The Geology of the British Isles

A three billion year journey through time

The Precambrian Era

Britain's oldest rocks - the Precambrian Basement

The oldest rocks in Britain are in the north-west of Scotland. Here, in the Hebrides there are very ancient crystalline rocks known as **Lewisian Gneiss**, thought to be some 3,000 million years old. These rocks are extremely hard and reveal a tortured history during which they have been squashed and heated during mountain-building episodes known as *orogenies*. This was the dawn of life and only simple single-celled life forms existed in the oceans. On top of this gneiss is the **Torridonian Sandstone** which now forms isolated hills such as Suilven and Stac Poly. This rock is brown in colour which is from oxidised iron - an indication that oxygen was being released by early organisms into the oceans.

The British Isles were at this time split into two with Scotland and Northern Ireland attached to North America and the rest of Britain attached to Europe. The two continents were situated south of the equator and were separated by an ocean known as the Iapetus Ocean. Multi-cellular life similar to jellyfish were now beginning to thrive in the oceans. The first of these to be discovered was a 'sea pen' found in the Charnwood Forest, Leicestershire by a schoolboy, Roger Mason, in the 1950s and named *Charnia masoni*.

The Palaeozoic Era

An explosion of life

Most of these early life forms became extinct at the end of the Precambrian era. This was followed by what is known as the 'Cambrian explosion', a huge increase in the diversity of life on Earth as animals rapidly evolved to fill vacant ecological niches. For the first time there were animals with hard parts and their shells and skeletons became preserved as fossils. The most famous of these were the trilobites, curious woodlouse-like creatures that lived in these oceans in their billions. Fossil trilobites helped geologists discover the former existence of the Iapetus Ocean; it neatly explained why the trilobites in Wales and Scotland were of completely different species.

Many of our British rocks were formed during this time, one famous example being the **Wenlock Limestone** of Silurian age, a limestone teeming with fossils which exists at Dudley in the West Midlands and on the Welsh borders.

The joining of Britain - the Caledonian Orogeny

No ocean lasts forever, and the forces of plate tectonics were now shrinking the Iapetus Ocean. The two halves of Britain came closer together as the ocean floor disappeared down the subduction zone beneath northern England. As the ocean floor melted in the intense heat of the Earth's mantle the molten rock (known as magma) slowly rose to through the crust to form volcanoes in North Wales and the Lake District. This was no minor volcanic activity, the magma was slow-moving and sticky, a characteristic of some of the most dangerous volcanoes in the world. The volcanism reached a crescendo with a cataclysmic explosion, the evidence for which is preserved in the mountains of the Lake District. Ash from these explosions gave us the **Cumbrian green slate**.

The final collision of these two continents thrust up the huge Caledonian mountain range, as high as the present-day Himalayas, the roots of which are now the mountains of eastern America, Scotland and Norway. Deep beneath these mountains the pressures affected a multitude of buried rocks which are now exposed as gneiss, schist and slate which make up the bulk of the Scottish highlands. Some enormous and complex fold structures developed which are bounded by faults hundreds of kilometres long known as the Great Glen Fault and

the Highland Boundary Fault. Masses of molten rock were intruded into the base of these mountains creating the **Scottish granite** so familiar to us in the Cairngorms and employed for building the granite city, Aberdeen. By coincidence the join between the two continents lies beneath Hadrian's Wall, the traditional border with Scotland, but it is deep below the surface, covered by younger rocks. The collision also affected much of Wales giving us the metamorphic rock **Welsh blue slate**.

The invasion of the land

Plants were beginning to invade the land, followed by arthropods (animals that include insects, spiders, crustaceans and scorpions). Fossils of the world's first vascular plants, and therefore the first true land plants, known as *Cooksonia*, have been found on the Welsh borders. It was another 50 million years before the vertebrates (animals with backbones) invaded the land. Lobe-finned fish first achieved this with their ability to breathe air.

The destruction of Caledonia

Nature creates and nature destroys. The destruction of the Caledonian mountains by erosion had begun. Thousands of metres of sand and boulders were accumulating in depressions to the north and south. This created the **Old Red Sandstone** which now forms much of southern Scotland and Wales, particularly the Brecon Beacons. To the north it forms the great cliffs of the north coast of Scotland and the Orkneys, notably the Old Man of Hoy.

This period, known as the Devonian, is also known as the 'age of fishes' and remarkable fossils have been found in lake sediments in the north of Scotland. Periodic changes in the salinity of the lakes killed huge numbers and beautifully preserved specimens can be found in the flagstone quarries of Caithness.

Equatorial Britain

Britain was part of a continent that continued to drift north due to the unstoppable process of plate tectonics. Britain now lay on the equator and to the south a deep ocean called the Rheic Ocean stretched across Cornwall and Devon and France. As sea levels rose this tropical ocean spread across Britain. The seas were teeming with life and the algae, shellfish and coral reefs produced an enormous thickness of **Carboniferous Limestone** which now forms the hills of the Yorkshire Dales, the Derbyshire Dales and the Mendips and most of Ireland. Shallowing of this sea gave us the **Millstone Grit** which gives us the character of the northern part of the Peak District; the quartz fragments of which it is composed originating from the continued erosion of Caledonia. As the sea retreated, swamps of dense vegetation gave us the **Coal Measures** upon which much of Britain's prosperity was based. Associated with the coal are layers of **Coal Measures Sandstone** commonly known as the 'York Stone' which has paved many of Britain's streets and built countless fireplaces. Shortly afterwards an injection of magma into the limestones gave us the **Great Whin Sill** upon which now stands Hadrian's Wall.

At this time the Midland Valley of Scotland was a less hospitable place. Here there were tropical forests, shark-infested lagoons and numerous volcanoes, the most famous of which is now Edinburgh's Castle Rock, Arthur's Seat and Salisbury Crags. Into this environment came the amphibians, the first four-legged creatures to walk on land. The most famous of these was the fossil of a small, lizard like creature nicknamed 'Lizzie', found in Scotland in 1988 by Stan Wood. It was the first animal with the ability to lay eggs on dry land.

The disappearance of the Rheic Ocean - the Variscan Orogeny

Like the Iapetus Ocean a hundred million years before, the Rheic Ocean was destined to disappear. During the late Carboniferous period the ocean floor sunk into the mantle and the continents collided pushing up a giant mountain range, the roots of which are now the varied landscape of Cornwall and Devon. Rocks buried beneath this mountain range were squeezed creating the slates such as **Delabole Slate** which is still quarried today.

Other deeply buried rocks were melted to form granites which rose upward, eventually to become exposed by millions of years of erosion as the **Dartmoor Granite** and the granite of Bodmin Moor, Land's End and the Scilly Isles. Part of the ocean floor somehow refused to sink and got caught up in this monumental rock pile, eventually to be eroded at the surface giving us the Lizard Peninsula. The Lizard is therefore unique in Britain, being composed of the rock serpentinite, more commonly called **serpentine**. The granite remained hot for millions of years and water circulating through it and through the surrounding rocks dissolved metals and redeposited them as minerals such as copper and tin in cracks and fissures. The world-famous mining industry of Cornwall, and the historic heritage of Cornish engine houses, therefore owes its origin to this continental collision.

The Permian Desert

In the Permian period all the continents of the world were now joined in one huge land mass known as Pangea. Britain was now north of the equator - about where the Sahara is today - and in the middle of a huge, hot desert. Vast dunes of sand moved across the land and these have been preserved as the **New Red Sandstone** in places such as Dawlish in Devon, Nottingham, Penrith and Dumfries in Scotland. This rock makes a fine building stone and examples can be seen in most towns and cities. Salt lakes existed in this desert, much like the Dead Sea today. Great thicknesses of **salt** were laid down giving us the productive salt mines of present day Cheshire. Other minerals also crystallised in these lakes, such as **anhydrite** and, that most useful of minerals, **gypsum**. Deposits of gypsum are to be found mostly in Nottinghamshire and Staffordshire. At this time the reptiles were flourishing and had split into two groups, one of which was to give rise to the mammals and the other to the dinosaurs. Another well known rock formed in the Permian period is the **Magnesian Limestone** of north-east England.

This period of Earth's history witnessed the most devastating extinction of all. The Permian-Triassic mass extinction around 250 million years ago extinguished 95% of all life on Earth, providing the opportunity for the remaining groups of animals to prosper, in particular the reptiles that were to give rise to the dinosaurs.

The Mesozoic Era

The reign of the reptiles

Several rocks were formed during the Triassic period, such as the **Keuper Marls** and **Bunter Pebble Beds.** Sea levels were now rising which led, in the succeeding Jurassic period, to all of Britain being submerged except the Scottish Highlands, East Anglia and Cornwall. Sea levels rose and fell over millions of years providing a great variety of limestones, sandstones and clays which were laid down in the shallow tropical seas. A belt of Jurassic rocks is exposed across Britain from Dorset to Yorkshire such as the **Lias**, the **Inferior Oolite**, the **Great Oolite**, the **Kellaways Beds**, the **Oxford Clay**, the **Ampthill Clay**, the **Kimmeridge Clay** and the **Portland** and **Purbeck Beds**. There are also some isolated occurrences of Jurassic rocks in Scotland such as the Isle of Skye and on the coast of Sutherland. All of these rocks contain the fossils of marine creatures but occasionally fossils of land animals are found such as the dinosaurs of Oxfordshire.

The most famous British dinosaurs are from the Cretaceous period. The **Hastings Beds** and **Weald Clay** of Sussex and the Isle of Wight represented a shallow water environment where dinosaurs became preserved in the rocks. The south west coast of the Isle of Wight is currently the best dinosaur collecting site in Europe. The Cretaceous also saw the arrival of flowering plants, in fact the world's oldest known flower, 130 million years old, is said to be from Cretaceous rocks of the Weald.

The Hastings Beds are mostly sandstones which provide much of the character of the central Weald. Above the Hastings Beds is the Weald Clay and above this is the **Lower Greensand** which contains a number of rock types including **Kentish Ragstone**, a building stone which

was used extensively in Medieval London. Above the Lower Greensand is an extensive rock known as the **Gault**, a clay laid down over much of southern England and yielding fine fossils at Folkestone in Kent. Equivalent in age to the Gault is the **Red Chalk** which provides the colour to the cliffs of Hunstanton in Norfolk. A shallowing of this sea led to the deposition of the **Upper Greensand**.

Flooding of the continents

A rise in sea levels at the end of the Cretaceous saw widespread flooding of the northern hemisphere which laid down a great thickness of **Chalk** over much of northern Europe. Chalk is a remarkable substance as it is very pure and made up almost entirely of the skeletons of microscopic marine algae. Chalk is present under most of southern and eastern England but isolated remnants can be found on the Antrim coast and around the Western Isles of Scotland. The Chalk reaches a total thickness of over two kilometres and was laid down over a period of some thirty million years.

At this time the Atlantic Ocean was forming as Europe and America began to split apart.

The Caenozoic Era

The age of the mammals

The end of the Mesozoic era saw the demise of the dinosaurs and some 50% of life on Earth. This great extinction paved the way for the rise of the mammals. The first rocks of the Caenozoic era are the 'Lower London Tertiaries' which include the **Oldhaven**, **Blackheath**, **Woolwich**, **Reading** and **Thanet Beds**. These are present around the edge of the London basin and are overlain by the **London Clay** which is one of the most widespread rocks in the south-east. Lying on top of the London Clay are **Bagshot Beds**. Around this time the Alps were being formed as the continent of Africa collided with Eurasia and the pressure from this collision folded and distorted the rocks of Southern England. Subsequent erosion has produced the distinctive surface geology of the south-east with older rocks exposed in The Weald, younger rocks in the London Basin, and the chalk hills of the North and South Downs and the Chilterns.

Also at this time there were active volcanoes in western Scotland, particularly on Skye and Mull, which produced great quantities of granite, gabbro and basalt. The most famous products of these eruptions are the polygonal basalt columns of Fingal's Cave on the Isle of Staffa and the Giant's Causeway on the Antrim coast. These eruptions were associated with the opening of the Atlantic Ocean.

In Hampshire and Sussex are the **Barton Beds** and the **Bracklesham Beds** which have produced such fine fossils and on the Isle of Wight are to be found the **Hamstead Beds** and the **Bembridge Marls**. Of similar age are the **Ball Clays** of Bovey Tracey in Devon which were of such value in the production of fine china.

As we move up the geological time scale there is a gap in the geological record during which the rocks of southern England were gently tilted and folded to create the Wealden anticline and the London basin. The next rocks encountered are the youthful **Coralline Crag**, **Red Crag** and **Norwich Crag**, shelly sands that cover much of East Anglia.

With the Norwich Crag, a rock only one or two million years old, we have arrived in the present Ice Age, a time that saw the great ice sheets carve the present shape of our highest mountains and deposit glacial clays, sands and gravels over large parts of lowland Britain.

And finally, a word about geological time. This four page story covers 3 billion years and contains roughly 3000 words. That's one million years per word. . . . . .

Produced by Gerald Lucy. 1999