# Key Stage 4

## A Geological Blink

## Student worksheet

This worksheet is about the age of the Earth and the origins of life on Earth.

### Paper Stratigraphy

*How old is the Earth?* Estimates suggest the Earth is around 4.6 billion years old, but modern humans may only have been around for as little as 200,000 years.

Think of a ream of paper (500 sheets) piled up. This ream of paper could describe the layers of rock beneath the ground. Only the top layer would describe human history – all 200,000 years of it. ...But how many sheets of paper would you need to make up all of Earth history? Use a calculator to work it out.

Researchers at the Oxford University are analysing samples of 1.4 billion years old mud from Northern Australia – fifteen times older than the oldest dinosaurs – to find clues about evolution, the history of life, and the geological history of the Earth. How many sheets/reams of paper would you need to make a 1.4 billion year timescale? Use a calculator to work it out.

### Your task: Paper Stratigraphy

As a class, you will work together to create a timeline for 1.4 billion years of evolutionary history. To do this you will need to:

1. Research what fossils, rock types, or traces of life can be found at points in Earth's history.
2. Find the correct sheet of paper by counting down from the top of the pile (remember, 1 sheet = 200,000 years or 0.2 million years).
3. Draw pictures or write down facts on the stratigraphic layers.

What do you notice as you go further and further back in time? Discuss this with your classmates.

### Lithification

**Lithification** is the compaction and/or cementation of deposited sediments to make new sedimentary rocks near the surface of the Earth, including the 1.4 billion year old mudstone of interest to the Oxford researchers. Sedimentary rocks may also contain plant and animal remains, which become fossils over time.

Over millions of years, the movement of tectonic plates downwards creates enough heat and pressure for sedimentary rocks to crystallise and become metamorphic rocks. Mudstone can crystallises into slate at lower temperatures and re-crystallise into schist at higher temperatures and pressures. Because of high temperatures and pressures, fossils are rare, except sometimes in slate. If the heat and pressure become so high that the rocks melt, magma is created, which cools igneous rocks which contain no fossils.

## Times Change

Strata are usually built up from the bottom upwards, but faulting, intrusions of magma and erosion complicate layering. Depth is a good indication of age, but can also be complicated, because sediments can be laid down faster in some times than others.

Different coloured layers give us information about changing conditions, such as a river drying out, or changes in the atmosphere. The **dry** atmosphere of Earth is currently 78% nitrogen, 21% oxygen, 0.04% carbon dioxide and other gases. However, as this changes, so do the living things that eventually die and become fossils in rocks. When there is more carbon dioxide in the atmosphere, we also find more carbonate rocks like limestones (during the Eocene, there was 0.3% carbon dioxide in the atmosphere – 8 times more than today!). Living things can act as a **carbon sink** to store up carbon, and then become new rocks such as coal.

Under heat and pressure, animal remains trapped in the layers of deposited rock can **change**. These changes include:

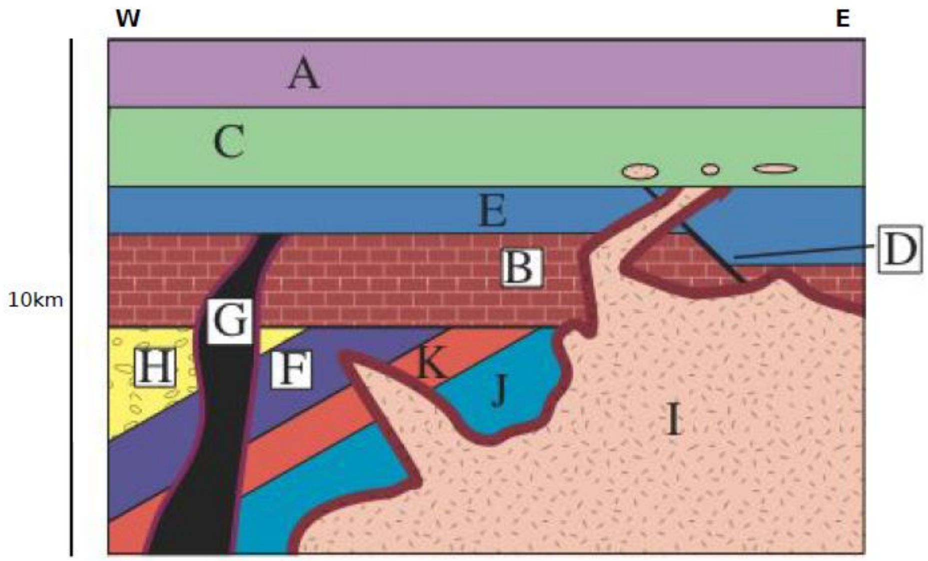
- Breakdown of some organic material (like skin and DNA) faster than others (like bone and nails)
- Warping/flattening of shape under heat and pressure
- Bleaching/loss of pigments and colour

The further back we go in time, the less we know about life. DNA, for example, is believed to survive up to 6.8 million years. Beyond this point, there is no DNA information about living things. Identify 6.8 million years on your paper stratigraphy.

https://www.oxfordsparks.ox.ac.uk/content/ancient-mysteries-marvellous-mud

## Your task: Date the Strata

1. Using what you know about strata, can you write the geological history of the cliff face shown in the diagram. Write the oldest event at the bottom of your page and work up to the youngest.

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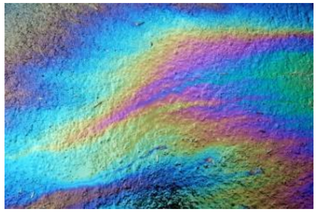
## Structural Colour

We already mentioned that bleaching or loss of pigments/colour is one of the changes that occur to fossils over time. Some scientists have used structural colour to identify the colours of dinosaurs and sea shells that are so old no DNA survives.

**Structural colour** is the **optical phenomenon** of seeing a colour because of the shape of something. We often see structural colour in nature, such as

- Soap bubbles
- Oil slicks
- Butterfly wings
- Seashells
- Beetle shells
- Fly wings



**Structural colour** arises because of microstructures that interfere with light**.** On the butterfly wing, for example, there is no blue pigment, but the wings often appear blue because of layers of ridged tiles that contain nanostructures shaped like fern leaves. When light bounces off these structures, it looks blue. **Structural colour** in oil slicks and soap bubbles comes about because of thin-film interference – the **constructive** and **destructive** interference of light waves reflected from the inside and outside surfaces of the oily film.

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**Constructive interference** is like when the peaks of two ocean waves meet and add up to make an even bigger wave. **Destructive interference** is the opposite – when the peak of a wave meets a trough and subtracts to leave a much smaller wave – or even possibly none!

## Your task: Make your own Oil Slick Rainbow

Make and capture a rainbow to take home using the principles of structural colour.

1. Lay a piece of thick black card into a tray and cover with water to ~1cm deep.
2. Use some clear nail polish to create a rainbow on the surface.
3. Pick up the piece of paper, collecting the rainbow of polish on top, and leave to dry.

## What is Biomineralisation?

The study of biomineralisation in rocks can help scientists to suggest which minerals were formed by living things. Minerals can be made by geochemical reactions – some of which take place on very long timescales – but also by biological processes. Some bacteria **respire, digest, and synthesise minerals.** Scientists can tell by looking at rock morphologies which minerals were laid down by early life forms.

One mineral, hydroxyapatite, $Ca_5(PO_4)_3(OH)$, only forms long fibres when it is made biologically. Finding **fibrous** hydroxyapatite crystals might indicate or “fingerprint” early life.

## Extension: Hard Water

The hardness of water tells us about its mineral content and provides clues about what kinds of rocks are nearby that the water has run over – perhaps ones which are high in carbonates, or calcium, like hydroxyapatite.

You will be testing the "hardness" of two samples of water, 1 and 2, and comparing them to a sample of deionised water.

1. Measure out $10cm^3$ of each sample of water.
2. Measure out $10cm^3$ of soap solution and add it to the water gradually stirring with a stirrer stick until it forms a permanent lather.
3. Stop adding soap solution and record how much you have remaining.
4. Repeat the experiment.

| Test | Soap solution left ($cm^3$) | Soap solution used ($cm^3$) |
|---|---|---|
| Deionised water | | |
| 1 | | |
| 2 | | |
| Repeat 1 | | |
| Repeat 2 | | |

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Why did you test and compare your findings to a sample of deionised water?

Why is it important to repeat the experiment?

## What is "hard water"?

The higher the dissolved mineral content of water, the "harder" it is. Common mineral ions found in water include calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$). Mineral ions dissolve in rainwater as it runs over rocks because it is slightly acidic. This means that the hardness of water varies from place to place, depending on the kinds of rocks that are present: in Wales, for example, the water is very very soft, whilst in the East Midlands it is extremely hard. You can see how hard or soft a sample of water is because the mineral ions react with soap – forming **scum** on the surface of the water – and so delaying the formation of a lather.

Water hardness can be temporary – where dissolved hydrogen carbonates are precipitated as carbonates on boiling – or permanent – where no precipitation happens after boiling and sulphates or chlorides are present.

Having read the paragraph above, write out the conclusions you have drawn from the experiment above.

**Conclusions:**

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