Will my gravestone last?
Testing scientific ideas in a graveyard

Most old graveyards have gravestones with a wide range of rock types, which were set up at known dates – so give excellent opportunities for pupils to propose and test different scientific hypotheses, whilst examining different sorts of rocks.

Prepare for a class visit by:

- revising the main groups of rocks – sedimentary, metamorphic and igneous (prepared samples can often be obtained from a local gravestone-maker).
- checking with the graveyard administrators that a visit is in order, and that a funeral is not due to take place when you wish to visit.
- visiting the graveyard yourself in advance, to decide on the best parts to survey and to prepare a risk assessment; plan for an adequate adult to pupil ratio for the visit.
- writing to parents to explain the visit and obtain their written permission for it (being aware that there may have been a recent death in the family); pupils will need to bring suitable clothing and shoes.
- ensuring that you have available: survey sheets, like the one below, clipboards, pens/pencils and a compass (to work out gravestone-facing directions, or aspect)

The visit:
Begin by gathering the pupils near a good range of gravestones and briefing the class. Remind them of some 'do's and don'ts':

DO respect the feelings of any other visitors.
DO NOT clamber about on the graves.
DO NOT make a lot of noise.
DO NOT wander out of earshot or out of view.

Ensure that they can identify the main rock types – possibly using a key. These may often be divided into sedimentary rocks, e.g. sandstones: metamorphic rocks, e.g. marble, slate or gneiss: igneous rocks, e.g. granite, of various colours. The level of detail you provide will depend on the age, background and ability of the pupils.
Point out the main ways in which the gravestones have been weathered, including:

- the effects of plant roots, mosses and lichens;
- shattering of rocks by freeze/thaw action;
- chemical weathering, resulting in discolouration (e.g. oxidation), or 'spalling' (the flaking off of a whole surface layer of rock);
- reaction between the rock and rainfall, which is slightly acidic, resulting in the surface dissolving and being removed in solution.

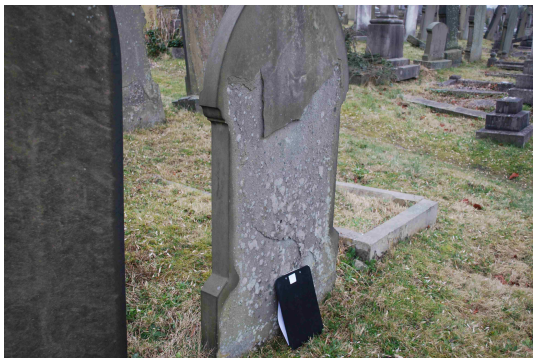
Ask pupils to set up different scientific ideas (hypotheses) which could be tested during their survey, e.g.

- sandstones weather more quickly than granites;
- west-facing sides of gravestones weather more quickly than east-facing ones;
- gravestones under trees weather more quickly than those in the open;
- the bases of gravestones weather faster than the upper parts, because they are damper longer;
- upright gravestones weather faster than those lying down;
- plant life (lichens and mosses) grows more quickly on calcium carbonate rocks (limestone or marble) than non-carbonate rocks (e.g. sandstone, granite);
- the rock types used for old gravestones differ from those chosen today:
- the variety of rock types chosen for gravestones increases with time;
- the age of gravestones increases with distance from the central graveyard building (church, chapel or monument);
- or any of their own ideas.

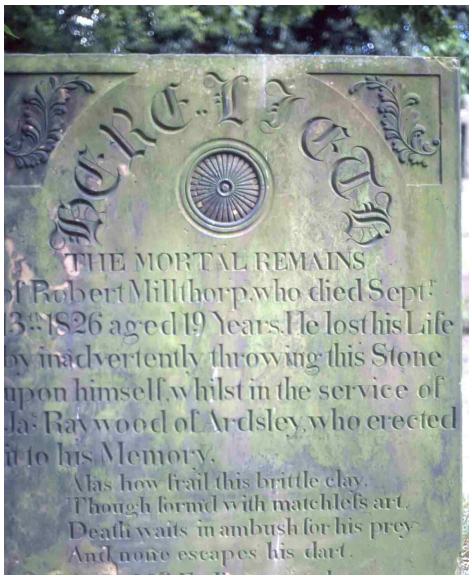
Then, allocate small groups of pupils to a row of graves per group and ask them to survey each grave and to record their findings on their sheets. Give them a time and place to meet when they have finished their survey and ensure each cluster of small groups is supervised by an adult. Afterwards, count heads and return safely to school!

Pupils studying gravestones closely (in a snow flurry!)

Red granite, used for the grave of a famous geologist in Sheffield, Ecclesall Churchyard, Sheffield

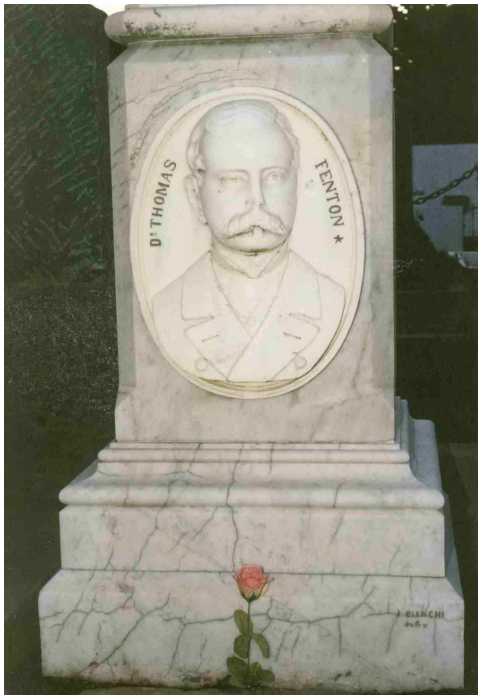


Spalling' of one side of a sandstone headstone (The other side was unaffected). Ecclesall Churchyard, Sheffield

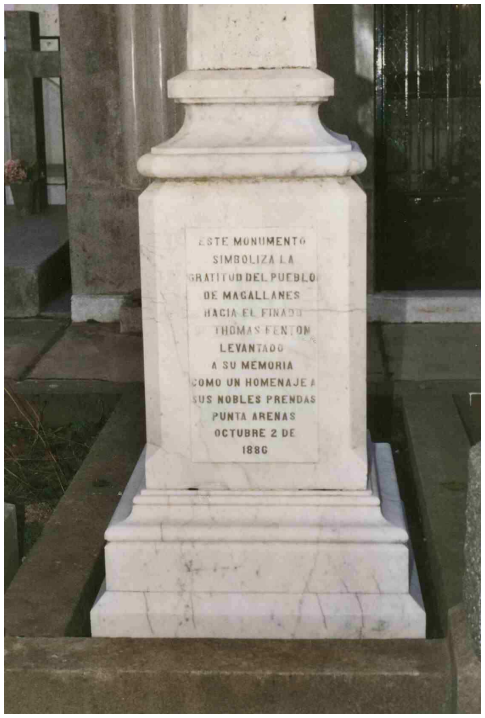


A sad safety warning from the 19th Century! Don't stand too close to a leaning grave slab! Darfield Churchyard, South Yorkshire

All photos: Peter Kennett



Marble gravestone in Punta Arenas, Chile. This east-facing side is in good condition.



On this west-facing side, the marble has been weathered by 2mm compared to the lead lettering.

The back up

Title: Will my gravestone last?

Subtitle: Testing scientific ideas in a graveyard

Topic: Using a local opportunity to enable pupils to see a wide range of rock types and to investigate different scientific hypotheses.

Age range of pupils: 8 – 80 years

Time needed to complete activity: About one hour in the graveyard, plus travel to the site, and preparation time in school.

Pupil learning outcomes: Pupils can:

- recognise a range of rock types under field conditions;
- set up hypotheses about rates of weathering and test them under field conditions;
- make careful observations and record them systematically;

- appreciate that it is not always possible to find the answers to hypotheses, especially under field conditions;
- learn how to work responsibly and as a member of a small team out of doors;
- appreciate how to approach respectfully a site of great significance to bereaved people;
- appreciate how people's choice of gravestones has changed over time and depending upon transportation facilities.

Context: Many different topics may be brought into play during this off-site visit. The scientific objectives are spelt out above, but pupils' own emotions may become involved, and can lead to questions of a spiritual nature, or to an awareness of high mortality rates in previous generations and wanting to investigate the reasons why.
Cultural sensitivities should be considered before taking children into a graveyard, e.g. some cultures do not like to touch gravestones, although the observations can usually be carried out without the need to do so.

Be sure to choose an old graveyard, as modern cemeteries may not have easily observable patterns and have many more modern burials and visitors.

Following up the activity: Pull together the class's findings and help them to establish any patterns. This may usefully be done briefly before leaving the cemetery. Later, pupils may be asked to plot out graphs of their observations. It is often found that the oldest graves are made from the local stone, with more exotic materials only appearing after the coming of good transport, such as railways or canals. The sources of the stones could be mapped.
Ask pupils to select the rock type they would choose for themselves if they wished the gravestone to be legible in 200 years time.
You can measure the rate of weathering of marble accurately because the lettering is first chiselled into these stones, and then lead is either poured in or hammered in to the etched letters. The whole surface is smoothed off before the stone is erected. So, a careful measurement of how much the surface of the lead lettering is raised today (since marble is weathered by naturally acid rain, while lead is not) set against the age of the gravestone will show how quickly the marble has weathered since erection.

Underlying principles: In simple terms, sedimentary rocks are mainly non-crystalline and consist of fragments 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 ones they are often aligned. (The crystals in marble are uniform, 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).
- Graves are usually set up within a year of death, so the date of death of the first person named is usually close to the date of the setting up of the stone. However, sometimes headstones are replaced or inscribed later, so care is needed in assigning a date.
- Weathering is the decay and disintegration of rock *in situ* at the Earth's surface, without the removal of solid rock fragments.
- Material carried away in solution is regarded as an aspect of weathering, rather than erosion.
- Weathering processes are often grouped into three:-
  physical weathering (e.g. the effects of freeze/thaw action; alternating heat and cold, or wetting and drying etc):
  chemical weathering (e.g. oxidation; the dissolving of soluble minerals like gypsum in rainwater; carbonation-solution of limestones by the action of natural acids derived from the atmosphere, from plants and from soil etc);
  biological weathering (e.g. the action of microbes, plants and animals, mostly allowing the other processes more access to the rock mass – so biological agents have physical and chemical effects).
- These weathering processes usually act together, and are only separated as a matter of convenience.

Thinking skill development:

- Setting up hypotheses to explain different degrees of weathering involves construction.
- Explaining why pupils' predictions are not always fulfilled involves cognitive conflict.
- Working out of doors provides a good opportunity to make a bridge with normal classroom studies.

Resource list:

- worksheets from Sheet 4, probably on a shared basis
- clipboards
- pencils
- a compass to find out the orientation of the graveyard
- a wash bottle of water
- tyre depth gauge, for measuring weathering of marble relative to the lead lettering
- (optional) a dropper bottle of very dilute hydrochloric acid (e.g. 0.5M) for staff use only.

Useful links: 'Will my gravestone last?' from http://www.esta-uk.net/jesei/index/htm and 'Weathering- rocks breaking up and breaking down', from www.earthlearningidea.com. See also the chart on page 5 showing the links between this activity and four other building stone activities.

Source: Devised by Peter Kennett of the Earthlearningidea team.

Will my gravestone last? – Survey Sheet

Survey of part of ..... graveyard Surveyor(s) ..... Date .....

Surname on grave	Date of death of **first** occupant	Type of stone eg • "Granite" (give colour) • Marble • Sandstone (coarse or fine) • Mixed stones (name types)	Weathering of stone, eg crumbling: split slabs: rough surface in place of polished: lead letters standing out from marble (not other stones).	Aspect (which face is east-facing, which face is most weathered? etc)	Is it under trees?	Vegetation growth on stone and its effects eg lichens, grass, brambles etc

Continue on another sheet, if necessary.

The following chart shows the relationship between each of the Earthlearningidea 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.