Earth science out-of-doors workshop

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

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 out-of-doors: preserving the evidence
What evidence of the present times might we find in a million years from now?

Take the class outside, to an area with some bare soil exposed, and perhaps some grass. Sitting beneath a large tree in the shade could make for an ideal setting – as well as being comfortable if it is hot!

Explain that we are going to look around us at familiar surroundings, but that we will think about what evidence of the present day might possibly become preserved in the geological record. Lead into the discussion by asking,

- "What is happening around us today, or has happened in the last few hours?" Ask the class to suggest at least six processes that they can tell are going on (*for example, the sun might be shining*).
- Then ask, "What is the evidence for these processes taking place?" (*e.g. I can feel the sun's heat, the ground has become dry and cracked*).
- Ask, "Which of these pieces of evidence might be preserved if this area became buried under more and more sediment?" (*e.g. mudcracks formed when the ground dried out may become buried*).
- Then ask, "Which of these pieces of evidence might still be preserved after millions of years?" (*e.g. mudcracks millions of years old can be found in the rock record).*
- Ask, "Using the evidence preserved in the rocks, what would you be able to say about the area in which the sediment was laid down; i.e. what was the environment like?"
- Explain that, in each of these stages, some of the evidence is lost, but some evidence is likely to be preserved.
- Finally, explain that this thinking sequence is the opposite of the way a geologist normally thinks. Get out a sedimentary rock with some key feature like mudcracks to show how geologists think. The mudcracks are millions of years old, they were buried by sediment, they provide evidence of warmth when the rock was being laid down, so it is likely that the sun was shining then as well. Similarly a dinosaur footprint shows not only that dinosaurs lived there in the past, but that the area was land, there was probably vegetation around for food or food for other animals being eaten) so the sun must have shone to cause photosynthesis for the plants to grow and it must have rained to give water, etc. We can build whole pictures of the past from small pieces of evidence.

A suitable setting for thinking about the environment (*Photo: Adam Slade, www.ituna.net*)

Sun-dried cracks in mud (*Photo: P. Kennett*)

Mudcracks in an ancient sedimentary rock (*Photo: P. Kennett*)

The back up

Title: Earth science out-of-doors: preserving the evidence

Subtitle: What evidence of the present times might we find in a million years from now?

Topic: A contemplative exercise, asking pupils to sit outdoors and to state what processes are going on around them; how they know; and what evidence of those processes might be preserved in the rocks of the future.

Age range of pupils: 10 -18 years

Time needed to complete activity: 15 minutes

Pupil learning outcomes: Pupils can:

- observe what processes are going on around them;
- state which of their senses have enabled them to observe these processes;
- use their experience of current conditions to predict what evidence might be preserved in the future;
- realise that rocks may contain good evidence about ancient conditions at the time when they were formed.

Context:
Possible answers to the questions asked during the activity could include:

- "What is happening around us today, or has happened in the last few hours?" (*It could be hot, cold, (temperature changing), raining, dry (humidity changing), windy, calm, (atmospheric pressure changing), etc. Plants might be growing, or wilting; animals such as worms or dogs might be moving; it might have rained during the last few hours, etc.*
- "What is the evidence for these processes taking place?" *(Pupils can use their senses to feel the heat, cold, wet, wind: to see the sun, leaves blowing about, rain drops falling, to smell the rain landing on the earth, flower scent etc. to touch wet ground, leaves etc.*
- "Which of these pieces of evidence might be preserved if this area became buried under more and more sediment?" *(mudcracks, piles of wind-blown sand; ripple marks in water-washed sand in a gully; soil structure seen in profile; worm burrows, footprints of dogs or people in hardened mud etc.)*
- "Which of these pieces of evidence might still be preserved after millions of years?" *(most of the things above may still be preserved, but some may be lost)*
- "Using the evidence preserved in the rocks, what would you be able to say about the area in which the sediment was laid down; i.e. what was the environment like?" *(For most school situations, the evidence would indicate a land environment. Such environments, by their very nature, often leave scant evidence, but pupils may be aware of such features as dinosaur footprints, where the animal walked across a damp muddy area. If there is a lake, a river or a sea shore nearby, which can be safely used for this exercise, then there is a wider range of evidence that would be more likely to be preserved in the record of the rocks.*
- Several types of sediment, sedimentary structure or fossil can be used to build a picture of the past

Following up the activity: Use real specimens, (or photographs from the internet) of rocks displaying good sedimentary features and encourage pupils to interpret the environment at the time of their deposition.

Underlying principles:

- The usual geologist's approach is to use Lyell's principle that "the present is the key to the past". The current activity involves geological reasoning in reverse, i.e. trying to predict the future from the present. Concerns about global climate change have recently involved geologists trying to predict the future from the past.

Thinking skill development:

- There is a progressive loss of evidence as we go back in time (a pattern).
- Considering which things are likely to be preserved involves potential cognitive conflict.
- This activity demonstrates the thinking of a geologist in reverse (bridging).

Resource list:

- access to an open space where pupils can be comfortable for 15 minutes or so and can observe processes going on around them.

Useful links: Try the Earthlearningidea activities 'What was it like to be there – in the rocky world' (published 14th January 2008) and 'What was it like to be there – bringing a fossil to life' (published 11th August 2008)

Source: This activity is based upon one devised by Chris King of the Earthlearningidea team and issued under the same title by the Earth Science Education Unit, www.earthscienceeducation.com.

Earth science out-of-doors: preserving the evidence record sheet

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

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

What is happening?
What is happening now or has 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. …………………………………………………	…………………………………………………

What is the evidence?
What is the evidence that these things are happening now or have happened recently?

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

What might be preserved?
Which of these pieces of evidence might be preserved if this area became buried under more and more sediment?

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

What clues might be found?
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?

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

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.

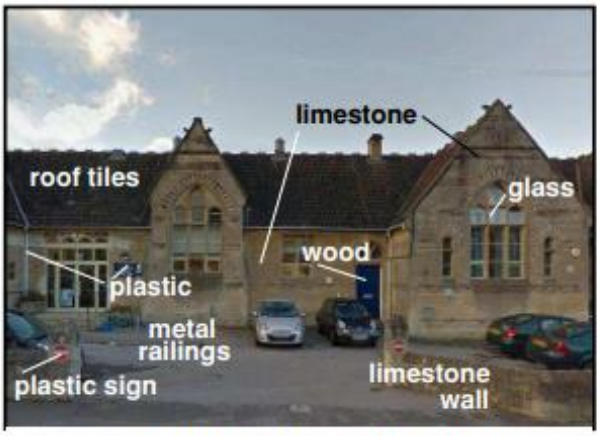
Provide the pupils with the key on page 3 and ask them to look at some of the natural materials more carefully. They should fill in Table 2. Even in a school where everything appears to be made of manufactured materials, it is often possible to find some examples of natural rocks.

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'.

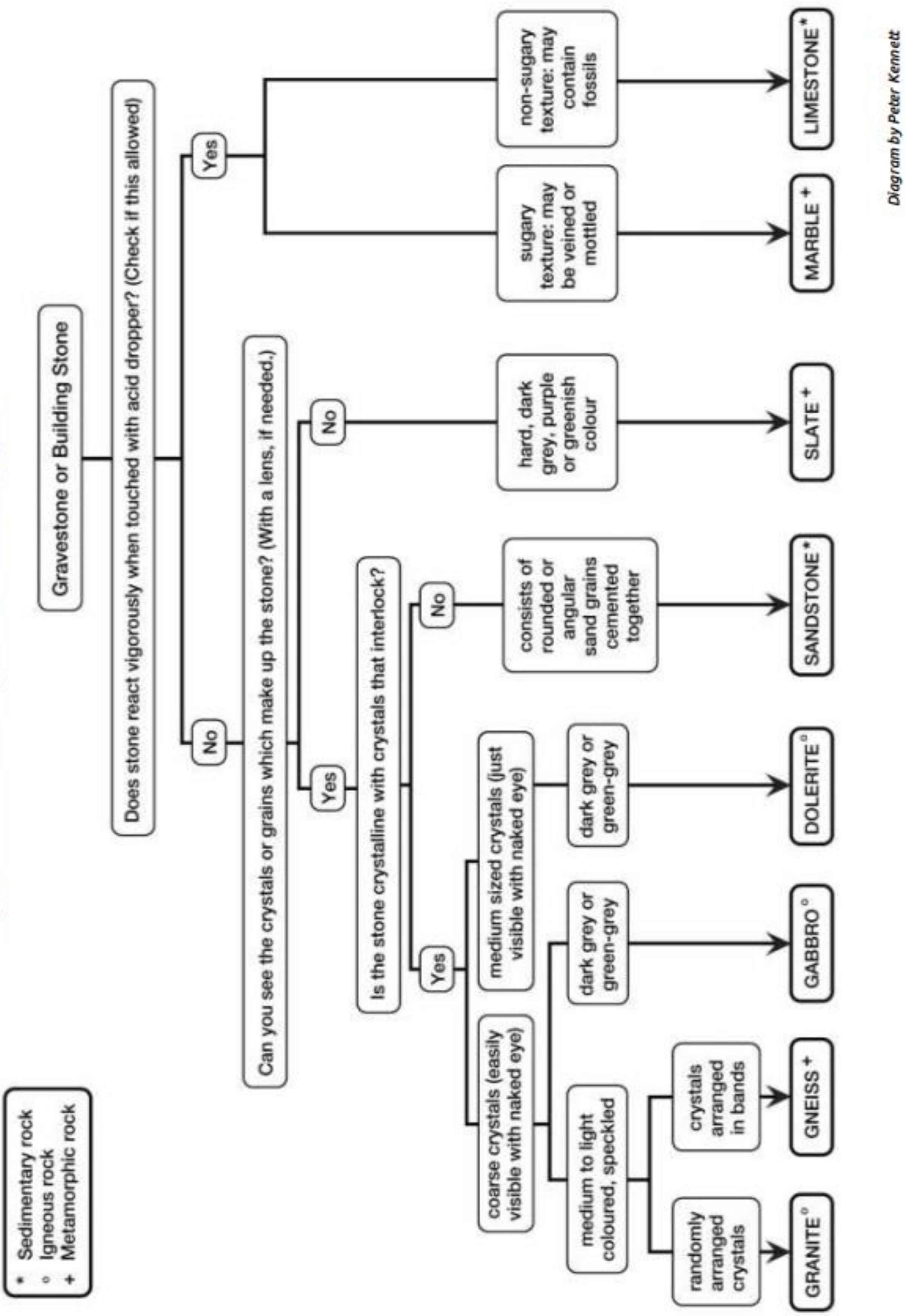
Underlying principles:
- In simple terms, sedimentary rocks are mainly non-crystalline and consist of fragments or grains compressed and cemented together. Metamorphic and igneous rocks are largely formed of interlocking crystals and so are impermeable. In igneous rocks the crystals usually show random 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



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

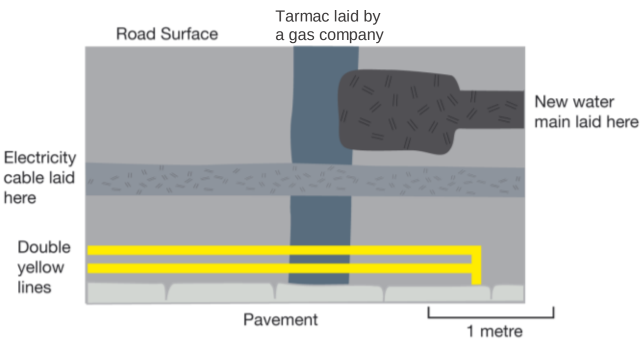
Principle or law?
Ask your pupils to complete the table below by writing if they think each sedimentary sequence statement is a 'Principle' or 'Law'.

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.

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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.

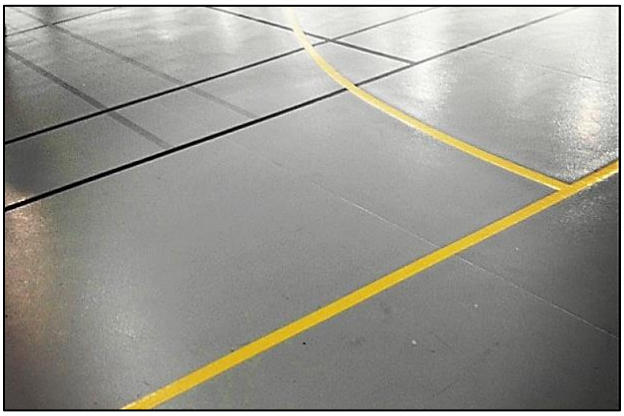
What is the tarmac sequence in the patched road below?

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

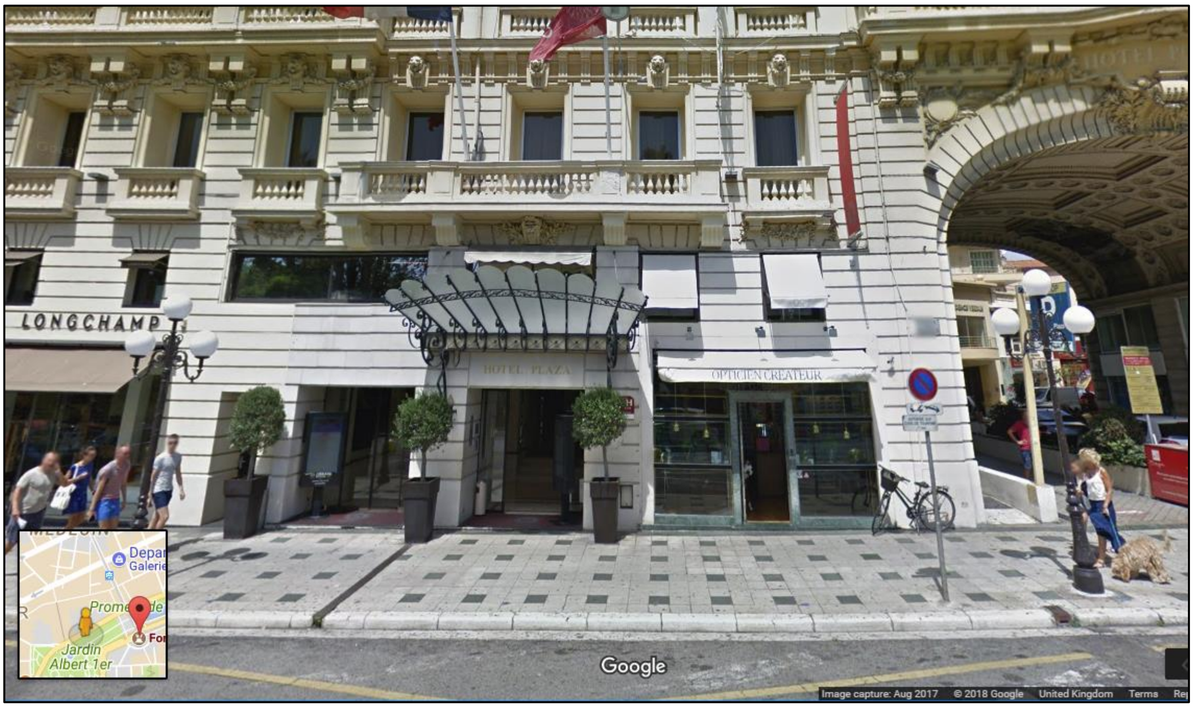
When you look at the stones used for buildings and in parks and cemeteries, there are key features to help you to work out the stories locked up in the rocks.

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).*

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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

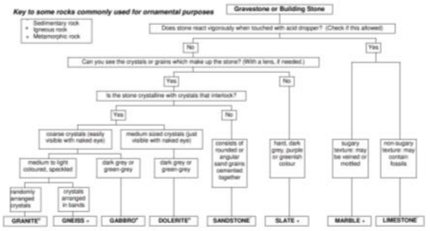
Time needed to complete activity: This depends on the building stone opportunities in the area.

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.

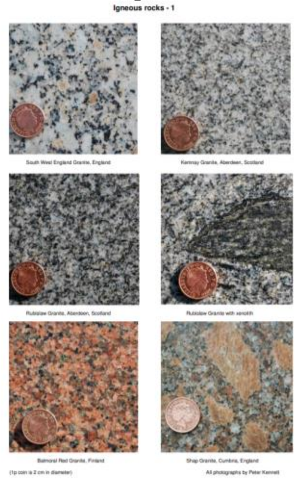
Context:
Pupils use sheets focussed on colours, lines and shapes to begin to tell the stories of the stones used in urban areas. This urban fieldwork helps them to see that, wherever stones are found or used, the features within them can be used to tell the stories of how they formed, and sometimes,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

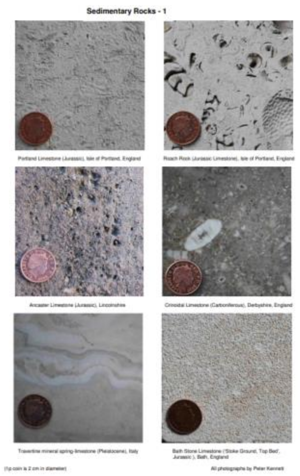
Building Stones 1– a resource for several Earthlearningidea activities: use a key to identify many different attractive-looking rocks



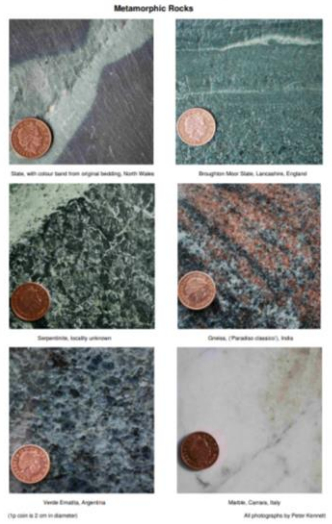
Building Stones 2 – Igneous rocks: What are the differences between igneous rocks commonly used as building stones?



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.

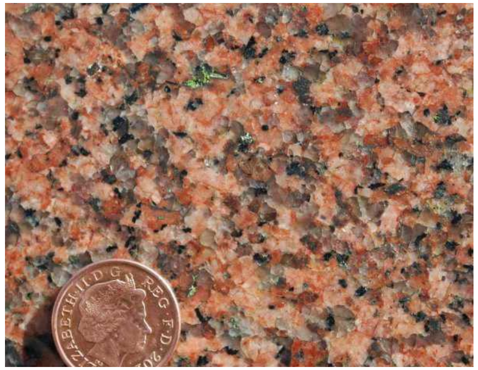
Resource list:

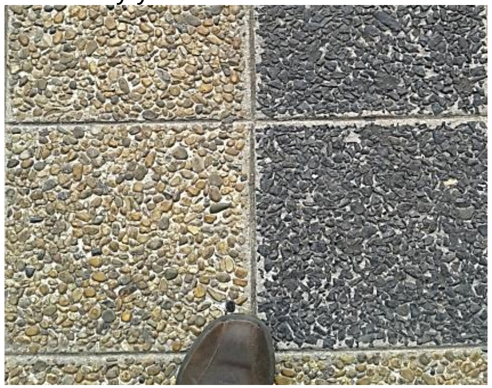
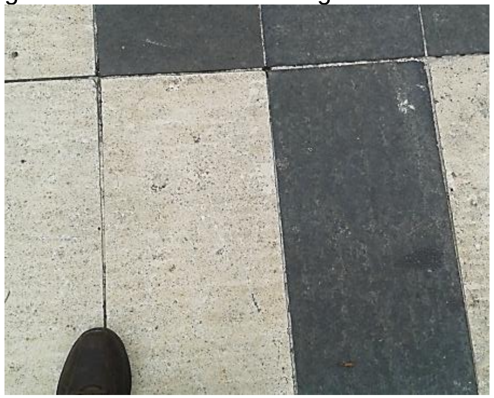
- the attached sheets, on colours, lines and shapes and the recording sheet

Useful links:
'Will my gravestone last?' from
http://www.earthlearningidea.com
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.

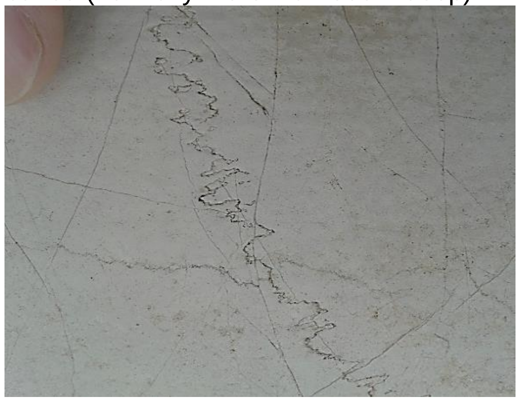
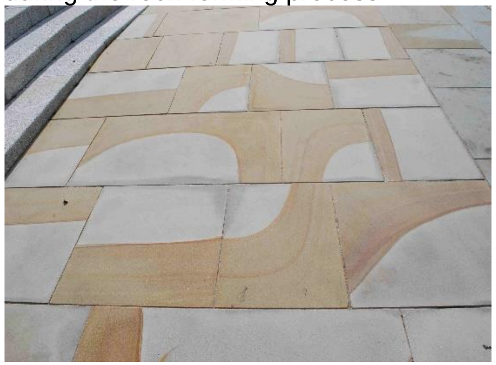
Colours

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).*

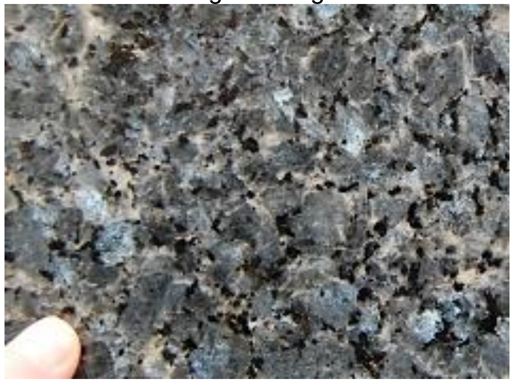
Yellowish-brown to dark brown	Mid grey	Dark grey	Greenish
Yellowish-brown to dark brown rocks contain oxidised iron; brown sedimentary rocks are laid down in many environments; weathering often brings iron to the outer surfaces, giving them rusty yellow colours.  Slabs surfaced by yellowish quartzite 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)*

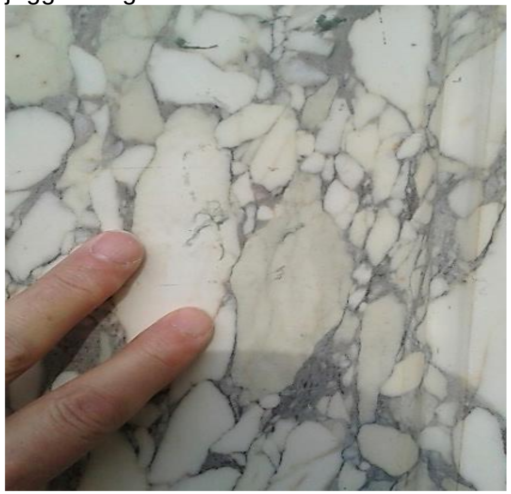
Lines (beware – some lines in building stones are the tool marks made during quarrying, and so tell us nothing about how the rock formed – careful observation is needed).

Bedding	Cross-bedding	Ripple marks
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.	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).*	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	Fractures	Fracture filled with minerals	Leisegang rings
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.	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).*	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.	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: