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

Give each small group of pupils copies of the two sheets of photographs of sedimentary rocks, including their labels (uncut). Point out that the photographs are all at natural scale (the 1p piece is 2 cm across). If you have any specimens of sedimentary rocks to display, they will greatly enhance the activity.
Also have available the photographs from the text of this activity, either on paper, or projected onto a screen.
Ask pupils to state, from the sheets of natural scale photographs:

- the evidence which shows that the rocks are of sedimentary origin and that they are not igneous or metamorphic in origin.
- which rocks contain evidence of having been formed under the sea?
- which rock formed where hot springs brought dissolved chemicals to the surface in the water?; as the water cooled, the chemicals crystallised out and were trapped by clumps of algae in curved, lumpy-looking structures.
- which of the sandstones show(s) evidence of ancient water currents moving the loose sand grains or ooids along before they became cemented together to form the rock? (You may wish to demonstrate this by stirring water in a washing up bowl over a bed of loose, washed sand – as seen in the "Sand ripples in a washbowl" Earthlearningidea in the Resource list).
- which of the rocks they would expect to weather more quickly if used as building stones in an industrial city.

Show pupils the photograph of Burbage Edge and ask them how they think sandstone blocks might be quarried from the natural outcrop.

Show pupils the photograph of Sheffield Town Hall. The original sandstone blocks were taken from a quarry and the newer stonework in the foreground, was taken from the same quarry a century later. Ask them what problems might occur in trying to match new building stones with older stonework.

A 'Millstone Grit' coarse sandstone outcrop, Burbage Edge, near Sheffield (Photo: *Peter Kennett*)

Sheffield Town Hall built in 1897, with new stonework in the foreground from 1999, using sandstone from the same quarry at Stoke Hall in Derbyshire.
(Photo: *Peter Kennett*)

Explain that most early gravestones were made of local sedimentary rocks but that most modern gravestones are made of imported rocks, usually igneous or metamorphic ones. Ask why this might be.

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The back up

Title: Building Stones 3 – Sedimentary rocks

Subtitle: How do the sedimentary rocks used for building stones differ?

Topic: A small group activity using photographs of sedimentary rocks used as building stones or for ornamental purposes. This activity follows 'Building Stones 1' and is intended for pupils to deepen their understanding of sedimentary rocks. A table showing how the series of Earthlearningidea building stone activities link together is given on the final page.

Age range of pupils: 12 – 18 years

Time needed to complete activity: 20 minutes for the classroom activity; much more for an outdoor visit to a town centre or a graveyard.

Pupil learning outcomes: Pupils can:

- learn the criteria by which sedimentary rocks are distinguished from one another;
- suggest the evidence which can be used to determine the environment of deposition of the rock;
- relate the composition of the rock to its reaction to the agencies of weathering;

- describe how sedimentary rocks are quarried and processed;
- understand why it is not always possible to match the stone used in older buildings when repair work is needed.

Context:
We have already introduced pupils to the range of rock types used as building or facing stones, or which are used in ornamental work, such as gravestones (See Earthlearningidea 'Building Stones 1 – a resource for several Earthlearningidea activities'). Now we are developing pupils' understanding of each of the three groups of rocks in turn, in this case, sedimentary rocks.

- What evidence shows that the rocks are of sedimentary origin? *They mostly appear to be composed of small grains cemented together, rather than crystals which interlock. Some contain fossils, whereas igneous rocks and most metamorphic rocks do not.*
- Which rocks show evidence of having been formed under the sea? *Portland Limestone, Crinoidal Limestone and Rudistid 'marble' all contain visible fossils of marine organisms. The Ancaster Limestone is also fossiliferous, although less obviously. In addition, the ooids (tiny spheres) in the Portland, Ancaster and Bath Limestones indicate a past shallow marine environment – like the Bahamas Bank today..*
- Which rock formed where hot springs brought chemicals to the surface in the water? *Travertine.*
- Which of the sandstones show(s) evidence of ancient water currents moving the loose sand grains or ooids along? *The Stanton Moor and St Bees Sandstones. The lines sloping from left to right show where river currents produced underwater dunes which migrated down the ancient river, moving from left to right. This 'current bedding' can also be seen in oolitic limestones, although not in the examples featured here. The 'Yorkstone' shows where moving water created ripples in the loose sand on the bed of the ancient river.*
- Which rocks would weather more quickly if used as building stones in an industrial city? *Any of the limestones. These consist largely of calcium carbonate, which is liable to react with acidic rain and to dissolve. Exhaust fumes from traffic and from the burning of fuels increases the proportion of naturally occurring acidic gases in the atmosphere.*
- How might sandstone blocks be quarried from the natural outcrop? *Show pupils the photograph of a block showing how it was separated from a larger rock mass. Explain that these holes were drilled by machine in the quarry. A set of plug and feathers (photograph) was then inserted into each hole and tapped in turn until the rock split evenly (a plug is a chisel, and feathers are half-cylinders of metal). The block was then transported to the works, where a diamond-tipped circular saw, 3m in diameter was used to saw the rock into slabs (photograph). Note that explosives are seldom used in building stone quarries, since this would fracture the rock.*

Drill holes in a block of sandstone, used in splitting the block from a larger mass, using 'plug and feathers' (The brown colour round the edges shows where weathering has oxidised the iron minerals in the rock).
(Johnsons Wellfield, Huddersfield. Photo: *Peter Kennett*)

Plug and feathers, Hardwick Hall, Derbyshire
(Photo: *Peter Kennett*)

A 3m diameter rock saw cutting sandstone into uniform slabs
(Johnsons Wellfield, Huddersfield. Photo: *Peter Kennett*)

- What problems might occur in trying to match older stonework today? *All too often, quarries which once supplied building stones have closed down, either because the accessible stone is exhausted, or because extraction proved uneconomic. Quarries are often in places of natural beauty, which are now* *conservation areas, with stringent rules about quarrying, which did not apply a century ago.*

- Why were many early gravestones made of local sedimentary rocks but most modern gravestones are made of imported rocks, usually igneous or metamorphic ones? *Before transport networks developed, only local rocks were available for gravestones and these were mostly sedimentary. Nowadays it is cheaper to import higher quality igneous and metamorphic rocks from overseas than it is to excavate local sedimentary rocks. Sedimentary rocks are easier to cut and inscribe, but do not resist weathering as well as the crystalline igneous and metamorphic rocks.*

Following up the activity:
If at all possible, follow the work in class with a visit to a nearby graveyard or town/ city centre. Give each group of pupils a set of the sedimentary rock sheets (with the rocks named) and ask them to match as many as they can.

Underlying principles:

- Sedimentary rocks are mainly non-crystalline and consist of fragments or grains cemented together.
- Rocks containing carbonate minerals, e.g. limestones, react with dilute hydrochloric acid.
- Sedimentary structures, such as cross bedding, can be used to indicate the strength and direction of a current which moved loose sand or ooids along a river bed or a sea floor at the time of deposition.
- Sedimentary rocks often contain fossils, which may be used to determine whether the sediment was laid down in the sea, in a river system, or on land.
- Geologists reserve the term marble for limestones which have been metamorphosed. However, in the building trade, some limestones that can take a polish are referred to as being 'marble'.

Thinking skill development:

- Pupils look for patterns within rocks to enable them to identify them.
- Working out of doors provides a good opportunity to make a bridge with normal classroom studies.

Resource list:
a) In class

- Per small group of pupils: one copy of each of the uncut sheets of photographs of sedimentary rocks

b) In a town centre or graveyard

- Per small group of pupils – a complete set of uncut sheets of photographs, with captions

Useful links: "Will my gravestone last?" "What was it like to be there – in the rocky world?" "Sand ripples in a washbowl" and Environmental detective' all from
http://www.earthlearningidea.com
http://geoscenic.bgs.ac.uk/asset-bank/action/viewAsset?id=344745&index=96&total=110&view=viewSearchItem

Source: Devised by Peter Kennett of the Earthlearningidea team, inspired by the enthusiasm of Eric Robinson and the set of sixteen postcards of Building Stones produced by Fred Broadhurst, Richard Porter and Paul Selden for the University of Manchester, and obtainable from Manchester Museum.

Sedimentary Rocks - 1

Portland Limestone (Jurassic), Isle of Portland, England

Roach Rock (Jurassic Limestone), Isle of Portland, England

Ancaster Limestone (Jurassic), Lincolnshire

Crinoidal Limestone (Carboniferous), Derbyshire, England

Travertine mineral spring-limestone (Pleistocene), Italy

Bath Stone Limestone ('Stoke Ground, Top Bed', Jurassic), Bath, England

(1p coin is 2 cm in diameter)

All photographs by Peter Kennett

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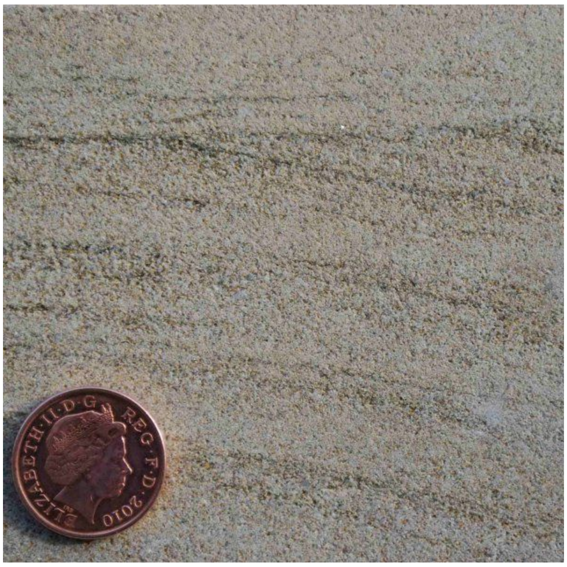
Sedimentary Rocks - 2



Cross-bedded sandstone (Carboniferous),
Stanton Moor, Derbyshire, England

"Rockingstone", shot sawn sandstone, (Carboniferous),
Huddersfield, England

St Bees Sandstone (Triassic), Cumbria, England

'Millstone Grit' sandstone (Carboniferous), Derbyshire, England

'Yorkstone', (Carboniferous), West Yorkshire, England

Rudistid limestone (Cretaceous), probably Portugal

(1p coin is 2 cm in diameter)

All photographs by Peter Kennett

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Sedimentary Rocks – 1

Portland Limestone, Isle of Portland, England (Sheffield City Library, 2012)
Portland Stone was popularised by Sir Christopher Wren, when he used it in the rebuilding of St Paul's Cathedral after the Great Fire of London in 1666, and it now features in many public buildings throughout the U.K. Examination under a hand lens shows that it is often composed of spherical ooids of calcium carbonate, 1mm or so in diameter. These were produced by the action of algae on a warm sea floor, and subjected to the action of currents, during the Jurassic Period (200-146 Ma). Shelly fossils of oysters resist weathering rather better than the bulk of the limestone and the extent to which they stand proud of the surface allows an estimate of weathering rates to be made when the age of the building is known, e.g. by using a tyre depth gauge.

Roach Rock, Isle of Portland, England (The Economist building, St James' Street, London, 2012)
The Roach Rock is part of the Portland Stone as described above, except for the remarkable preservation of the fossil gastropods and bivalves. (The gastropods are the 'screw stones' occupying most of the field of view: the 'dimpled' shape in the right hand corner is a bivalve, of *Trigonia* type). The fossils are preserved as moulds, formed where the actual animal shells pressed into the limey mud of the sea floor at the time. Later, the shells dissolved and the space was not taken up by other minerals, as usually happens. The gaps left in the stone make weathering more likely, but this example has been in place since the 1960s without any obvious sign of deterioration.

Ancaster Limestone, Lincolnshire, England (Seat in Fargate, Sheffield, 2012)
The Jurassic limestone belt which crosses England from the Dorset Coast to Yorkshire contains many different building stones, many of them oolitic, like the Portland Stone. The public seat comprises white, blue-grey and reddish Ancaster Limestone sections, which respond differently to weathering, and already after only 13 years, this reddish variety is looking rather degraded.

Crinoidal Limestone (Carboniferous), Derbyshire, England (Portion of a work surface, 2012)
In this example of a limestone of Carboniferous age, virtually all the rock is composed of the debris produced by the break up of countless crinoids. These crinoids were animals, related to sea urchins, although they grew from the sea floor on a 'stalk'. In Derbyshire, it is mainly the 'stalks' and 'arms' which become preserved, and the body chamber of the animal is very rarely seen – presumably they were destroyed by the violence of water currents at the time. This specimen comes from Once-a-Week Quarry near Sheldon.

Travertine (Pleistocene), Italy (Front of a former McDonalds café, Pinstone Street, Sheffield, 2012)
Travertine is produced where hot springs bring mineralising fluids to the surface, which precipitate out as they cool. This often happens in association with algae and other plants, resulting in the layers and curved surfaces seen in the photograph. Elsewhere in the same shop front, fragments of newly formed rock had broken off by shrinkage of local movement and had then been incorporated in the deposit as it continued to form. Many McDonalds' outlets use travertine as their facing stone.

Bath Stone Limestone ('Stoke Ground, Top Bed'), Bath, England (A sample slab provided by the Bath Stone Group, 2012)
This limestone from Bath is of Middle Jurassic age (176-161 Ma) and is another oolitic limestone (See Portland Limestone above). The photograph shows its even texture and lack of fractures, which make it an excellent freestone (a type of rock which can be cut to shape in any direction). In this example, most of the ooids on the surface have weathered out, leaving tiny holes. Bath Stone is often more brown in hue than this sample, and is associated with old 'mellow' looking buildings. It is still worked at Limpley Stoke near Bath, Avon and at Box in Wiltshire.

Sedimentary Rocks - 2

Cross-bedded sandstone (Carboniferous), Stanton Moor, Derbyshire, England (Crucible Corner, Sheffield, 2012)
This Carboniferous (359-299 Ma) sandstone has similar composition to the gritstone described below, but is of finer grain size. This sample shows cross bedding, produced by currents in an ancient river moving the sand grains along its bed and forming them into underwater dunes. The cross beds slope to the right, indicating an ancient current flowing from the left. Near the top of the photograph, the horizontal plane indicates where the water velocity increased enough to erode the top of the underlying dune, before more sand was deposited. The sharp junction indicates that this specimen is the right way up.

"Rockingstone", shot-sawn sandstone, (Carboniferous), Huddersfield, England (Peace Gardens, Sheffield, 2012)
The iron oxides present in the natural cement of this sandstone are clearly indicated by the rusty brown colour of the rock. In order to make a rough non-slip surface for paving a public area, the stone has been 'shot-sawn'. A series of steel blades, like a huge bread slicer, are drawn backwards and forwards across the block of stone, whilst steel shot is sprayed onto the block in a slurry of water.

St Bees Sandstone (Triassic), Cumbria, England (Shop front on St Paul's Parade, Sheffield, 2012)

Like the Stanton Moor sandstone, this Triassic (251-200 Ma) rock is also cross bedded and the gently curving layers indicate that it has been placed the right way up in the building (although nearby blocks are upside down!). The deep red colour (enhanced by spraying with a little water) suggests that the conditions at the time of its formation were rather arid, and it was probably deposited in an ephemeral river, such as occurs after heavy rainfall in desert regions. This is one line of evidence to show that the British Isles were at one time in desert latitudes, 20^{o} to 30^{o} from the Equator.

'Millstone Grit' coarse sandstone (Carboniferous), Derbyshire, England (Sheffield Cathedral, 2012)
The photograph shows part of a new block of gritstone, used to replace badly weathered stone on the south wall of the Cathedral. The vertical lines are mason's tool marks. It probably comes from Stancliffe Quarries in Derbyshire. A gritstone is a very coarse sandstone, with angular grains of quartz and feldspar, cemented together with a largely iron oxide cement. This example shows sub-rounded granules of pink feldspar and grey quartz. Millstones made from it were formerly used for grinding grain.

'Yorkstone', flaggy sandstone (Carboniferous), West Yorkshire, England. (This flagstone was being laid as part of the pavement outside the Geological Society, Piccadilly, London on 3rd May 2012!)
West Yorkshire is noted as a supplier of flagstones to England's major cities. The trade name 'Yorkstone' does not imply that it came from the city of York itself. The surface in the photograph has been sawn, not riven with a chisel, as it would have been in former times. It displays faint grey swirling marks, which show where underwater ripples were formed in the ancient river currents at the time when the sand was being deposited. The brown section on the left of the photograph shows where weathering by oxidation has occurred. Although the edge of the slab has been trimmed, there was probably a natural joint nearby, which allowed to passage of oxygenated water through the rock.

Rudistid limestone (Cretaceous), probably Portugal, (Café front, formerly Norwich Union building, St James' Street, London, 2012)
Although loosely called 'marble', because it takes a polish, this rock is actually a limestone, with well preserved fossils, set in a reddish lime mud. The fossils are strange, thick shelled bivalves known as rudistids, which are typical of the Cretaceous deposits of the ancient Tethys Ocean. They are common in southern Europe, but are not found further north. This example was probably quarried in Portugal.

Footnote:
The natural scale photographs of building stones were taken using a Nikon D60 digital SLR camera, with the lens on the 55mm zoom setting. The front of the lens was kept at a standard 23cm from rock surface, using a short stick cut to length. The 1p coin is 2 cm in diameter.

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The following chart shows the relationship between each of the activities on the theme of building stones. Each activity can be taken as a free-standing entity, since photographs and details of rocks are repeated. However, it is hoped that pupils will deepen their understanding of the topic and their enthusiasm for looking at the built environment around them by following all the activities in sequence, if this is appropriate to their local setting. The photographs were mostly taken using local opportunities in the U.K., but many of the building stones have come from across the world.

Title of activity	Topic	Resources provided	Indoor activity	Outdoor activity
Building Stones 1 - a resource for several Earthlearningidea activities. ("BS1")	Identification of building stones from each of the three groups of rocks.	Six sheets of photographs of building stones at natural scale, to be cut into separate photographs; Descriptions of all the stones; Key to the identification of building stones.	Identifying all the stones from the photographs, using the key; Competitive approach; opportunity for playing games with the photos.	Identifying building stones from the complete sheets of photographs, in a graveyard or town/city centre.
Building Stones 2 – igneous rocks	Using the photographs of igneous rocks to investigate their features in more detail and to comment on the conditions under which some of the rocks were formed.	Three sheets of igneous rocks, (taken from the whole set in BS1); Photographs of igneous rocks in use in a city centre; Descriptions of igneous rocks, as in BS1; A simple classification chart for the igneous rocks featured in the activity.	Grouping the photographs according to a) grain size; b) colour (and hence mineral content); Assessing the value of igneous rocks for ornamental or functional purposes.	Identifying building stones of igneous origin, from the sheets of photographs, in a graveyard or town/city centre; Explaining detailed features seen in igneous rocks used in buildings.
Building Stones 3 – sedimentary rocks	Using the photographs of sedimentary rocks to investigate their features in more detail and to comment on the conditions under which some of the rocks were formed.	Two sheets of sedimentary rocks, (taken from the whole set in BS1) Photographs of sedimentary rocks at outcrop, in use in a city centre and being processed for use as building stones; Descriptions of sedimentary rocks, as in BS1.	Relating the sedimentary rocks to their environments of deposition; Discussing their relative merits in resisting weathering; Showing how sedimentary rocks are cut for use, and why matching stones used in older buildings may be difficult.	Identifying building stones of sedimentary origin, from the sheets of photographs, in a graveyard or town/city centre; Explaining detailed features seen in sedimentary rocks used in buildings.
Building Stones 4 – metamorphic rocks	Using the photographs of metamorphic rocks to investigate their features in more detail and to comment on the conditions under which some of the rocks were formed.	One sheet of metamorphic rocks, (taken from the whole set in BS1) Photographs of metamorphic rocks at outcrop and in use in a city centre; Descriptions of metamorphic rocks, as in BS1.	Using evidence from photographs at natural scale and of metamorphic rocks outdoors to decide how they were formed and the factors affecting their use.	Identifying building stones of metamorphic origin, from the sheets of photographs, in a graveyard or town/city centre; Explaining detailed features seen in metamorphic rocks used in buildings.
Will my gravestone last?	Using a local opportunity to enable pupils to see a wide range of rock types and to investigate different scientific hypotheses.	An outline of how to conduct a graveyard survey, including suggested preparation and follow up activities; a plotting chart for pupils' observations; Hypotheses which might be tested are suggested. The sheets from Building Stones 1 should be used for this activity.	Preparing for the graveyard visit, by revising pupils' knowledge of sedimentary, igneous and metamorphic rocks. Following up the visit by assessing the validity of hypotheses about weathering rates etc and plotting graphs of data gathered during the visit.	Identifying ornamental stones from the complete sheets of photographs in a graveyard; Testing hypotheses regarding the rates of weathering of different rock types and the choice of different rock types over time.