

Building Stones 2 – Igneous rocks

What are the differences between igneous rocks commonly used as building stones?

Give each small group of pupils a set of the photographs of igneous rocks, printed onto card and trimmed to remove the names. Point out that the photographs are all at natural scale (the 1p coin is 2 cm across). If you have any samples of real igneous rocks to display, they will greatly enhance the activity.

Ask pupils to:

- state the evidence which shows that the rocks are of igneous origin (cooled from a melt) and that they are not sedimentary or metamorphic.
- estimate the average grain size (size of the crystals) in each rock, write it on a small piece of paper and place this on each photograph. (Two rocks - Shap Granite and 'Baltic Brown' Granite - contain some crystals which are much larger than the average, which can be ignored for now).
- place the cards on the table in order of increasing grain size.
- make statement cards like the ones below and put the building stone cards next to them, in the right places.

These rocks cooled and solidified from a melt very slowly.

These rocks cooled and solidified from a melt more quickly.

- explain how they think the Shap Granite and 'Baltic Brown' Granite came to have some abnormally large feldspar crystals in them.
- remove the cards containing pink crystals (which can be misleading) and place the remaining cards on the table in order from pale to dark.
- make statement cards like the ones below and put the building stone cards next to them, in the right places.

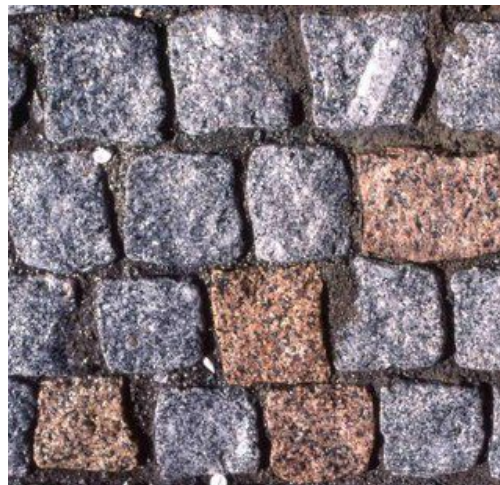
These pale-coloured igneous rocks contain a lot of silicon and not much iron and magnesium.

These dark-coloured igneous rocks contain a lot of iron and magnesium and not much silicon.

- if they had to choose a gravestone made of igneous rock for themselves, which rock would they choose, and why?

Show pupils the three photographs of building stones in use in a city centre. Ask them:

- why igneous rocks are often used as setts to make roads and pavements in areas of heavy wear in town/city centres (Photo 1).
- why igneous rocks are often used as a plinth at the base of an office front, even when the rest of the frontage is made of sedimentary rock (Photo 2).



1. Granite setts, using Portuguese granites (Sheffield)



2. Facing stones made of grey granite and sandstone, Halifax Bank, Sheffield. (Photos: Peter Kennett)

The back up

Title: Building Stones 2 – Igneous rocks

Subtitle: What are the differences between igneous rocks commonly used as building stones?

Topic: A small group activity using photographs of igneous rocks used for ornamental purposes. This activity follows 'Building Stones 1' and is intended for pupils to deepen their understanding of igneous 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 igneous rocks are distinguished from one another;
- judge the best rock to use for a given situation;
- express an opinion about the aesthetic value of different rocks.

Context:

We have already introduced pupils to the range of rock types used to enhance buildings 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.

Possible responses to the questions posed to pupils are:

- State what evidence shows that the rocks are of igneous origin – *they all appear to be crystalline, with an interlocking texture and a random arrangement of crystals.*
- Estimate the average grain size of each rock – *See chart below.*
- Make statement cards and put the building stone cards in the right places near them: slow cooling; quicker cooling. *The coarse-grained rocks cooled slowly, deep underground in major intrusions. The medium-grained rocks cooled more quickly, in minor intrusions such as dykes and sills and the fine grained basalt in a lava flow which cooled the quickest of all (eg in days).*
- Why do Shap Granite and 'Baltic Brown' Granite have some abnormally large crystals in them? – *The simplest explanation is that the large crystals formed first in the molten magma, and were free to develop good crystal shapes. The rest of the magma then solidified at a slightly faster rate, producing the more uniform coarse ground mass. In the Baltic Brown Granite, the early formed feldspars were 'eroded' within the magma and so have become rounded.*
- Ranking the cards in order from pale to dark (You have removed the cards containing pink crystals because the change in colour is more difficult to see when the rocks containing them are included - feldspar is normally a pale silicon-rich mineral, but trace amounts of iron change it to a darker pink colour).
- Make statement cards and put the building stone cards in the right places near them: pale silicon-rich; dark iron/magnesium-rich. *See chart below.*
- Choice of gravestone – *a personal decision! Gabbro and dolerite could be expected to weather rather more rapidly than the granites, but in practice old graves of granite, dolerite or gabbro show very little difference in weathering rates.*
- Igneous rocks are often used as setts in areas of heavy wear, *because they withstand both weathering and erosion better than most sedimentary rocks, or even concrete.*
- Igneous rocks are often used as a plinth at the base of an office front - *for the same reason. The bases of buildings are more exposed to rising damp, splash from heavy rain and the effects of salt in icy weather than areas higher up the buildings. This is well seen in the photo of the Halifax Bank, where the grey granite has*

remained in good condition, compared with the crumbling sandstone pillar, (if it has been there for the same length of time).

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 igneous rock sheets (with the rocks named) and ask them to match as many as they can.

Underlying principles:

- Igneous rocks were formed by crystallisation from molten rock known as magma, as it rose from deeper, hotter parts of the Earth's crust, or from the Earth's mantle.
- The arrangement of the crystals in most igneous rocks is random (although some may exhibit flow-banding, or may have had some alignment imposed on them by a later phase of Earth movements).
- Igneous rocks are classified on the basis of their grain size and their colour/ composition (which in turn reflects their mineral content).
- Rocks with a high proportion of silicon contain quartz and are referred to as *silicic*. Rocks which contain a higher proportion of iron and magnesium minerals are called *mafic*.
- Silicic rocks are usually pale-coloured; mafic rocks are usually darker.
- Feldspar minerals are abundant in most igneous rocks and show a wide range of colours, depending on small amounts of trace elements, particularly iron.
- The chart on page 3 provides a simple classification of igneous rocks and shows where each of our examples fits:

Colour	Pale	Intermediate	Dark	Very dark
Colour/ composition	Silicic (silicon-rich)	Intermediate	Mafic (iron/magnesium-rich)	Ultramafic (very iron/magnesium-rich) – none included in this selection of building stones
Grain size				
Fine (crystals too small to see, even with a lens) – none included in this selection of building stones			Basalt	
Medium (crystals visible, but need a lens to identify them)	Alentejo Granite		Dolerite	
Coarse (crystals easily seen with naked eye)	SW England Granite Kemnay Granite Rubislaw Granite	Larvikite – Emerald Pearl Larvikite- Blue Pearl	Gabbro	
	Pale with pink feldspar			
	Balmoral Red Granite Shap Granite Ross of Mull Granite Imperial Mahogany Granite Rose Swede Granite Peterhead Granite Rosa Porrino Granite 'Baltic Brown' Granite			

Classification of igneous rocks, based on grain size and colour/composition (only the rocks used in this activity are shown here).

Thinking skill development:

- Pupils look for patterns within rocks to enable them to construct a simple classification system.
- 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.

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?' from <http://www.earthlearningidea.com>
<http://geoscenic.bgs.ac.uk/asset-bank/action/viewAsset?id=344745&index=96&total=110&view=viewSearchItem>

Resource list:

a) In class

- For the teacher's reference: one copy of each of the sheets of photographs of igneous rocks and their descriptions
- Per small group of pupils – a complete set of photographs of the rocks at natural scale, printed onto card and cut into separate pictures, without any captions.
- a school ruler

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.

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Building stone notes

(These brief notes are intended mainly for the teacher's use, and have been written in a more technical style than the rest of the text. The date is the year in which the photographs were taken).

Igneous rocks - 1

South West England Granite, England (Ecclesall Churchyard, Sheffield, 2012)

There are many large outcrops of granite of Variscan age (late-Palaeozoic, 380-280 Ma, million years old) in Devon and Cornwall, linked underground in a vast batholith. The specimen consists of white to buff-coloured feldspar, colourless quartz and dark ferromagnesian minerals, mostly biotite mica. The texture is slightly porphyritic i.e. some of the feldspars are larger than the average crystal size.

Kemnay Granite, Aberdeen, Scotland (Ecclesall Churchyard, Sheffield, 2012)

This granite is of Caledonian age (mid-Palaeozoic, 490-390 Ma). It is composed of quartz, feldspars and micas, in this case, mostly muscovite mica, which results in a pale grey colour, often with a hint of oatmeal colour. This rock has been used for the new Scottish Parliament building in Edinburgh.

Rubislaw Granite, Aberdeen, Scotland (Ecclesall Churchyard, Sheffield, 2012)

Rubislaw Granite is another Caledonian granite and is similar to the Kemnay Granite, except that a higher proportion of dark ferromagnesian minerals results in it being a darker grey colour. It usually exhibits some foliation (alignment of minerals), resulting from a later phase of Earth movements. The quarry from which it came is now a deep flooded hole, but it still retains the 'Blondin Wire' running across it, by means of which blocks of granite were lifted up from the quarry floor for cutting. It was very popular for gravestones in the Victorian period.

Rubislaw Granite with xenolith, Aberdeen, Scotland (Ecclesall Churchyard, Sheffield, 2012)

The dark inclusion within the granite is known as a xenolith (Greek for 'rock stranger'). It represents some older rock broken off by the granitic magma as it intruded. The molten magma heated the loose block of rock so much that it became highly metamorphosed.

Balmoral Red Granite, Finland (Ecclesall Churchyard, Sheffield, 2012)

This rock was given the name 'Balmoral Red' at a time when Queen Victoria had made the Highlands of Scotland very popular, even though its only connection with Scotland was that it was imported from Finland via Aberdeen! The deep red feldspar and clear quartz, of uniform texture, makes this a popular rock for ornamental work. It is still quarried in Finland for use in repairs, but a similar-looking granite is now obtained in large quantities from China, much more cheaply.

Shap Granite, Shap Fell, Cumbria, England (Sheffield Law Courts, 2012)

Shap Granite is of Caledonian age and is noted for its highly porphyritic texture, where large pink well-formed crystals of feldspar are set in a ground mass of clear quartz, pink feldspars and micas. Xenoliths (known as 'heathen' to the quarry staff) are common, although not shown here.

Igneous rocks - 2

Ross of Mull Granite, Scotland (Ecclesall Churchyard, Sheffield, 2012)

Another distinctive pink granite, again due to the colour of the orthoclase feldspars. The clear mineral (which can appear quite dark at times) is quartz and the greenish mineral is hornblende. It was quarried on the Isle of Mull, right next to the sea, which made transport by ship very easy.

Imperial Mahogany Granite, Red Hills, South Dakota, USA (Jessops shop front, Sheffield, 2012)

The attractive red-brown colour comes from the feldspars, and the pale blue is quartz. The dark minerals are ferromagnesian minerals. The presence of blue quartz in an igneous rock usually indicates that it has undergone some degree of metamorphism after it had cooled. This is borne out by the appearance of subtle banding in the rock when seen in bulk. It is of Precambrian age (i.e. more than 542 Ma).

Rose Swede Granite, Graverfors, Sweden (Ecclesall Churchyard, Sheffield, 2012)

Again, the feldspars give the striking red colour to this rock, and the unusually deep blue of the quartz crystals provides the clue to a later phase of metamorphism. This is a Caledonian granite.

Peterhead Granite, Peterhead, Scotland (Ecclesall Churchyard, Sheffield, 2012)

As ever, the pink colour comes from the feldspars, and the clear, greyish mineral is quartz. There are very few ferromagnesian minerals in this Caledonian age granite, although it frequently contains dark xenoliths of older rocks which became caught up in the rising magma. It is a very popular stone in city centre buildings and gravestones, although it is no longer quarried.

Rosa Porrino Granite, Spain (Pisani plc, Cromford, Derbyshire, 2012)

This granite is actively extracted today from quarries in Spain, near the border with Portugal, and is frequently seen in shop fronts, gravestones and kitchen work surfaces. The usual combination of pink

feldspars, clear quartz and dark ferromagnesian minerals make up the rock, with the feldspars tending to clump together somewhat.

'Baltic Brown' Granite, Finland (Bank front, Yorkshire Bank, Sheffield, 2012)

This Precambrian granite (i.e. more than 542 Ma) displays orbicular texture. The pink orthoclase feldspars have been made roughly spherical, probably by movement within the magma, and have then become coated with a greenish plagioclase feldspar as they cooled and the surrounding rock solidified. The dark minerals filling the spaces between the feldspars are ferromagnesian minerals. The rock is nicknamed the 'Scotch Egg Rock', from its resemblance to a British delicacy, a hard-boiled egg encased in sausage meat! The Finnish name is the Rapakivi Granite, and the rock is currently popular in work surfaces in the U.K.

Igneous Rocks - 3

Larvikite – Blue Pearl, Oslofjord, Norway (Shop front, Pinstone Street, Sheffield, 2012)

The only source in the world of Larvikite, both the Blue Pearl and the Emerald Pearl, is near the town of Larvik, on Oslofjord. However, huge quantities are shipped to India and China for processing and are then re-exported, which can cause confusion. Although related to granite, Larvikite has a smaller percentage of silica making up its minerals, so it is classed as an Intermediate igneous rock. (i.e. intermediate between silica-rich granites and iron/magnesium-rich gabbros). It consists mostly of feldspars and ferromagnesian minerals. The distinctive blue iridescent sheen comes from the feldspars and is called schillerisation.

Larvikite – Emerald Pearl, Oslofjord, Norway (Ecclesall Churchyard, Sheffield, 2012)

See the notes for the Blue Pearl, above. Both colours of Larvikite are popular for work surfaces. There is considerable variation in colour, in both Emerald Pearl and in Blue Pearl, depending on which parts of the quarries are being worked

Alentejo Granite, Portugal (Kerbstones in Sheffield City Centre, 2012)

The finer texture of this blue-grey granite means that it should correctly be called a microgranite, if not an intermediate igneous rock, to judge from the abundance of ferromagnesian minerals. It is now commonly used for kerbstones and rainwater channels at ground level.

Gabbro, 'Bon Accord', South Africa (Ecclesall Churchyard, Sheffield, 2012)

This is known as 'black granite' in the trade but it is not a granite at all, although it is of slow-cooled igneous origin. The silica content of the minerals is lower than in granite and so the main minerals are grey feldspar and dark ferromagnesian minerals. There is no quartz. This example probably comes from the Bushveld Complex, near Johannesburg and is of Precambrian age (i.e. more than 542 Ma). A wide range of 'black granites' is now imported from India and China for ornamental purposes, for gravestones and for work surfaces.

Dolerite, source unknown (Ecclesall Churchyard, Sheffield, 2012)

Dolerite is the medium-grained equivalent of gabbro, so the same comments apply as above. It is found in minor intrusions, such as dykes and sills, at no great depth below the Earth's surface, where it cooled more quickly than gabbro, resulting in smaller crystal sizes.

Basalt, Italy (Pisani plc, Cromford, Derbyshire, 2012)

Basalt is the fine grained equivalent of gabbro and dolerite, mostly formed when a magma of gabbroic composition reached the Earth's surface, and erupted to form basalt lava. The rapid cooling resulted in a much finer grain size than either gabbro or dolerite. The sample in the photograph has been cut smooth, but has not been polished.

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.

Thanks are due to the Managing Director of Pisani plc, Mr. Costas Sakellarios, and his colleagues, to Dr J.E. Robinson and to Mr. Ian Thomas of the National Stone Centre for their helpful advice.

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 UK, 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.

Igneous rocks - 1



South West England Granite, England



Kemnay Granite, Aberdeen, Scotland



Rubislaw Granite, Aberdeen, Scotland



Rubislaw Granite with xenolith



Balmoral Red Granite, Finland

(1p coin is 2 cm in diameter)



Shap Granite, Cumbria, England

All photographs by Peter Kennett

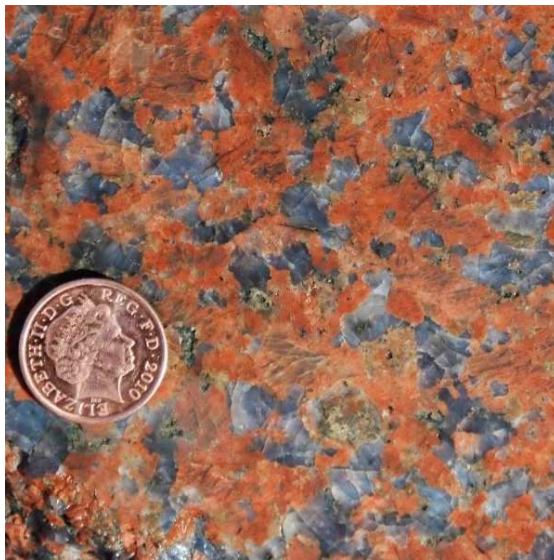
Igneous Rocks - 2



Ross of Mull Granite, Scotland



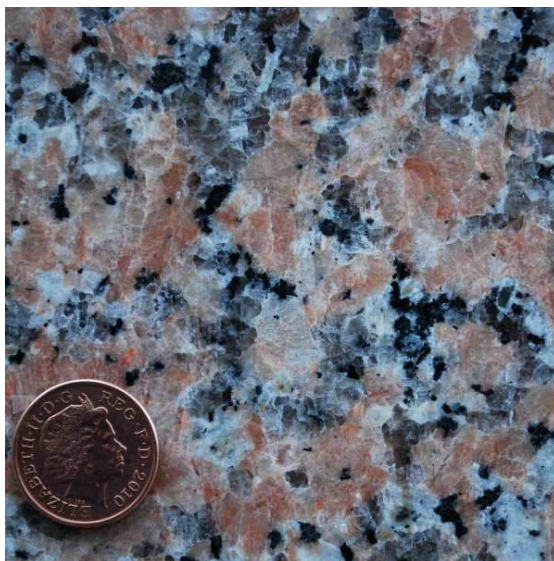
Imperial Mahogany Granite, South Dakota, U.S.A.



Rose Swede Granite, Sweden



Peterhead Granite, Peterhead, Scotland



Rosa Porrino Granite, Spain



'Baltic Brown' Granite, Finland

(1p coin is 2 cm in diameter)

All photographs by Peter Kennett

Igneous Rocks - 3



Larvikite – Blue Pearl, Oslo region, Norway



Larvikite – Emerald Pearl, Oslo region, Norway



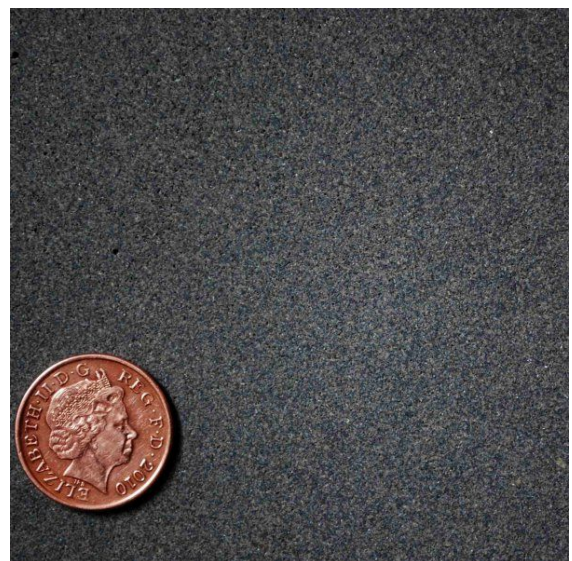
Alentejo Granite, Portugal



Gabbro, South Africa



Dolerite, source unknown



Basalt, Italy

(1p coin is 2 cm in diameter)

All photographs by Peter Kennett