>

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

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