# Teaching the Dynamic Earth

## Earth Science Out of Doors

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Earth Science Out of Doors

an Earth science investigation on the school campus, or in a nearby quarry

Objectives: To show 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.

The National Science Curriculum (2000) Perspective

The session is aimed at the following National Science Curriculum statements:

Key Stage 3, Sc3 - 2. Geological changes

“Pupils should be taught:

d) how forces generated by expansion, contraction and the freezing of water can lead to the physical weathering of rocks;

e) about the formation of rocks by processes that take place over different timescales, and that the mode of formation determines their texture and the minerals they contain;

f) how igneous rocks are formed by the cooling of magma, sedimentary rocks by processes including the deposition of rock fragments or organic material, or as a result of evaporation, and metamorphic rocks by the action of heat and pressure on existing rocks;

Key Stage 3, Sc3 - 3. Acids and bases

“g) how acids in the environment can lead to corrosion of some metals and chemical weathering of rock [for example, limestone]”

Key Stage 4, Sc3 – 2. Changes to the Earth and atmosphere

Depending upon the local situation, the investigations can be focussed on KS4 requirements, e.g. “2r – how the sequence of, and evidence for, rock formation and deformation is obtained from the rock record.”

Key Stage 3, Sc1 – Scientific enquiry

The field study offers scope for developing many of the investigative skills involved in planning, obtaining & presenting evidence, considering evidence and in evaluating it.

Of particular relevance is:

2. Investigative skills

“Pupils should be taught to:

d) consider key factors that need to be taken into account when collecting evidence, and how evidence may be collected in contexts [for example, fieldwork, surveys] in which the variables cannot readily be controlled”.

Coverage of QCA Scheme of Work

Unit 8H The Rock Cycle; 8G Rocks and Weathering – Most of the ‘lessons’ in the QCA Schemes are applied to the outdoor situation in Earth Science Out of Doors. Aspects of Unit 9G Environmental Chemistry are also dealt with.
Earth Science Out-of-Doors: preserving the evidence

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Grid Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 add six more from the rest of the group.

<table>
<thead>
<tr>
<th>Six active processes</th>
<th>Six processes from the rest of the group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
</tr>
</tbody>
</table>

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?

|                                         |                                         |
|                                         |                                         |
|                                         |                                         |
|                                         |                                         |
|                                         |                                         |
|                                         |                                         |
Neighbourhood Stone Watch

1. School Spot
1.1 What different types of building material are used in constructing the School and school area? Are they natural or manufactured?

Draw a table like the one below in your book and complete it as you make your observations around the School.

<table>
<thead>
<tr>
<th>Type of material</th>
<th>Where I saw it being used</th>
<th>Natural or manufactured?</th>
<th>If manufactured, did the original raw material(s) come from the ground?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eg. glass</td>
<td>Lab. windows</td>
<td>Manufactured</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1.2 Look at some of the natural materials more carefully. For each of these, write down:
   a) where you saw it being used;
   b) what it is used for;
   c) what type of rock it is, as far as you can (use the key opposite to help you);
   d) what clues tell you which rock type it is;
   e) whether or not it is standing up to the weather well;
   f) do you think it is a good use for this stone? Do you like it?

2. Homeward Rock Spot
On your way home, 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, note down the answers to the six points, a) to f) above. Present your results neatly.

Survey your own school
Earth science out of doors

Sorting out sequences

The Stratigraphic Principles for Sedimentary Sequences – Principles or Laws?

**Superposition of Strata** – states that: ‘the layer on top is the youngest.’

Is this a **principle** or a **law**? Circle the correct answer – if it is a principle add an ‘… unless….’

**Cross-cutting Relationships** – states that: ‘anything that cuts across anything else must be

Is this a **principle** or a **law**? Circle the correct answer – if it is a principle add an ‘… unless….’

**Included fragments** - states that: ‘anything included in anything else must be older.’

Is this a **principle** or a **law**? Circle the correct answer – if it is a principle add an ‘… unless….’

**Applying the Principles**

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

- Outdoor (or indoor) courts (eg. tennis or badminton courts) with several lines
- A patched piece of road or pavement

- A cracked wall
- A local rock exposure
- A geological map sequence
Key to some rocks commonly used for ornamental purposes

**Gravestone or Building Stone**

Does stone react vigorously when touched with acid dropper? (Check if this allowed)

- No

Can you see the crystals or grains which make up the stone? (With a lens, if needed.)

- Yes
- No

Is the stone crystalline with crystals that interlock?

- Yes
- No

**Coarse crystals (easily visible with naked eye)**

- medium to light coloured, speckled
  - has quartz, feldspars & some dark minerals
    - GRANITE
  - has feldspars & dark minerals but very little quartz. May be iridescent
    - SYENITE OR DIORITE

- dark grey or green-grey
  - GABBRO

**Medium sized crystals (just visible with naked eye)**

- pale or speckled
  - OTHER IGNEOUS ROCK

- dark grey or green-grey
  - DOLERITE

**Consists of rounded or angular sand grains cemented together**

- pale grey, brown or red, often weathered black
  - fine-grained sandstone

- hard, dark grey, purple or greenish colour
  - very fine grained sandstone

- hard, dull black
  - slate

**Sedimentary rock**

- medium to light coloured, speckled
  - sandstone

- dark grey or green-grey
  - dolomite

- pale or speckled
  - limestone

**Igneous rock**

- hard, dark grey or green-grey
  - basalt

- very fine grained sandstone
  - granite

- very fine grained sandstone
  - syenite or diorite

- very fine grained sandstone
  - gabbro

**Metamorphic rock**

- sugary texture may be veined or mottled
  - marble

- non-sugary texture may contain fossils
  - limestone
**Tackling Rock Exposures Scientifically**

When you visit an exposure of sedimentary rocks, try ‘tackling them scientifically’; ask yourself these questions; look for clues to the answers; write down the answers and the clues too.

1. **What was it like here when the sediments were laid down and buried?**

   - Colour clues: usually …
     - red and khaki green rocks formed in deserts;
     - black or dark grey rocks formed without oxygen;
     - red, brown and yellow rocks contain iron;
     - pale grey rocks are limestones.
   - Grain type clues: usually …
     - if the rock reacts strongly with dilute acid it is limestone made of $\text{CaCO}_3$
     - limestones formed in clear, tropical, shallow seas;
     - other types of sediment could be formed in many conditions.

2. **What changes happened before the sedimentary rocks came back to the surface?**

3. **How is the rock being attacked now?**
   - What effect has this had on the shape of the land?

4. **What could the rocks be used for?**
   - Have they been used in the past?

**Clues to look for**

To answer these questions, you need to look for the clues in the rocks. These are just some of the clues that will help. Most of the clues usually work, but not always, so you need as many clues as you can find.

Write down all the clues in your notebook when you find them, even if you are not sure what they mean.

**1. What was it like here when the sediments were laid down and buried?**
Earth science out of doors

Grain size clues:

- rocks with big grains were deposited by fast water currents;
- sands were moved by winds or water;
- fine grained sediments were laid down in calm waters;
- sediments of mixed sizes were laid down quickly;
- rounded pebbles have travelled a long way, pebbles with sharp corners have not travelled far.

Sedimentary structure clues:

- flat layers were formed in water;
- layers sloping in different directions were laid down by water currents (but sloping layers more than 1 metre thick were deposited by wind currents) and the main direction of slope was the main current direction;
- ripple marks with one side steeper than the other had the steeper side facing down current;
- ripple marks with equal slopes were formed by waves;
- cracked mud formed when the mud was dried out;
- salt crystals formed in desert conditions.

Fossil clues:

- if the fossils are well preserved they were fossilised where they lived, or nearby;
- if the fossils are piled up, broken or worn, they were moved here after they died;
- if the sediment contains burrows, trails or footprints, the animals that made these trace fossils lived here;
- if only fossils of floating organisms are found, then this is a sea bed deposit where nothing lived;
- shell fossils are most common in sea sediments, less common in fresh water sediments;
- corals only grew in clear; tropical, shallow seas;
- coal and fossil soils formed in fresh water swamps.

2. What changes happened before the sedimentary rocks came back to the surface?

Sediment to rock clues:

- muds have been compressed to form mudstone or shale (shale has very thin layers that make it fall apart in your hand);
- sands have been cemented to form sandstones, and gravels have been cemented to form conglomerates (tough cements make tough rocks, weak cements make weak rocks);
- CaCO₃ has been cemented to form limestones.

Cracks across the layers:

- these cut across the rocks and so must have come after the rock formed.

Faults:

- these cut across the rocks and so must have come after the rocks formed.

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Faults:

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2. What changes happened before the sedimentary rocks came back to the surface?
Earth science out of doors

- some faults may have been filled with broken material and minerals may have been formed later in the gaps.

Folding and tilting: folding and tilting must come after the rocks were first laid down. usually ..
- tilted rocks were originally laid down flat (it is unusual for thick layers of rock to be laid down at an angle);
- some rocks have bent into folds under pressure;
- the pressures that formed the folds were from the sides: this can help you to work out the directions of the pressures.

Intrusions: these cut across the rocks and so must have come after the rock formed.
 usually ...
- hot liquid rocks can force their way through weaknesses in the rock, then cool down to become solid (crystalline);
- if they are thin layers that cut across the layers in the rocks they are called dykes, if they follow the layers, they are called sills;
- if they have large crystals, they cooled slowly, if they have small crystals, they cooled quickly;
- intrusions can form as large masses.

Cleavage: usually ...
- rocks that break to form thin sheets, like roofing slates, have been changed by metamorphism which produced cleavage.

3. How is the rock being attacked now? What effect has this had on the shape of the land?

Rock attack clues: usually ...
- if the rock has lots of broken fragments at the bottom of the exposure, it is being attacked by ice in the winter;
- if the rock has lots of small grains at the bottom, it is being attacked by water, wind and weather;
- if the rock has plants growing over it, it is being attacked by them;
- if the rock has a discoloured surface, it is being attacked by the chemical activity of the rainwater;
- holes and scratches are caused by animals (sometimes by human animals!).

Land shape clues: usually ...
- tougher rocks make hills and headlands, weaker rocks make valleys and bays;
- tough rocks with weaker rocks underneath form plateaus if they are flat, ridges with steep and shallow slopes if they are gently tilted, and ridges with two steep sides if they are steeply tilted;
- flat areas have weak rocks underneath and steep and rugged areas have tough rocks underneath;
- faults may form steep slopes or valleys;
- springs and streams can cut their own valleys.

4. What could the rocks be used for? Have they been used in the past?

Quarry clues: if your rock exposure is in a quarry, it must have been used for something;
- rock possible use
  a tough stone making roads, railways, buildings
  clay making bricks, tiles or pottery,
  weak sandstone building-sand,
  limestone road-building, lime for acid soils, etc.
  slate roofing slates,
  an attractive stone tombstones, facing stones for shops.
Earth science out of doors

<table>
<thead>
<tr>
<th>Cutting clues:</th>
<th>the material removed from road, rail or canal cuttings was often used to fill in a valley somewhere else.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal and mineral clues:</td>
<td>most exposures of coal and metal minerals will have been mined at some time in the past.</td>
</tr>
<tr>
<td>Water clues:</td>
<td>Drinking water from springs and wells.</td>
</tr>
<tr>
<td>Soil and environment clues:</td>
<td>the soil formed from the rock may be a good or poor soil; local stones may have been used to make stone walls and older buildings; farmers might have dug pits for lime-rich rock to neutralise acid soils.</td>
</tr>
</tbody>
</table>
### Teaching Points of ‘Earth Science Out-of-Doors’

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<th>Activity</th>
<th>Pattern (construction)</th>
<th>Challenge (cognitive conflict)</th>
<th>Explanation of thinking (metacognition)</th>
<th>Relevance (bridging)</th>
<th>Practical teaching points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preserving the evidence</td>
<td>There is progressive loss of evidence as we go back in time</td>
<td>Considering which things are likely to be preserved</td>
<td>Discussion</td>
<td>This demonstrates the thinking of a geologist in reverse</td>
<td>A good idea to have a ‘good’ specimen in your pocket (e.g. of salt pseudomorphs or ripples) to demonstrate the latter</td>
</tr>
<tr>
<td>Neighbourhood Stone Watch</td>
<td>Most materials in the built environment are Earth materials from under the ground</td>
<td>Weathering can be linked to rock type</td>
<td></td>
<td>Dilute HCl acid can be used to show the wide use of limestone (e.g. in aggregate) and that concrete is a carbonate made form limestone</td>
<td></td>
</tr>
<tr>
<td>Sorting out sequences (dating and interpreting sequences)</td>
<td>These emerge from dating techniques</td>
<td>Some sequences are simple, some have more challenge</td>
<td>Discussion</td>
<td>The same principles are applied to working out age relationships in most rocks</td>
<td>Can be demonstrated quickly indoors using sheets of paper: a) last one laid down in a pile is youngest (superposition); b) tear the sheets, which came first, sheets of tear (cross-cutting); c) which came first, the sheets or the pile of paper (included fragments)</td>
</tr>
<tr>
<td>Tackling rock exposures scientifically</td>
<td>These are given in the sheet</td>
<td>Application of given patterns</td>
<td>Discussion around application of patterns</td>
<td>These sheets can be applied to any sedimentary rock, <em>in situ</em> or not</td>
<td></td>
</tr>
</tbody>
</table>