William Smith - 'The Father of English Geology'
Thinking like William Smith

William Smith was born in 1769 in Oxfordshire, England. The late 1700s were the beginning of the Industrial Revolution in the UK and iron production and coal mining were flourishing. At the time, most people believed that the Earth had been formed by God over seven days, about 6000 years ago. William had very little formal education but he was very interested in science and the Earth.

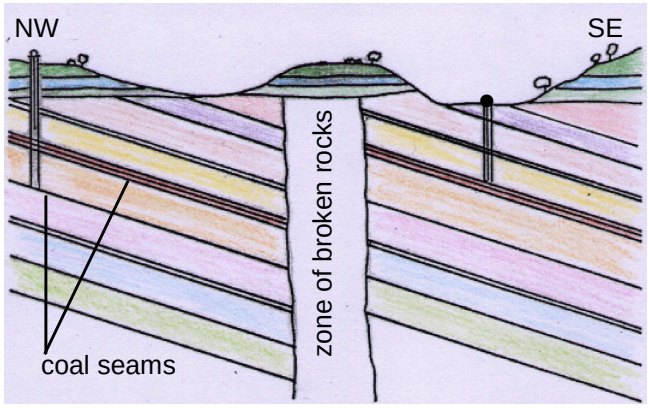
Ask the pupils to try to think like William Smith by answering the following questions:-

Q. William found objects like the ones shown in the photograph below in ploughed fields around his home. If you found these objects, how would you explain them? Describe them fully to each other. How do you think they got into the soil? What are your conclusions?

Strange objects found in a ploughed field *Photo: Elizabeth Devon*

A. *These objects are fossils of living creatures that once lived in the seas that covered the area we now call Oxfordshire. The one on the right is a sea urchin (Clypeas ploti). In William Smith's day it was known to everyone as an Oxfordshire pound-stone or Chedworth Bun and was used by the dairy-maids for weighing the butter. William was convinced that this fossil had once been an animal like a sea urchin. What was a sea creature doing preserved in a rock? Later, when others accepted that these had once been living creatures, they were told that they had been washed into Oxfordshire by Noah's Flood.*
The other objects in the photo are also fossils. They are brachiopods and they too lived in the sea. In William's time people collected these 'figured' stones and children played 'marbles' with them.

Q. When William was 18 he became an assistant surveyor and, in 1792, aged 23, he was employed to survey a local coal mine. He was given a copy of the geological section of the mine that had been drawn by John Strachey, Describe the angles at which the rock layers are lying; there are two different sets of layers. What happens to the layers on either side of the zone of broken rocks. What conclusions about this area can you draw from the following diagram?



Sketch from John Strachey's 1719 drawing of Mearns Colliery, Somerset

A. William noticed that the rocks near the surface were in nearly horizontal layers but the rocks beneath them, although also in layers, sloped downwards (dipped) towards the south-east. He could also see that a fault (zone of broken rocks) affected the layers. Coal seams stopped at faults and could be found on the other side, either at a higher level or at a lower level. William did not realise that the ground had moved on either side of the fault. He thought that it had always been like that.

It was in about 1792 when William was surveying the coal mine, that James Hutton (Earth Learning Idea 'James Hutton - or Mr. Rock cycle') recognised the processes of the rock cycle and realised that these processes had taken place over very long time periods, much longer than the 6000 years that most people had thought.

Q. William noticed something very interesting about the fossils in the layers of rocks. Certain fossils were always found in certain layers. What conclusions do you think he came to when he saw the following:-

sandstone
siltstone
mudstone with fresh-water bivalve, *Carbonicola*
siltstone with burrowing brachiopod, *Lingula*
coal seam
sandstone
siltstone
coal seam

Typical sequence of rocks familar to William Smith.
(The oldest rocks are at the bottom of the sequence)

A. *Knowing the sequence of the layers and the fossils, it is possible to forecast where the coal will occur, e.g. In this area, if you find the fossil Lingula in a siltstone, it is likely that a coal seam will be just beneath.*

William was employed to carry out survey work for the nearby proposed Somerset Coal Canal. Digging the canal meant that the country was sliced open to reveal layers of rock, or strata, gently sloping downwards towards the east. He quickly realised that his observations about the rocks and their fossils were true here too. This discovery, made by William in 1794, led to the very important geological '**Principle of Faunal Succession'.** Strata of rock of the same ages can be correlated (linked together in time) from one place to another based on the fossils they contain. Remember that William had no idea about relative ages of the strata or about geological time. He refers to the 'wonderful order' as a high and ancient order written by God.

In 1798, William bought his first house (with an 81% mortgage). He was now regarded as a gentleman, had an elegant house and admiring, influential friends. He made special cabinets for his new house to exhibit his growing fossil collection.

Q. If you had a collection of a variety of fossils, e.g. ammonites, nautiloids, belemnites, bivalves, brachiopods and gastropods, how would you display them?

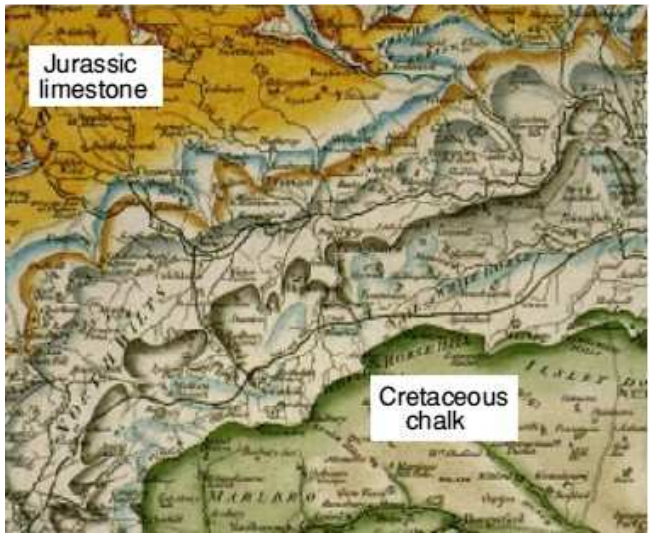
A. *Most people would group them into their various types but William Smith displayed them in their correct sequence in the rocks. He did not realise that he was actually putting them in age order with the oldest at the bottom of the sequence.*

Q. If you had discovered that there were many rock layers and that each one contained particular fossils, what would you do with that discovery?

A. *In June 1799 William, now aged 30, dictated his 'Table of Strata' to two of his friends. He named 23 rock layers, together with their thicknesses and typical fossils. He believed his method could be applied across the country. William gave away copies of his table because he wanted everyone to know about his amazing discovery.*

Between 1800 and 1815 William travelled the country recording the rocks, their dips and their fossils. He made a close study of more than 50,000 square miles of land. The Earth Learning Idea Mapwork activities will help you to understand how William mapped the geology of the country.

Q. Study the geological map shown opposite. If the rocks all dip (slope downwards) towards the south-east, which rock unit is at the base of the geological sequence?



Detail from William Smith's map.
The base of each rock unit is shown in a darker colour

A. *The rock unit at the base of the sequence is shown by the yellow colour. Imagine layers of books, tip them to the south-east and then let them slide down to show a sequence like this.*
We now know that, provided the sequence has not been turned upside down, the oldest rock is at the bottom. William Smith did not know this.

The story of William Smith's life now becomes rather sad; the miserable years began in about 1806. In 1807 the Geological Society of London was founded but William was not asked to join despite his great contribution to geology. He was not of the right social class. His personal life was in crisis and he was in debt at this time too.

However, despite all this, he produced the first geological map of a country, (England, Wales and southern Scotland) in 1815 to great acclaim.
Even though the map was unique, William still owed money and he was put in prison, (the King's Bench debtors' prison) in Southwark, London in 1819 for 11 weeks.

When he was released, he travelled to Yorkshire but remained very poor for the next twelve years. Finally, however, through hard work, he became richer and in 1824, he designed the Rotunda in Scarborough. In the museum, which is the shape of a cylinder, his thousands of fossils could be displayed in the proper chronological (age) order. It was first opened in 1830. It has now been renovated and it re-opened in 2008. Images of the building and the displays can be found on the internet.

The story has a happy ending as in 1832 William Smith received the first ever Wollaston Medal from The Geological Society. This is like an Oscar in the world of rocks. Adam Sedgwick, who presented the award, described William as the 'Father of English Geology'.

The back up:

Title: 'The Father of English Geology'

Subtitle: Thinking like William Smith

Topic: A series of questions and answers that attempt to outline the possible thoughts of William Smith, 'Father of English Geology', as he developed his ideas.

Age range of pupils: 14 – 18 years

Time needed to complete activity: 15 minutes

Pupil learning outcomes: Pupils can:
- explain that fossils are the remains of living organisms;
- describe how sedimentary rocks occur in layers or strata which may be horizontal or dipping;
- realise that the layers of rock may be broken by faults;
- explain that, if they are fossiliferous, each rock layer contains a specific set of fossils;
- realise that these rock layers with their particular fossils can be correlated (linked together in time) from one place to another;
- realise that scientific thinking in the 18th century was greatly influenced by religious beliefs;
- realise that in the 18th century it was very difficult for a clever man from a poor background with little education to join the world of the rich and educated.

Context:
When William Smith was reaching maturity, questions were being asked about the age of the Earth. Beliefs of the time were being challenged by people like Joseph Priestley (1733-1804) and Erasmus Darwin, (1731-1802), grandfather of Charles Darwin. Geology was established as a science at around this time, originally to enquire about the nature of the Earth before and after the Deluge, (Noah's Flood).
It is remarkable that William Smith, a poorly-educated Oxfordshire labourer, working alone, managed to survey and record the rocks of England, Wales and part of southern Scotland so accurately, especially as he did most of his travelling by horse-drawn carriage. His original geological map looks very similar to a modern geological map.

Following up the activity:
Follow up the development of Smith's thinking by studying Hutton's thinking in the Earth Learning Idea 'James Hutton - or Mr. Rock cycle' and Darwin's thinking in the Earth Learning Ideas entitled 'Darwin's 'big soil idea'' and 'Darwin's 'big coral atoll idea''.

Underlying principles:
- The sedimentary rocks at the bottom of the sequence are the oldest, unless the sequence has been turned upside down, (inverted sequences were unknown to Smith).
- Specific fossils can be found in specific sequences and show an evolutionary progression, (that the progression was due to evolution was unknown to Smith).

Thinking skill development:
'Thinking like Smith' involves bridging between the current ideas of the pupils and the ways in which geologists may have thought in the past. By its nature, such a process also involves construction, cognitive conflict and metacognition.

Resource list:
- imaginative minds
- copies of these sheets
- some real or replica fossils - optional.

Useful links:
You can find more about William Smith, how his thinking developed, and how important this was in the development of geology, by typing "William Smith" into an internet search engine, like Google.

Source: Developed by Elizabeth Devon of the Earth Learning Idea Team.