www.earthlearningidea.com
Earth Learning Idea
Innovative, Earth-related teaching ideas

EARTH SCIENCE | GEOLOGY | ENVIRONMENTAL SCIENCE
PHYSICAL GEOGRAPHY

Practical activities • minimal equipment • teachers' back-up
FREE pdf DOWNLOADS

Earth science out-of-doors workshop

Earth science out-of-doors
Earth science investigations in the school grounds or in nearby areas

Used by Earthlearningidea by kind permission of the Director, ESEU

Contents

Summary

Use these Earthlearningideas (from http://www.earthlearningidea.com/) to see how Earth science principles can be illustrated out of doors, often without a rock in sight, and how pupils can be engaged in discussions about Earth processes and products.

Earth Science Education Unit workshops

These workshops have been devised for teachers and trainee teachers. They are intended to provide participants with a range of activities that can be used in the classroom and out-of-doors, whilst helping them to develop the skills for using the activities in an engaging and motivating way that will enthuse and educate their pupils, whilst developing their critical thinking skills. The workshops should also develop the background Earth science knowledge and understanding of the teachers involved.

The workshop format may be transposed directly into a classroom or outdoor situation, but often this is not appropriate. Similarly, individual activities, and the worksheets on which these are based, may be transferable directly into a classroom/outdoor situation, but will often require modification for the classes and situations in which they are used, during which suitable risk assessments are undertaken.

Workshop Outcomes

The workshop and its activities provide the following outcomes:

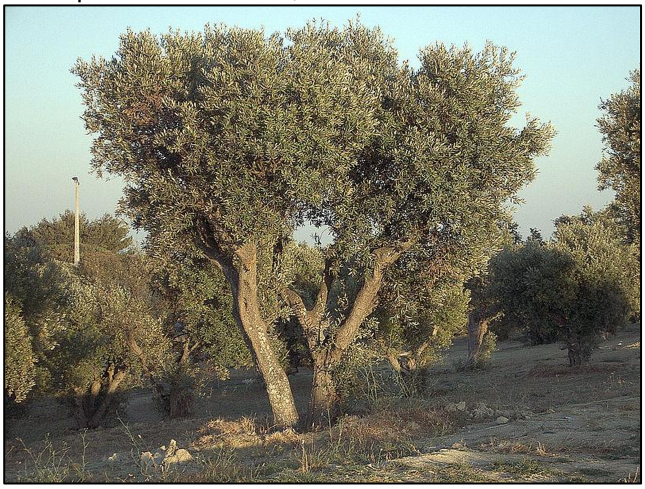
- use of outdoor opportunities within the school grounds for enhancing the teaching of Earth science, its principles and processes;
- an approach to Earth science through an inquiry context.

Fieldwork: Applying 'the present is the key to the past'

An outdoor activity to apply the present to the past - using Earth science-thinking in reverse

This five-phase outdoor activity is used to explain how Earth scientists use the Principle of Uniformitarianism, often simply stated as 'the present is the key to the past', by considering the present environment and thinking how it might be preserved geologically.

Phase 1: What is happening now?
This activity can be run anywhere outside, but probably works best near a tree with some bare soil exposed underneath, like this one.



Ask the group 'What processes are happening now or have happened in the past few hours?', and give as an example 'The wind is blowing'. You could ask them, singly or in groups to write down as many things as they can – then add to their list during discussion. Answers might include:

• Wind blowing
• Clouds moving
• Temperature changing
• Evaporation
• Raining
• Humidity changing
• Air pressure changing
• Growth
• Photosynthesis
• Respiration
• Digestion
• Transpiration
• Leaves falling
• Decay
• Nitrogen is being fixed
• Soil forming
• Worms burrowing
• People walking
• Insects crawling
• Birds singing
• Cars driving

• Birds flying
• Weathering
• Erosion
• Ground being compacted
• Sun radiating visible light
• Sun's rays scattering making the sky blue
• Sun radiating heat
• Sun radiating ultraviolet light
• We are receiving ionising radiation (eg. gamma rays)
• We are receiving microwaves/radio waves
• Cosmic dust is raining down
• Neutrinos are passing through us

• We are receiving chemical pollution

• We are receiving sound pollution
• Ground vibrating

Phase 2: What evidence is there for what is happening now?
Ask the group what evidence they can sense for the processes that are happening, and give as an example something like, 'The wind is blowing your hair and I can feel it on my face'. They could add examples of evidence to their previous list. There are fewer examples in this list, including:

• Wind blowing	You can feel/see it
• Clouds moving	You can see them
• Temperature changing	'I'm feeling cold'
• Evaporation	Cracks in the soil
• Raining	Rain pits in the soil or 'I can feel it'
• Growth	Buds; small and large examples of the same species
• Photosynthesis	Because things are green they must be photosynthesising – but rather a second-hand argument
• Respiration	We are here and we're respiring – second-hand
• Digestion	We can hear our stomachs
• Leaves falling	Leaves on the ground
• Decay	Leaves turning brown
• Worms burrowing	Worm casts
• People walking	We can see them
• Insects crawling	We can see them
• Birds singing	We can hear them
• Birds flying	We can see them
• Erosion	Our footprints are eroding the ground
• Ground being compacted	We are compacting the ground – second-hand
• Sun radiating visible light	We can see
• Sun radiating heat	We can feel the warmth
• Cars driving	We can see them
• We are receiving chemical pollution	We can smell/taste it
• We are receiving sound pollution	We can hear it

Phase 3: What evidence could be preserved by a thick blanket of volcanic ash?
Ask them which examples from their evidence list would be preserved if there were a huge volcanic eruption nearby and everything were buried under a thick blanket of cold volcanic ash. There are fewer potential answers here too, which include:

• Wind blowing	Piles of wind-blown leaves may be preserved
• Evaporation	Soil cracks could be preserved

• Raining	Rain pits could be preserved
• Growth	Buds; small and large examples of the same species could all be preserved
• Photosynthesis	Because plants are preserved, they must have been photosynthesising – but rather a second-hand argument
• Respiration	Our bodies are here and so we must have been respiring – second-hand
• Digestion	Our bodies are here and so we must have been able to digest – second-hand
• Leaves falling	Leaves preserved
• Worms burrowing	Worm casts could be preserved
• People walking	Human bodies are preserved – so they must have been able to walk
• Insects crawling	Insects could be preserved
• Erosion	Footprints could be preserved
• Cars driving	Cars could be preserved

Phase 4: What evidence could be preserved after __200 million years__?
Ask what evidence might be preserved under the volcanic ash 200 million years later. Only the following four examples might be preserved (unless there is exceptional preservation or second-hand evidence is included, as for the examples in italics below).

• Evaporation	Soil cracks could be preserved
• Raining	Rain pits could be preserved
Growth	*Exceptionally: buds; small and large examples of the same species could all be preserved*
Photosynthesis	*Exceptionally: because plants are preserved, they must have been photosynthesising – but rather a second-hand argument*
Respiration	*Exceptionally: Our bones, teeth, metal zips, etc are here and so we must have been respiring – second-hand*
Digestion	*As above*
Leaves falling	*Exceptionally: leaves preserved*
• Worms burrowing	Worm casts could be preserved
People walking	*Exceptionally: Human footprints are preserved – so they must have been able to walk*
• Erosion	Footprints could be preserved
Cars driving	*Exceptionally: cars preserved*

Note that, at each phase, fewer and fewer examples are preserved – evidence is lost progressively through the preservation processes.

Explain that this outdoor thinking exercise, of applying the present as the key to the past, is the way an Earth scientist works, in reverse.

Phase 5: __Building a picture of the past__ from the evidence preserved
Show how an Earth scientist uses the Principle of Uniformitarianism to work out what the past was like by referring to a nearby sedimentary rock (in an exposure or building stone) or taking a rock or fossil out of your pocket and asking what we can tell about the past from this example.

A dinosaur Theropod footprint (a trace fossil).

For the example of a small plaster cast or photo of a dinosaur footprint we can tell:

• On land	Dinosaur was walking
• Muddy	Footprint preserved
• Some water	To make mud and for dinosaurs to drink
• Clouds	To give rain
• Plants photosynthesising	Dinosaurs ate plants, or ate animals that ate plants; plants photosynthesised
• Plants were green	Photosynthesis possible due to green chlorophyll
• Sky was blue	Sun's rays and scattering
• Sound pollution	Dinosaurs were noisy
• **Etc.**	**Many more processes from the first list**

The picture of the past was very similar to the picture today, but with different organisms, many of which are now extinct.

The back up

Title: Fieldwork: Applying 'the present is the key to the past'

Subtitle: An outdoor activity to apply the present to the past - using Earth science-thinking in reverse

Topic: An outdoor-based thought experiment to show how Earth scientists use evidence from rock sequences to understand past environments.

Age range of pupils: 10-18 years

Time needed to complete activity: 20 minutes

Pupil learning outcomes: Pupils can:

- explain how Earth scientists use the present as the key to the past through the Principle of Uniformitarianism;
- describe a range of physical, chemical and biological processes that act out of doors;
- explain the evidence for some of these processes;
- explain how the evidence for Earth processes can be preserved geologically.

Context:
Pupils use an outdoor thought experiment to develop their understanding of the Principle of Uniformitarianism (the present is the key to the past), first developed by scientists in the late 1700s.

Following up the activity:
The final phase of the activity can be applied to a range of sedimentary rocks and fossils.

Underlying principles:

- All the processes happening on Earth today also operated in the geological past (even though they may have operated somewhat differently in the early Earth, especially before life developed)
- Earth scientists apply their understanding of present day processes to interpret evidence from the past, preserved in rock sequences.

Thinking skill development:
Pupils use the pattern of today's processes (construction) to picture past environments (further construction); discussion may produce differing views (cognitive conflict) and explanation (metacognition) whilst the whole activity involves bridging from one phase to the next. Creativity and imagination are also required.

Resource list:

- either a nearby sedimentary rock or building stone or a pocket-sized rock, fossil, plaster-cast or photo of a fossil

Source: Devised by Chris King of the Earthlearningidea Team.

Earth science out-of-doors: applying 'the present is the key to the past' worksheet

For this area of open ground, with some bare soil exposed, what is the locality name and grid reference?

Location: ……………………………… Grid Reference: ……………………………

Phase 1: What is happening now?
What processes are happening now or have happened over the past few hours in this area?
List six processes that are active now or have been active recently.
We will then add six more from the rest of the group.

Six active processes	Six processes from the rest of the group
1. ……………………………………………………	……………………………………………………
2. ……………………………………………………	……………………………………………………
3. ……………………………………………………	……………………………………………………
4. ……………………………………………………	……………………………………………………
5. ……………………………………………………	……………………………………………………
6. ……………………………………………………	……………………………………………………

Phase 2: What evidence is there for what is happening now?
What is the evidence that these things are happening now or have happened recently?

1. ……………………………………………………	……………………………………………………
2. ……………………………………………………	……………………………………………………
3. ……………………………………………………	……………………………………………………
4. ……………………………………………………	……………………………………………………
5. ……………………………………………………	……………………………………………………
6. ……………………………………………………	……………………………………………………

Phase 3: What evidence could be preserved by a thick blanket of cold volcanic ash?
Which of these pieces of evidence might be preserved if this area suddenly became buried under ash?

……………………………………………………..	……………………………………………………
……………………………………………………..	……………………………………………………
……………………………………………………..	……………………………………………………
……………………………………………………..	……………………………………………………

Phase 4: What evidence could be preserved after 200 million years?
If you found a rock containing this evidence, what would you be able to say about the area in which the sediment was laid down – what palaeoenvironmental interpretation could you make?

……………………………………………………..	……………………………………………………
……………………………………………………..	……………………………………………………
……………………………………………………..	……………………………………………………
……………………………………………………..	……………………………………………………

Phase 5: Building a picture of the past from the evidence preserved – led by your teacher.

Examples of evidence which could be preserved after many millions of years and understood by using 'the present is the key to the past'


Fossil mud cracks, India

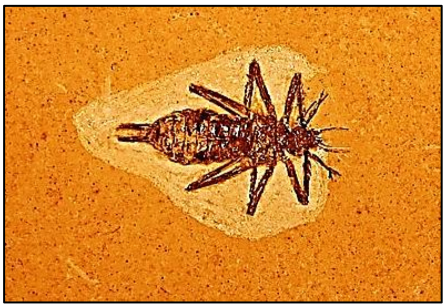

Fossil raindrop pits, Spain


Fossil leaves around 180 million years old, England

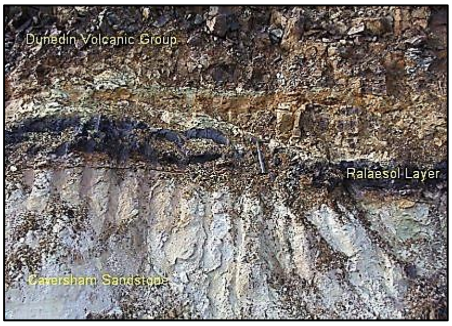

Fossil footprints, Argentina


Fossil poo (coprolite) around 80 million years old, Canada


Fossil worm burrows


Fossil insect


Fossil tree root around 300 million years old, Canada



Fossil soil, or paleosol, around 20 million years old, New Zealand


Fossil channel filled with sandstone, Scotland, UK

Rock around your school

Investigating the building materials around your school and in your area

Use your own school and local area to introduce your pupils to the wide range of materials used to make buildings. First visit the sites and plan your trip.

Divide the pupils into groups and supply each group with table 1 and 2 (like those shown below), clipboard, paper and pencils.

Ask the pupils to fill in Table 1 with as many materials as they can see. The teacher will need to be on hand to answer queries.

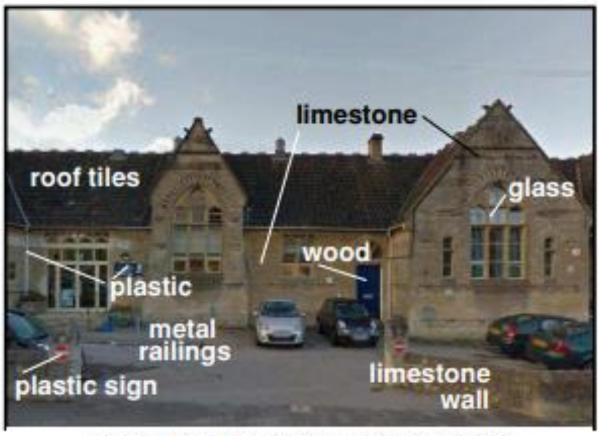
Provide the pupils with the key on page 3 and ask them to look at some of the natural materials more carefully. They should fill in Table 2. Even in a school where everything appears to be made of manufactured materials, it is often possible to find some examples of natural rocks.

Thirdly, ask the pupils to carry out a similar exercise on their way home from school. If they travel by car, ask them to do the exercise at home or with their parents or guardians.

Carry out the following:-

- Find eight different natural stones used for building, or for facing stones, or in pathways or rockeries, or for gravestones or fireplaces (not including those you have already seen in the school!).
- For each of these, fill in a second copy of Table 2

The teacher could try to discover the geology of the area surrounding the school. In the UK, this is fairly easy as geological maps of the whole of the UK are freely available online from the British Geological Survey's Opensgeoscience website http://www.bgs.ac.uk/opengeoscience/
Also, pupils enjoy using the free apps for smart 'phones or tablets - iGeology and iGeology 3D. iGeology will tell them what the rock is beneath their feet and iGeology 3D will tell them the geology of nearby hills or mountains.



Box Church of England Primary School, Wiltshire
(Elizabeth Devon)

TABLE 1: Materials used in the buildings and in their surroundings (natural and manufactured)

Type of material	Where I saw it being used	Natural or manufactured?	If manufactured, did the original material come from the ground?
e.g. glass	classroom windows	manufactured	yes

TABLE 2: Natural materials used in the buildings and their surroundings

Natural materials	Where I saw it being used	What it is used for	Type of rock	Clues to tell me rock type	Is it standing up to the weather well?	Is this a good use for this rock?	Do you like it?

The back up:

Title: Rock around your school

Subtitle: Investigating the building materials around the school and in the area

Topic: This activity can be used in science or geography lessons. It illustrates Earth science principles out of doors, often without a natural rock in sight, and engages pupils in discussions about Earth processes and products.

Age range of pupils: 8 - 18 years

Time needed to complete activity: 30 minutes around the school grounds

Pupil learning outcomes: Pupils can:
- distinguish between natural and manufactured materials;
- follow a branching key;
- use the criteria by which rocks are distinguished;
- identify a wide range of rock types;
- realise that all building materials whether natural or manufactured come from the ground;
- avoid the temptation to make a sample fit the key if it is inappropriate;

Context:
Pupils are encouraged to distinguish between manufactured and natural materials. They discuss the origins of all these materials.

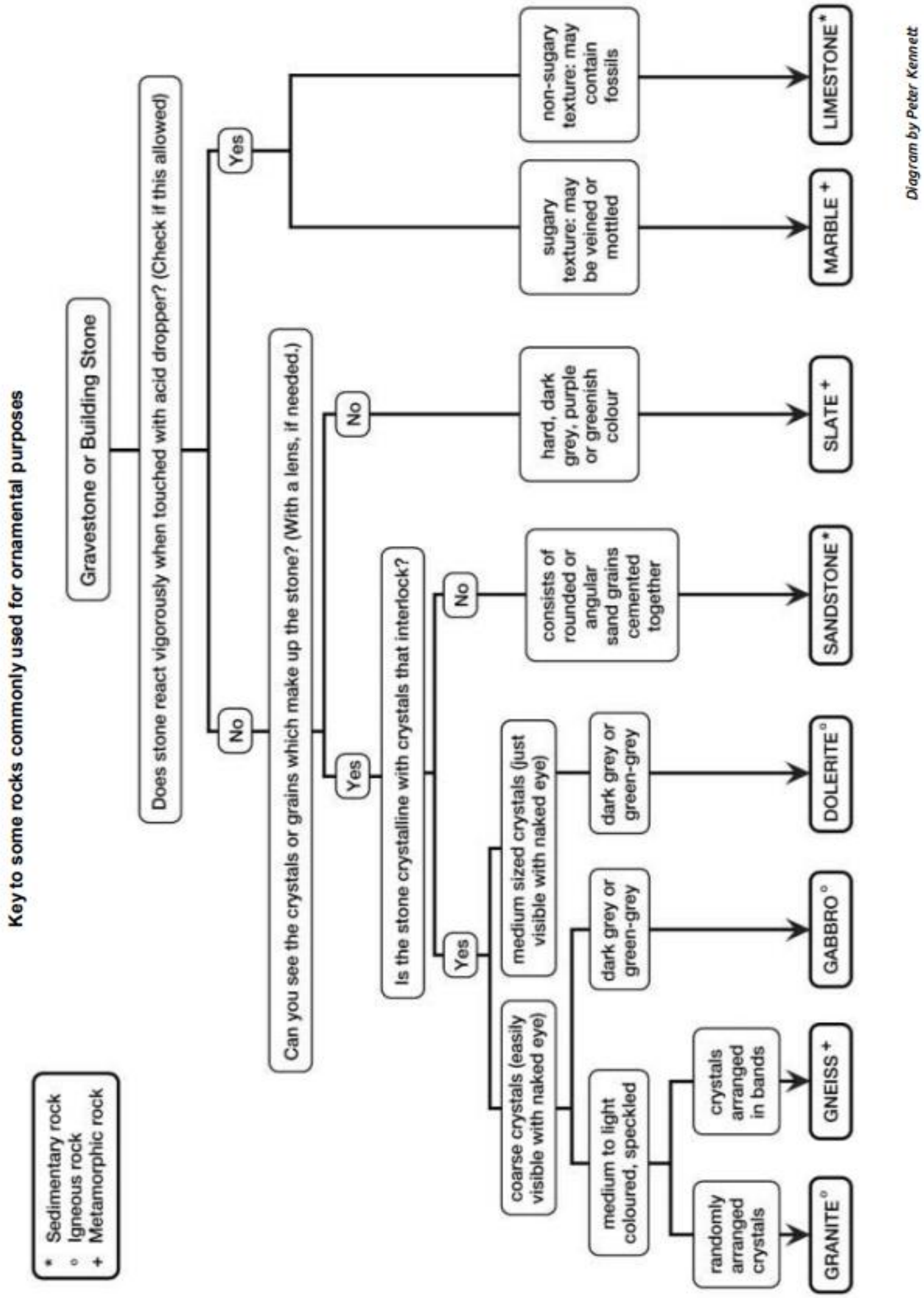
Following up the activity:
Pupils could try some of the following Earthlearningideas http://www.earthlearningidea.com:
- Earth science out of doors: preserving the evidence
- Rocks from the big screen
- Building stones 1 - general resource
- Will my gravestone last?
- Building stones 2 - Igneous rocks
- Building stones 3 - Sedimentary rocks
- Building stones 4 - Metamorphic rocks
- What was it like to be there - in the rocky world?
- Fieldwork: Applying 'the present is the key to the past'.

Underlying principles:
- In simple terms, sedimentary rocks are mainly non-crystalline and consist of fragments or grains compressed and cemented together. Metamorphic and igneous rocks are largely formed of interlocking crystals and so are impermeable. In igneous rocks the crystals usually show random alignment, but in metamorphic rocks they are often aligned. Some metamorphic rocks which do not show alignment e.g. marble, are usually made of one mineral but impurities sometimes show streaky patterns.
- Rocks containing carbonate minerals, i.e. marble and limestones, will react with dilute hydrochloric acid. (This should only be done with permission, although it leaves very little sign on the stone - and gravestones are sometimes cleaned using acid).
- Igneous and most metamorphic rocks are more impermeable than most sedimentary rocks. They resist weathering better and are more capable of taking a polish on the displayed surface.
- Igneous and metamorphic rocks are often attractive in themselves, owing to the range of colours of their constituent minerals.
- The overall colour of an igneous or metamorphic rock is often controlled by small amounts of trace elements in the minerals. In a sedimentary rock, the composition of the (natural) cement which binds the grains together usually influences the colour of the rock.

Thinking skill development:
By using a key, pupils are involved in thought processes of construction. The fact that rocks such as granite may occur in many different colours may involve cognitive conflict. Working out of doors provides a good opportunity to make a bridge with normal classroom studies.

Resource list:
- copies of the key to common rocks
- paper and pencils
- clipboards
- dilute hydrochloric acid (0·5M) or limescale remover to test for the calcium carbonate in limestone and marble (optional)
- wash bottle filled with tap water

Source: Developed by Elizabeth Devon from an activity written for ESEU CPD sessions by Peter Kennett


Key to some rocks commonly used for ornamental purposes
* Sedimentary rock
° Igneous rock
+ Metamorphic rock
Gravestone or Building Stone
Does stone react vigorously when touched with acid dropper? (Check if this allowed)
Yes
No
sugary texture: may be veined or mottled
non-sugary texture: may contain fossils
MARBLE +
LIMESTONE *
Can you see the crystals or grains which make up the stone? (With a lens, if needed.)
No
hard, dark grey, purple or greenish colour
SLATE +
Yes
Is the stone crystalline with crystals that interlock?
No
consists of rounded or angular sand grains cemented together
SANDSTONE *
Yes
medium sized crystals (just visible with naked eye)
dark grey or green-grey
DOLERITE °
coarse crystals (easily visible with naked eye)
dark grey or green-grey
GABBRO °
medium to light coloured, speckled
crystals arranged in bands
GNEISS +
randomly arranged crystals
GRANITE °
Diagram by Peter Kennett

What happened when?: sorting out sequences using stratigraphic principles
Are the stratigraphic principles, principles or laws – and how do you use them?

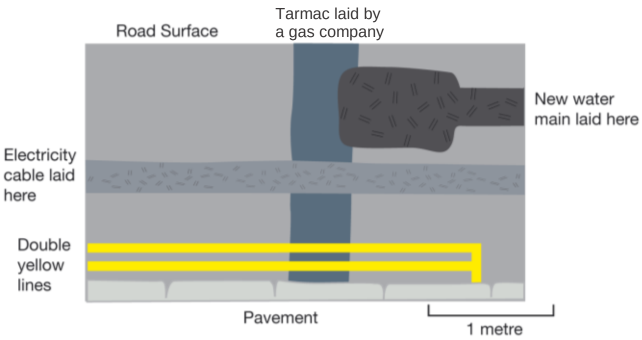
Principle or law?
Ask your pupils to complete the table below by writing if they think each sedimentary sequence statement is a 'Principle' or 'Law'.

If they think the statement is a 'Principle' they should add any exceptions to the rule.

Sedimentary sequence	Principle or law?	
	Principle	Law
Superposition of strata – states that: 'the layer on top is the youngest.'		
Cross-cutting relationships – states that: 'anything that cuts across anything else must be younger.'		
Included fragments - states that: 'anything included in anything else must be older.'		

Applying the principles
Now ask them to go and apply the principles to work out the age relationships in:

- a patched piece of road or pavement;



- outdoor (or indoor) courts (e.g. tennis or badminton courts) with several lines;
- a cracked wall;

- a local rock exposure;
- a geological map.

The back up
Title: What happened when?: sorting out sequences using stratigraphic principles

Subtitle: Are the stratigraphic principles, principles or laws – and how do you use them?

Topic: Understanding and applying stratigraphic principles, indoors and outdoors.

Age range of pupils: 11-18 years

Time needed to complete activity: 15 minutes

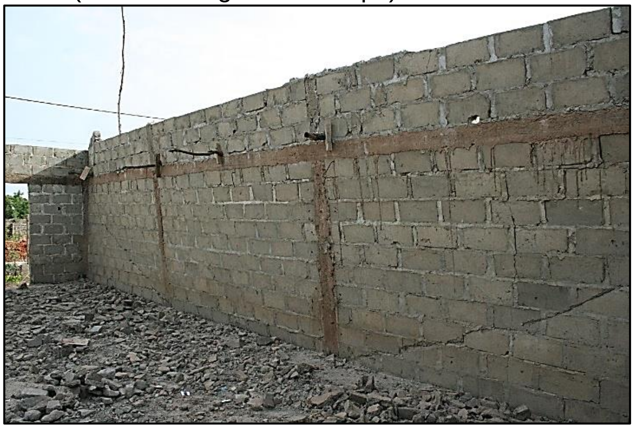
Pupil learning outcomes: Pupils can:
- determine whether the stratigraphic principles used for age sequencing are principles (usually apply) or laws (always apply);
- apply the principles in a range of indoor and outdoor situations, natural and produced by humans.

Context:
The stratigraphic principles used for age sequencing can be applied in indoor and outdoor exercises using natural and constructed situations.

What is the tarmac sequence in the patched road below?

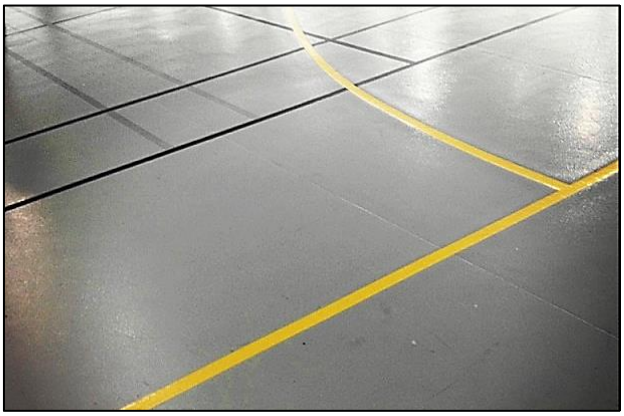
Patched road outside a farm house – which tarmac was laid first?

In this cracked wall, which came first, the cement blocks (included fragments), the blocks at the bottom or the top (superposition of strata) or the crack (cross-cutting relationships)?



A wall damaged by monsoon weather in the Gambia.

In the photo of an indoor court, use the principle of superposition of strata to work out which tape was laid first, the yellow, the black or the grey?



Indoor courts laid out by tape, Issy les Moulineaux, France.

Following up the activity:
Try the '*Laying down the principles'* Earthlearningidea to extend the teaching to include more stratigraphic principles. Then apply them further in the '*Where shall we drill for oil?*' Earthlearningidea.

Underlying principles:
- These principles are the fundamental methods used by geoscientists to sequence rocks and rock events.

Thinking skill development:
- The principles are patterns applied to sequences (construction).
- How the principles should (and should not) be applied causes cognitive conflict.
- Discussion of the application of the principles involves metacognition.
- The principles can be applied (bridged) to a range of other contexts including archaeological and forensic ones.

Resource list:
- suitable outdoor and indoor situations

Useful links:
Try: http://www.esta-uk.net/jesei/index2.htm and the quizlet activities at: https://quizlet.com/194800271/stratigraphic-principles-flash-cards/

Source: Devised by Chris King of the Earthlearningidea Team, based on an Earth Science Education Unit activity. The ESEU is thanked for use of the diagrams.

Urban fieldwork: the stories from materials, colours, lines and shapes
Find out the stories told by materials used in building and for decoration

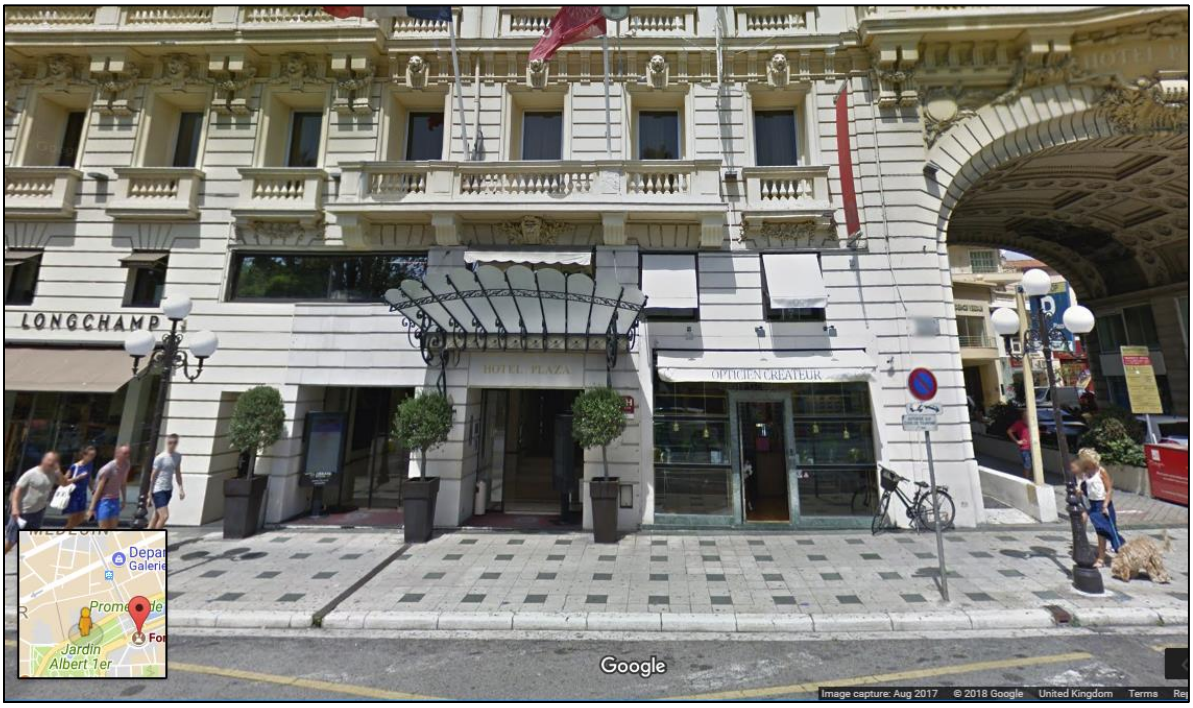
When you look at the stones used for buildings and in parks and cemeteries, there are key features to help you to work out the stories locked up in the rocks.

Use the sheets on pages 12 (colour), 13 (lines), 14 (shapes) and the recording sheet on page 15 to note down what the stones can tell you.

Materials – natural or not
First look carefully at the materials to see if they are natural or have been manufactured. Most of the features below tell you that they are natural. If they are manufactured, go to the '*Rock around your school'* Earthlearningidea to discover the stories that manufactured materials can tell you.

Natural materials
If the stones are natural materials, the sheets on colours, lines and shapes will help you to find out their stories.

If you want to try to identify the different types of stones, use the Earthlearningideas on building stones (see 'The back up') to match the stones you find in the streets with the pictures given – to add even more to the stories of the stones.



Building stones used to add interest to a pavement, hotel and shop fronts in Nice, France. *(Google Maps street view).*

The back up

Title: Urban fieldwork – the stories from materials, colours, lines and shapes.

Subtitle: Find out the stories told by materials used in building and for decoration.

Topic: Using the colours, lines and shapes of building stones and other natural decorative materials to help to tell their stories.

Age range of pupils: 8 – 80 years

Time needed to complete activity: This depends on the building stone opportunities in the area.

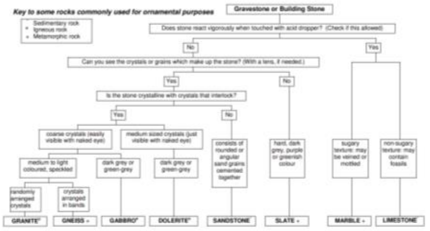
Pupil learning outcomes: Pupils can:

- use the more 'obvious' features of building stones, their colours, lines and shapes, to describe how the rocks formed or were later deformed;
- explain how building and decorative stones with different features can be used to add character to an area.

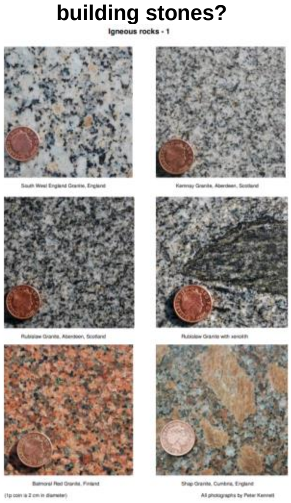
Context:
Pupils use sheets focussed on colours, lines and shapes to begin to tell the stories of the stones used in urban areas. This urban fieldwork helps them to see that, wherever stones are found or used, the features within them can be used to tell the stories of how they formed, and sometimes, how they were later deformed.

Following up the activity:
Use the sheets in the building stone Earthlearningideas to identify, name and find out much more about the rocks the pupils find.

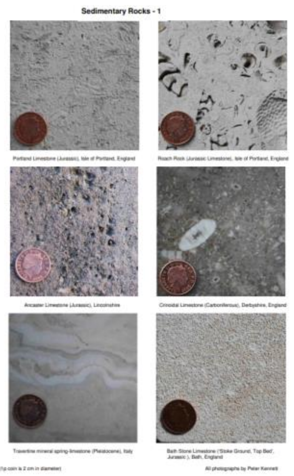
Building Stones 1– a resource for several Earthlearningidea activities: use a key to identify many different attractive-looking rocks



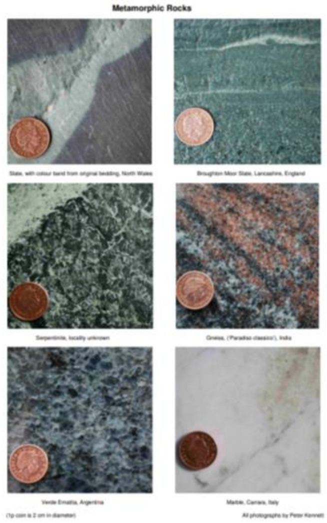
Building Stones 2 – Igneous rocks: What are the differences between igneous rocks commonly used as building stones?



Building Stones 3 – Sedimentary rocks How do the sedimentary rocks used for building stones differ?



Building Stones 4 - Metamorphic rocks: What are the differences between metamorphic rocks commonly used as building stones?



Underlying principles:
- The more 'obvious' features of, colour, lines and shapes of the building stones seen in urban fieldwork can all help to tell their stories.

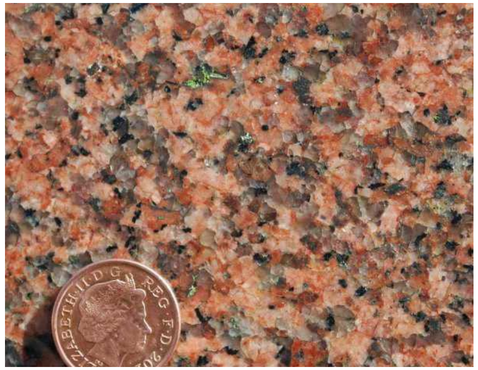
Thinking skill development:
- Pupils look for patterns within rocks to enable them to distinguish between them.
- Working out of doors provides a good opportunity to make a bridge with normal classroom studies.

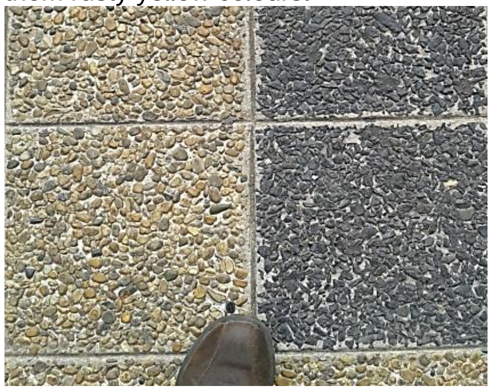
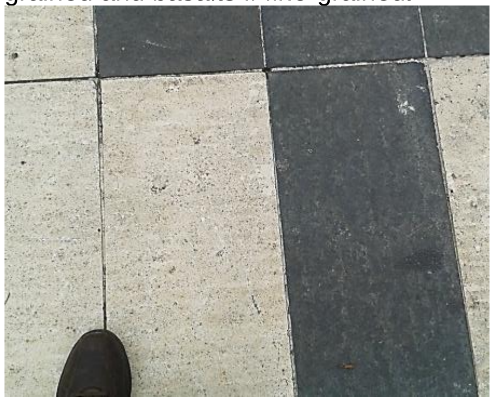
Resource list:
- the attached sheets, on colours, lines and shapes and the recording sheet

Useful links:
'Will my gravestone last?' from https://www.earthlearningidea.com/PDF/135_Gravestones.pdf and https://www.earthlearningidea.com/Video/V14_Gravestones1.html
http://www.nationalstonecentre.org.uk
http://geoscenic.bgs.ac.uk/asset-bank/action/viewAsset?id=344745&index=96&total=110&view=viewSearchItem

Source: Chris King of the Earthlearningidea Team. Photos by Chris King, unless otherwise stated.

Colours

White	Pale colours	Speckled white	Dark pink and reddish
Usually formed of pure calcium carbonate, if sedimentary they are limestones, if metamorphic, they are marbles*.  White marble and reddish marble. * Some metaquartzites are white but are not common building stones; they do not react with dilute acid when calcium carbonate rocks do.	Probably calcium carbonate with impurities – giving a range of colours including pinks, greens and greys.  Decoration with white, grey and green marble. *(Licensed by Illustratedjc – Creative Commons Attribution-Share Alike 4.0 International licence).*	Speckled whitish rocks are probably the pale-coloured igneous rock, granite; individual white or pale crystals are large enough to be seen, with dark mica crystals between them.  The whitish minerals in granite, with dark micas.	Dark pink and reddish materials usually contain oxidised iron minerals; in sedimentary rocks, this usually means they formed in tropical conditions; pink minerals in igneous rocks are feldspars, containing small amounts of trace elements.  Pink feldspars in granite (coin here and in later photos 2cm across). *(Peter Kennett).*

Yellowish-brown to dark brown	Mid grey	Dark grey	Greenish
Yellowish-brown to dark brown rocks contain oxidised iron; brown sedimentary rocks are laid down in many environments; weathering often brings iron to the outer surfaces, giving them rusty yellow colours.  Slabs surfaced by yellowish quartzite pebbles and crushed dark grey basalt.	Mid-grey sedimentary rocks are usually quartz-rich sandstones/ siltstones/ mudstones or carbonate-rich limestones – with a lot of clay minerals giving the grey colour; if the finer rocks have become metamorphosed, they form grey slates.  Pale-grey sandstone and pure-white limestone.	Dark grey sedimentary rocks usually contain a lot of clay minerals or organic material; dark grey igneous rocks have dark iron-rich minerals and are gabbros if coarse-grained, dolerites if medium-grained and basalts if fine-grained.  White fairly-pure marble, with dark-grey slate.	Greenish rocks are either marble with impurities or are fine volcanic ash or slates formed by metamorphism of the ash.  Greenish slate, metamorphosed from original volcanic ash. *(Peter Kennett)*

Lines (beware – some lines in building stones are the tool marks made during quarrying, and so tell us nothing about how the rock formed – careful observation is needed).

Bedding

The lines seen in many sedimentary rocks are the layers or beds which formed as the original sediments were laid down – called bedding.

A slab that has been cut across the bedding showing the straight bedding lines.

Bedding in a pale-coloured limestone called travertine.

Cross-bedding

Some sedimentary rocks show layers at shallow angles to the main bedding – this is cross bedding, where the original sediments were laid down on a slope; the downward slope direction is the flow direction of the current that laid down the sediment.

Cross bedding in sandstone, current flow from left to right. *(Peter Kennett).*

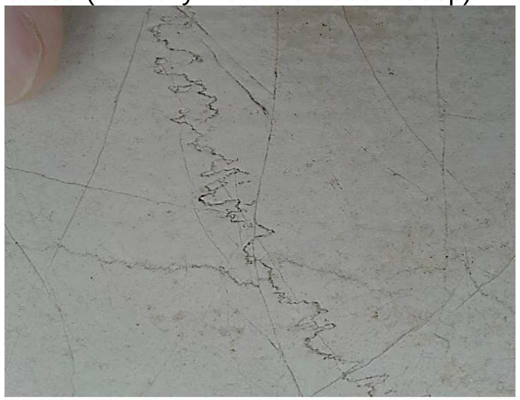
Ripple marks

The broad parallel lines across some sedimentary rocks are ripple marks, formed by waves as the sediment was first deposited; ripple marks form parallel to wave crests, which are often parallel to coasts.

A ripple-marked sandstone – the original coastline probably ran from left to right.

Stylolites

The wiggly lines in some limestones and marbles are stylolites – that formed as some of the rock dissolved under pressure, usually when it was deeply buried (normally more than 500m deep).



A stylolite and fractures in white marble.

Fractures

The fractures seems in some building stones are small faults (if the rock on either side has moved) or joints (if it has not). They usually formed as the original rocks were pulled apart by tension deep in the crust.

Small faults and joints in a piece of slate. *(Peter Kennett).*

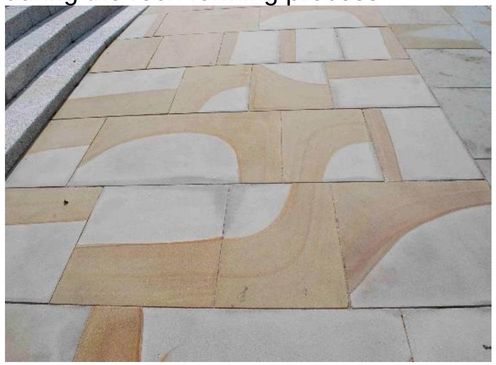
Fracture filled with minerals

Mineral veins form when, long after the rocks first formed, they were cracked by pressures in the crust; then water flowed along the crack and minerals crystallised from the water, filling the crack.

White mineral vein in pink marble.

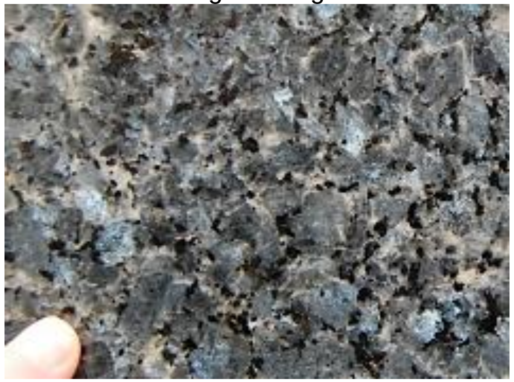
Leisegang rings

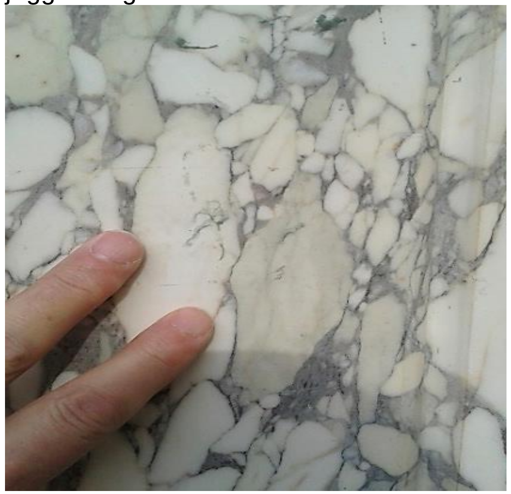
Lines of rusty yellowish, reddish and brownish colours can cross building stones, often cutting across other features. These are called Leisegang rings and are formed of iron minerals during the rock-forming process.



Rust-coloured Leisegang rings in sandstone paving stones. *(Peter Kennett).*

Shapes

Interlocking crystals		Fossils	
Igneous rocks are made of minerals which grew together as they crystallised from the molten rock. Their interlocking shapes can be seen in coarse-grained igneous rocks.		Fossils form the shapes found in many sedimentary rocks; they come in a range of shapes and sizes.	
 Interlocking pale and dark crystals in a granite.	 Interlocking crystals in a dark igneous rock – Larvikite.	 Fossil casts in Portland Limestone. *(Peter Kennett).*	 Fossil crinoids in limestone. *(Peter Kennett).*

Rounded crystal clumps	Broken fragments	Angular pieces	Rounded pieces
Some granites used for buildings have rounded crystals with concentric layers that crystallised in this way as the granite solidified.	Some rocks are made of broken fragments of other original rocks, when the broken fragments usually have sharp jagged edges.	Slabs are sometimes surfaced by crushed rock; the angular fragments have sharp edges.	The rounded rock fragments on some slabs were rounded as they were transported as sedimentary particles by currents in rivers or the sea.
 Orbicular granite from Finland. *(Peter Kennett).*	 Rock formed of broken fragments of a white rock, cemented together by a darker cement.	 Slab surfaced with angular fragments of broken fine-grained igneous rock – basalt.	 Slab surfaced with rounded fragments of river or beach gravel.

Urban fieldwork – the stories from materials, colours, lines and shapes
Find out the stories told by materials used in building and decoration

Recording sheet

Example stone

Where I saw the stone:
On the steps of the Boscolo Hotel, Avenue Verdun, Nice in France.

The stone is: natural/manufactured

The colour tells me:
The white rock is likely to be marble; the pink rock is likely to be marble too, coloured by containing some iron – both are metamorphic rocks

The lines tell me:
The lines in the white rock are stylolites, wiggly lines formed when the rock was buried; the line in the pink rock is a fracture filled by white material – a mineral vein – this formed long after the pink rock was first formed

The shapes tell me:
No shapes can be seen in this rock

Summary – the story of this stone is:
Both rocks are metamorphic rocks formed of calcium carbonate, called marble; both show later changes, the stylolites in the white rock and the mineral vein in the pink rock.

………

Stone 1

Where I saw the stone:

The stone is: natural/manufactured

The colour tells me:

The lines tell me:

The shapes tell me:

Summary – the story of this stone is:

………

Stone 2

Where I saw the stone:

The stone is: natural/manufactured

The colour tells me:

The lines tell me:

The shapes tell me:

Summary – the story of this stone is:

………

Stone 3

Where I saw the stone:

The stone is: natural/manufactured

The colour tells me:

The lines tell me:

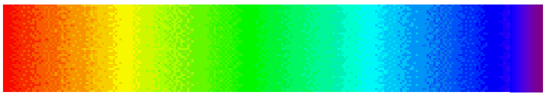
The shapes tell me:

Summary – the story of this stone is:

The watery world of underground chemistry
Using pH to link the atmosphere, hydrosphere, biosphere and lithosphere together

Running the 'watery world' activity
This activity works best out of doors, but can be run in the classroom. It also works best if pupils are asked to contribute to the discussion through the questions and answers suggested below.

First introduce pupils to the pH scale and how pH can be measured using Universal indicator. The colour chart shows that strong acids give red indicator colours, weaker acids range from orange to yellow, neutral solutions are green, while weakly alkaline solutions are greenish blue to dark blue and strong alkalis give a purple colour.



Tap water (rainwater)
1. Have tap water in a bottle (or even better, some rain water you have collected), a drinking glass and some Universal indicator. Also have hidden a drinking straw and a bottle of unopened spring water.
2. Pour some tap water into the drinking glass. Ask what colour they expect Universal indicator to turn when it is added – most will predict that the water is not acid or alkali, but will show a neutral green colour.
3. Add indicator, it will normally turn green or slightly bluish green, showing it is neutral or slightly alkaline.
4. Ask what will happen when the water is poured onto the ground – most pupils will say it will soak into the soil.

Soil water
5. Pour the water onto the ground and watch it soak into the soil. Ask what will happen to the water in the soil; you may have to remind pupils that the soil contains decaying vegetation that is likely to produce acid, and that it contains animals that are respiring, producing carbon dioxide – pupils may then predict that the water will turn acid.
6. Ask how we could mimic the effect that carbon dioxide from respiring animals has on the water – pupils may suggest that someone blows air into the water using a straw, and that indicator will go yellow.

7. Put some more water into the glass, add indicator, get out the straw and ask someone to blow into the water for some time (eg. 30 seconds) – the indicator will normally turn yellow (sometimes orange), showing that a weak acid has formed.
8. Ask what then will happen to the acid water in the soil – pupils may suggest that some will stay in the soil, some will be lost through transpiration by plants or evaporation from the soil surface, but some will trickle into the rocks below to become groundwater.

Groundwater
9. Ask how the acid water is likely to affect the rocks – most will suggest that a chemical reaction will occur and the water will become neutral again.
10. Ask what will happen to this water over time; you may have to give the clue that water will flow through pore spaces in the rocks and will also flow downhill – some pupils will say that the water will flow sideways.
11. Ask whether this water will come out of the ground – some will say the groundwater will leak out in a spring.

Spring water
12. Following all this discussion, ask what colour they would expect Universal indicator to turn in spring water – most will predict it will turn a neutral green colour.
13. Get out the bottle of spring water, open it, pour some into the glass and test it with indicator. It will normally go a neutral green or a slightly alkaline bluish green.

Linking the Earth's spheres
14. Ask which of the Earth's spheres have been mentioned in the discussion; the atmosphere, hydrosphere, biosphere or lithosphere – many pupils will realise that (atmosphere (rainwater, origin of tap water); hydrosphere (trickling into the soil, soil water, groundwater, springs); lithosphere (soil and rock); and biosphere (animals and plants in the soil)) have all been discussed.

Photo of tapwater taken by de: Benutzer: Alex Anlicker. Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License.

The soil profile image is a work of a United States Department of Agriculture employee, and so is in the public domain.

The photo of the bottle of San Pellegrino mineral water was taken by Andrew Rendle. This file is licensed under the Creative Commons Attribution ShareAlike 2.5 Licence.

The back up

Title: The watery world of underground chemistry.

Subtitle: Using pH to link the atmosphere, hydrosphere, biosphere and lithosphere together.

Topic: A discussion, with demonstrations, of the likely change in pH of water as it goes through the underground part of the water cycle.

Age range of pupils: 10 – 18 years

Time needed to complete activity: 15 mins

Pupil learning outcomes: Pupils can:

- describe how the colour of Universal indicator shows the pH of a solution;
- describe and explain the likely changes in pH of water as it goes through the underground part of the water cycle.

Context: The pH of water is used as the basis of a discussion of how water flows through, and interacts with, the rocks and soil during the underground part of the water cycle – integrating aspects of the atmosphere, hydrosphere, biosphere and lithosphere.

Following up the activity:

1. In the discussion of the groundwater section, where pupils are asked, **'**how the acid water is likely to affect the rocks', try adding some powdered chalk (eg. enough to cover your small fingernail) to the yellow-coloured weakly-acid water. The water, when shaken, will soon turn a cloudy green colour; it is cloudy because of the chalk, and green showing that the acid has reacted with the chalk to form a neutral solution.
2. For those in coastal areas, who have access to some sea water:

- Ask what would happen to acid soil water that flows into the sea? – pupils will probably answer that it will go neutral.
- Ask, could this be replicated by adding salt (NaCl) to the acid 'soil water' – they will probably answer 'yes'.
- Add salt to the yellow-coloured water, it often turns the water green for a brief moment, then it reverts back to yellow again. This is because salt has no effect on the pH, since it produces a neutral solution.
- Ask – so, what will happen if we test sea water for pH using Universal indicator? – pupils will probably answer, from what they have seen that, it will go yellow.
- Add Universal indicator to sea water. It will usually go green to bluish green showing it is slightly alkaline. Explain that when acid soil water flows into the sea, a range of reversible reactions takes place involving much of the dissolved material, in addition to sodium chloride (NaCl). These reactions adjust and so absorb the acidity of the soil water without the seawater becoming acid itself. This is just as well, since it allows the oceans to absorb a lot of the carbon dioxide put into the atmosphere by human activities, and so reduces the global warming effect of CO_2.
- Ask, how could the effect of acid soil water flowing into sea water be reproduced? Pupils will probably suggest that someone blows through a straw into the sea water containing Universal indicator to see how quickly the pH of the seawater changes.
- Use a straw to blow into the seawater with the Universal indicator. You will find it takes much longer to change the pH of sea water than it does with fresh water, because of all the reversible reactions that can accommodate the CO_2 until it 'can't take any more'! This 'buffering' effect of the reversible reactions in sea water is vital to the well-being of our planet. If the oceans ever 'can't take any more' and they become acid, the Earth system will be in very difficult circumstances!
- Ask, which parts of the Earth system have been brought into this extended discussion? The answer is that all of them have (atmosphere (CO_2 in the atmosphere), hydrosphere (soil water, seawater), lithosphere (water from the soil) and biosphere (human activities producing CO_2)).

3. Ask the pupils to look at the label on a bottle of shop-bought spring water, and discuss how the chemicals in the water got there.
4. Try the 'From rain to spring- water from the ground' activity on the Earthlearningidea website http:// [www.earthlearningidea.com/English /Resources_and_Environment](http://www.earthlearningidea.com/English/Resources_and_Environment).

Underlying principles:

- The pH of liquids can be found using Universal indicator.
- As it flows through soil and bedrock, the pH of groundwater changes in response to biological processes (eg. respiration and decay) and chemical processes (reaction with the rock and soil).
- The pH of seawater is buffered by a wide range of reversible reactions, which allow it to absorb a lot of CO_2 without becoming acid.

Thinking skill development:

Pupils **construct** a picture of how the pH of water is likely to change at different stages of the underground rock cycle; **cognitive conflict** comes each time they are asked to make a prediction, and particularly when their predictions are wrong, as is often the case with sea water; if handled carefully the discussion can involve pupils in **metacognition**; the **bridging** element is the link between the discussion and the 'real world', such as in when spring water is tested.

Resource list:

- tap water (from a tap or in a bottle) or rainwater
- Universal indicator solution (*health and safety information: wear eye protection; flammable; do not swallow)*
- eye protection
- drinking glass or wine glass
- a drinking straw
- a bottle of spring water
- Optional, for follow up activity 1: some powdered chalk (enough to cover a small fingernail)
- Optional, for follow up activity 2: a bottle of sea water and a teaspoonful of salt (NaCl)

Useful links:
See the interactive water game at: http://www.scottishwater.co.uk/education/html/aboutWater/aboutWater7.html

Source: Originally published by Chris King as 'The watery world of underground chemistry' in King, C. (2009) 'Bring and Share' ideas from the post-16 day at the ESTA Conference, Liverpool, 2008. *Teaching Earth Sciences*, 34.1, 43-56.