

The Age of the Earth
and the
Evolution of Life



In partial fulfillment of the requirements for
the History of Science Course 2006

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Based on the lecture of Dr. David Knight

- Professor of History of Science at University of Durham, England
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Lecture Delivered in Durham, England



on the river Wear



At the Science History Tour 2006

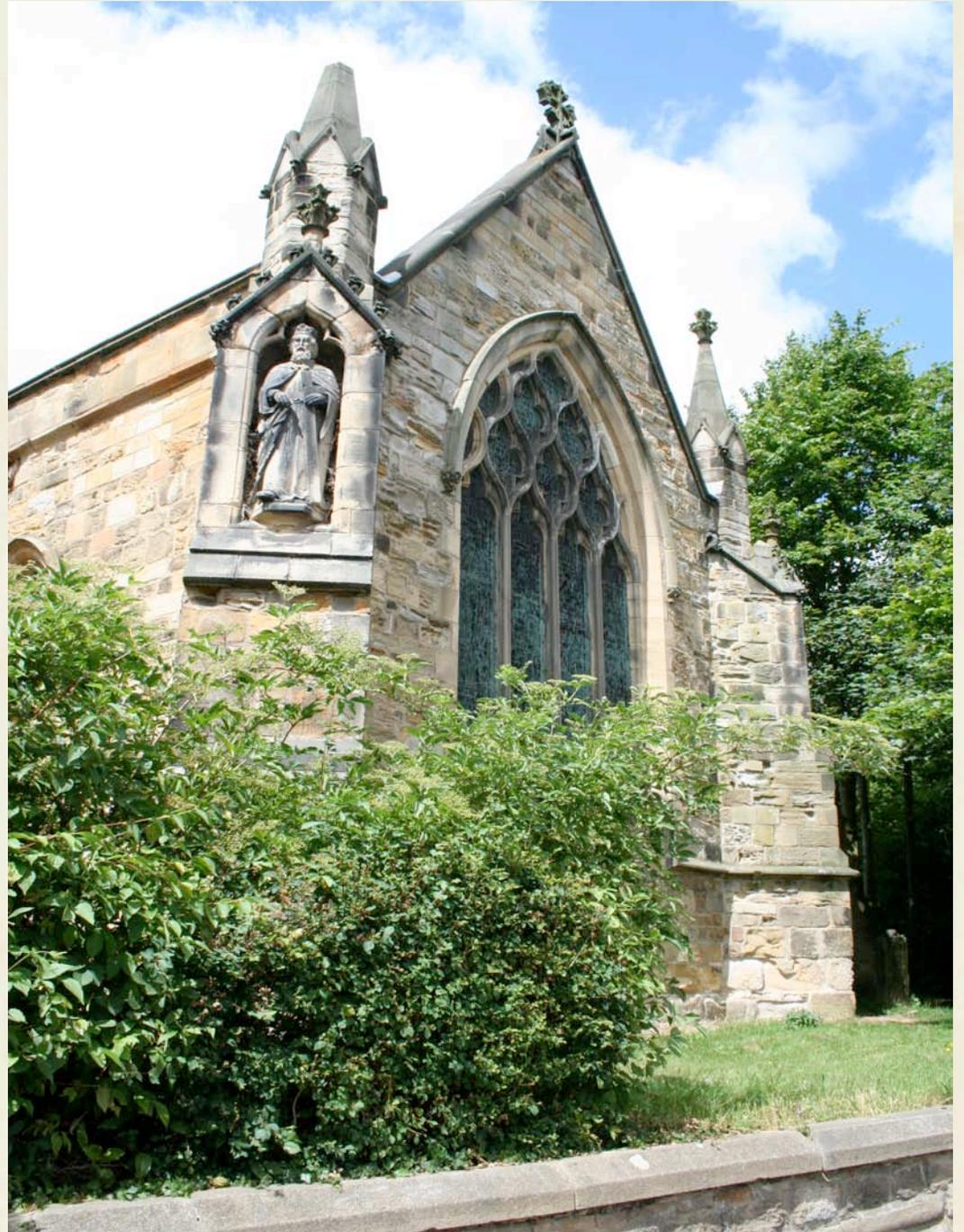


How old is the Earth?

- In 1650, Archbishop James Usher of Ireland calculated the age of the earth based on the genealogies presented in the Bible. He concluded that the earth was created in 4004 B.C.



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- At the Church of Saint Oswald in Durham



in the Cemetery





there is the
grave of the
Chaplain of
the Masons,
George
Baron
Jackson.





His tombstone shows the date that he died, not only from the Year of the Lord, A.D. (1810) but also from the Year of the World. A.M. (5810)
Note that on this tombstone, the year of creation was calculated as 4000 BC and not 4004 BC.

in late CHAMPLAIN
CON JACKSON MA
y. A. M. 5810 AD 1810
48 Years



Science and Religion conflict?

- Since education was usually only reserved for the clergy
- And being a naturalist involved reading, especially in classical languages
- Most natural philosophers were also clergymen who saw it their duty to explore the wonders of God's creation.
- Therefore, natural philosophers were not always objective in their conclusions.

Victoria Cave is located in the hills of Scotland



on a high ridge in a sheep pasture.









Questions?

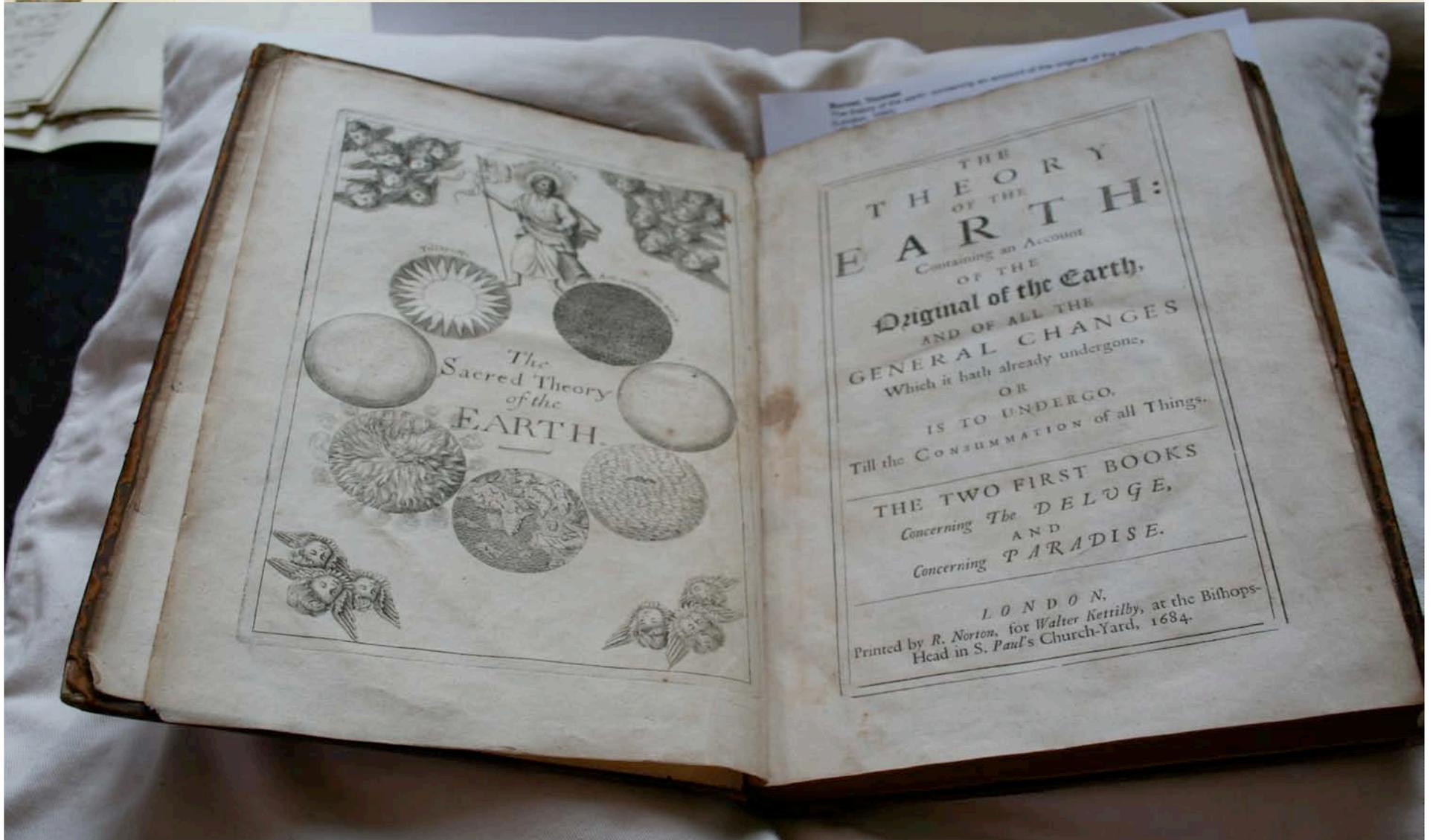
- Mastodons were found in North America.
Were they mistakes that God buried?
- Did all the fossils date back to the Great Flood?
- Had there been more than one Great Flood?



Answers?

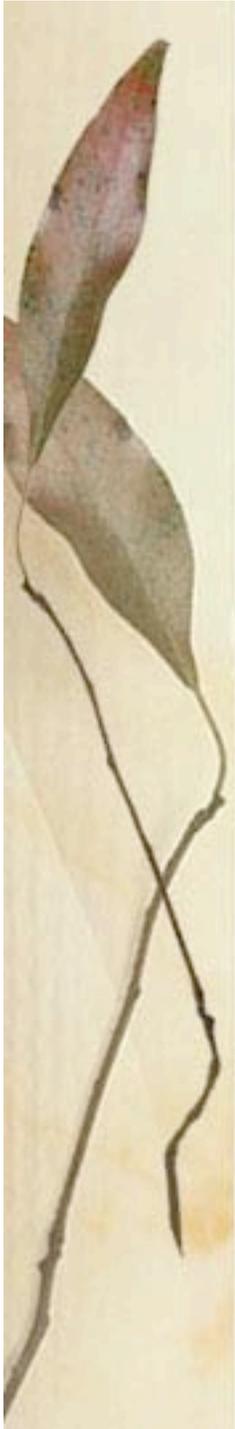
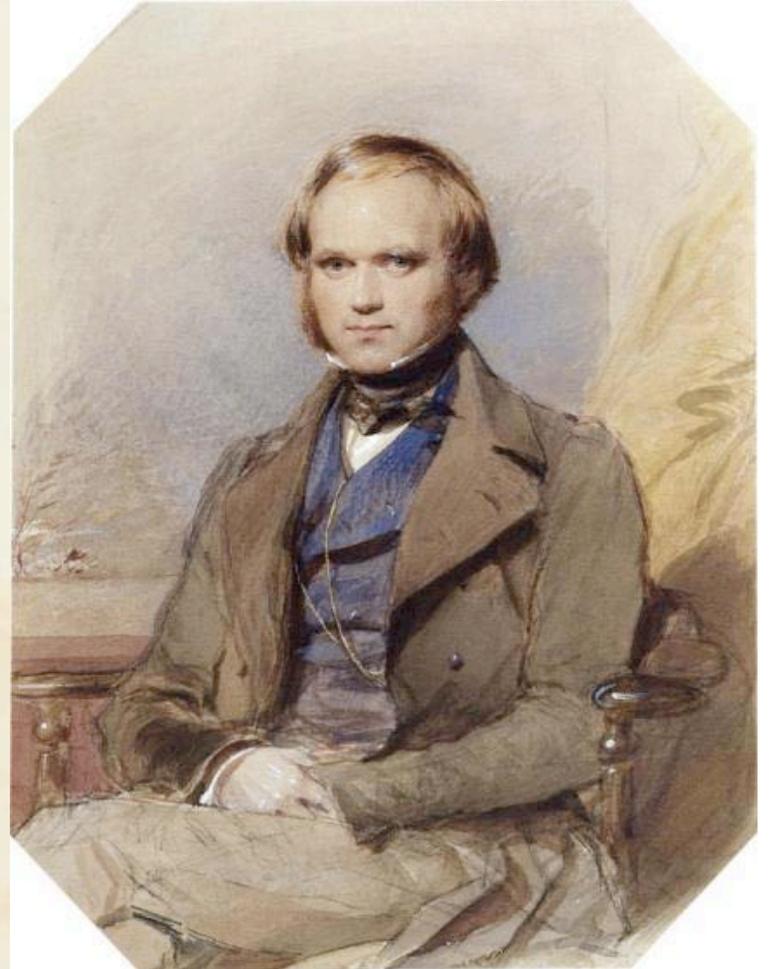
- Baron G. Cuvier proposed a stable earth until a catastrophic event occurred. The earth had suffered a series of these.
- The Reverend William Buckland proposed that “In the beginning” actually referred to a few million years.
- Buckland’s student, Charles Lyell felt that the processes that occur today should be a key to the past.

Books were published expounding these new theories.



A student of Charles Lyell was
Charles Darwin.

- An English naturalist who first developed an interest in medicine and theology while studying at the University of Edinburgh.

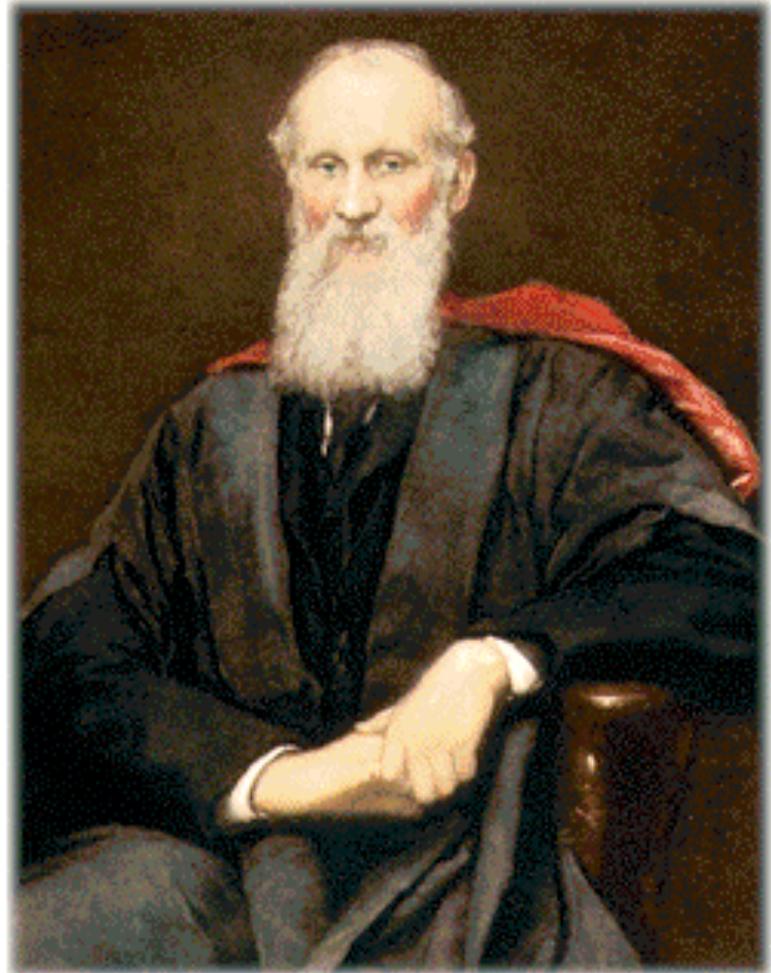


- Darwin's five year voyage of the *Beagle* led him to eminence as a geologist and a pronouncement that the earth was at least 400 million years old.



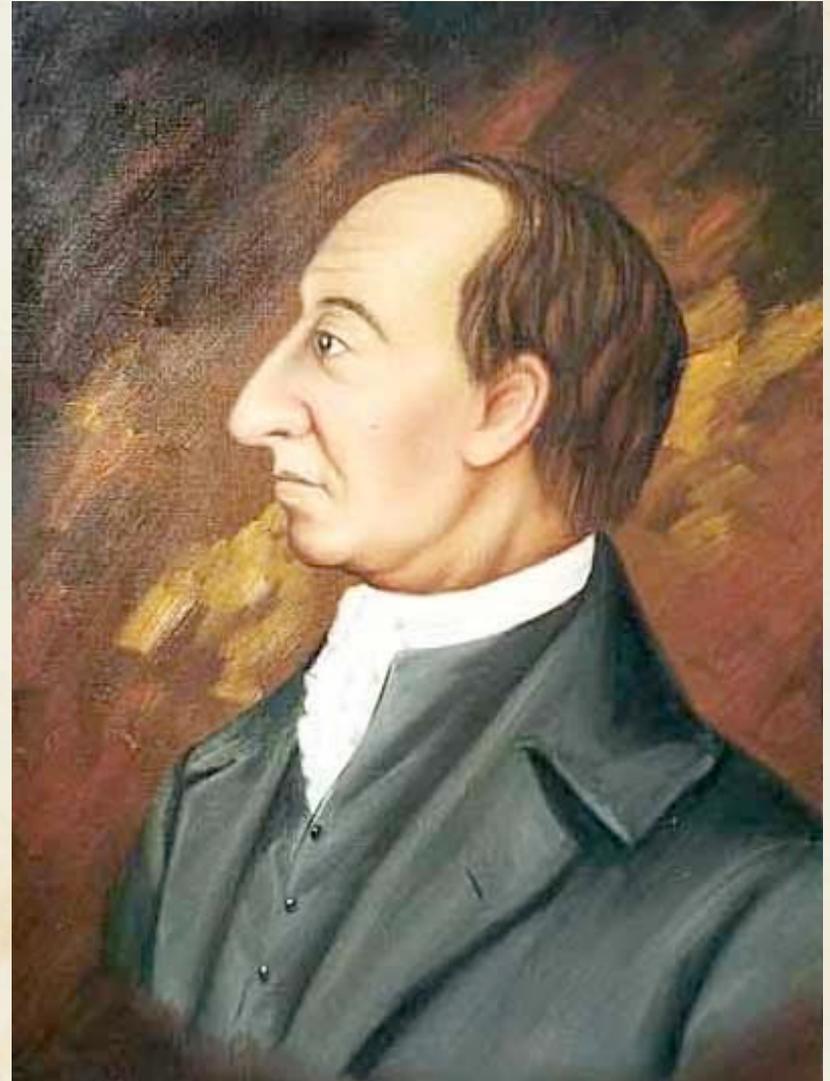
Lord Kelvin

- Lord Kelvin tried to determine the age of the earth by heat loss. He assumed it had been a red-hot globe and had cooled off so humans could inhabit it. The age was given as 100 000 000 years.



James Hutton

was a Scottish gentleman trained as a doctor and lawyer. He found himself attracted the science of geology.





Knockan Crag, located in the Scottish Highlands, is an important geological feature that attracted Hutton's attention.

At this site, internal pressure forced older rocks up and over younger rocks. This overthrust, the Moine thrust, showed that rocks could break, slip, and slide from their original positions. Geologists now began to think of a dynamic earth

Scottish Highlands







At Knockan Craig





Sea of time

Look closely and you'll see this rock outcrop contains two different layers. The top rock is younger than the one below, just like putting today's newspaper on top of yesterday's.

Both rocks formed in the same place, but the top layer is younger because it contains fossils of the animals that lived when the sea was shallow. The bottom layer is older because it contains fossils of the animals that lived when the sea was deep.



Seas of time

Look closely and you'll see this rock outcrop contains two different layers. The top rock is younger than the one below, just like placing today's newspaper on top of yesterday's.

Both rocks formed in warm shallow seas about 520 million years ago. The top one is known as Salterella Grit, because it contains fossils of a tiny snail-like animal called Salterella. Underneath are Fucoid Beds, which have trilobite fossils. These early life forms eventually developed into the horseshoe crabs you find in American and Japanese seas today.



Knockan Puzzle
The many layers
seen in this display
were deposited in a
series of stages over
a long period of
time.

Morris Schist

Salterella Grit

Durness Limestone

Fucoid Beds

Piper Rocks

Basal Quartzite

Torrington Sandstone



Knockan Puzzle

The crag above you is like a layer cake, with sheets of different rocks piled on top of one another.

Normally, the oldest rocks are at the bottom of the pile and the youngest at the top. But something strange has happened here: the top layer is much older than the rocks underneath.

Follow the path to find out why.

Moine

Salter

Basal Qu



Hutton found another geologic anomaly in the Salisbury Craigs near Arthur's Seat at the city of Edinburgh. Here more recent volcanic eruptions clearly intrude on older ones.



This is now known as Hutton's Section.

HOLYROOD PARK

HUTTON'S SECTION

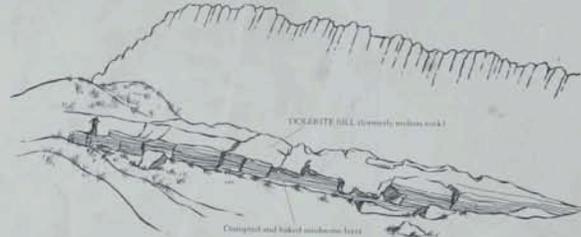
It was at this location that a fundamental discovery was made by James Hutton (1726-1797), regarded as the founder of modern geology. Using exposures created by the quarry then active on Salisbury Crag, he demonstrated that the rocks of the Crag had been formed from hot molten material.

The revolutionary idea advanced from the accepted wisdom of the day that rocks were formed from cold precipitation was to the sea. He developed his ideas on geology over many years, using numerous locations in and around the Edinburgh area. His book 'Theory of the Earth' was published in 1795.

About 100m further up the road, on the right, is Hutton's Rock. This is an early example of a natural exposure where Hutton is reputed to have noted the importance of seeing the rock as it showed a fine example of an igneous rock.



James Hutton was something of a polymath: a farmer, scientist, philosopher, and even poet who is known as the Scottish Enlightenment. This was the name given to the period in the history of the eighteenth century which was characterised by enlightenment, intellectual activity, and which put Edinburgh at the forefront of cultural and scientific advancement.



The Park is governed as a Scheduled Ancient Monument and as a Site of Special Scientific Interest. The Park Regulations are posted in full at each of the main entrances, however visitors should observe the following restrictions:
No off-road cycling
No dog walking on grass
No climbing other than in designated areas (green equipment)
No musical instruments



HISTORIC SCOTLAND









He also noted what became known as
“Hutton’s Unconformity” at Siccar Point
on the Berwickshire coast midway
between Dunbar and Eyemouth, some 30
miles east of Edinburgh.







SICCAR POINT

James Hutton (1726 – 1797) known as the founding father of geology was a man of genius.

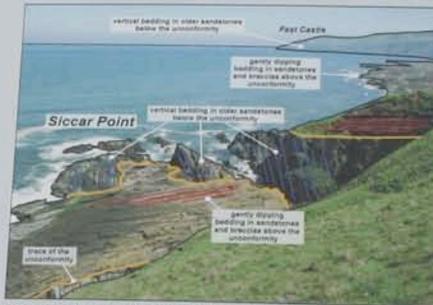
Whilst farming nearby, he indulged in his passion for geology. The rocks here at Siccar Point were the defining proof for his revolutionary Theory of the Earth. Most people at this time thought the world no older than a few thousand years. Hutton realised that earth processes are cyclical and that geological time is virtually unlimited. What we see today is very much how he would have seen it over 200 years ago (but a moment in geological time!).

SAFETY WARNING
The slope down to the unconformity is steep and dangerous. Please proceed with care at your own risk along the field boundary to your right. You do not need to go down to the shore to observe what these photographs illustrate.



A close-up of the unconformity from the shore

To find out more about Hutton AND THE TRAIL take a trip to the James Hutton Exhibition located at the Reiver Country Farm shop in Auchencrow.



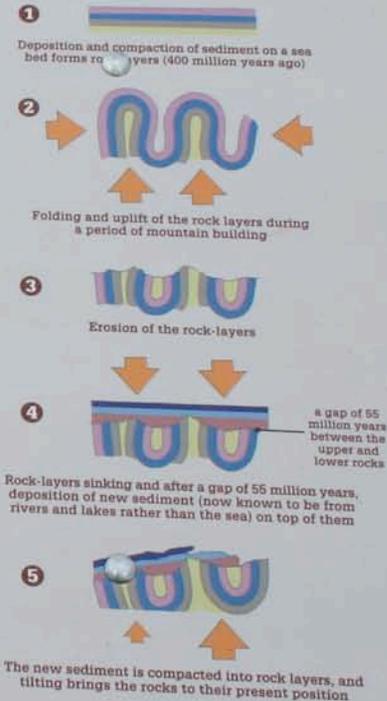
A view onto the unconformity from the top of the slope.

The yellow lines mark the time gap between the underlying vertical rock-layers (greyish in colour and called 'Greywackes') and the overlying gently dipping rock-layers (reddish in colour and called 'Old Red Sandstone and Conglomerates'). The gap represents 55 million years.

During this time the underlying rocks formed from layers of sediment deposited on the floor of an ancient ocean, had been folded, uplifted and eroded. This produced an uneven land surface onto which the overlying rocks were then deposited as sand and gravel. The irregular surface between the vertical and the gently dipping rock-layers is known as an unconformity.

"Having taken boat at Dungleess Burn, we set out to explore the coast," writes James Hutton of his trip down the Berwickshire coast with his friends John Playfair and James Hall from nearby Dungleess, to find the proof for his theory, and this they did. "At Siccar Point," he wrote, "... we found a beautiful picture of this junction washed bare by the sea". John Playfair, deeply moved by the significance of what they observed wrote later "The mind seemed to grow giddy by looking so far into the abyss of time".

HOW THE UNCONFORMITY WAS FORMED



Going down for a closer look



Here the lower part of the cliff shows layers of gray shale tilted to lie almost vertically, then immediately above this, lie nearly horizontal layers of red sandstone.



- Hutton reasoned there must have been several cycles involving deposition on the seabed, uplift and tilting with erosion, then under the sea again for further deposition.



- 
- At Siccar Point, around 1786, he remarked of his discovery of geological time, that “we find no vestige of a beginning, no vestige of an end.”

An abstract of Hutton’s theory was published in the transactions of the Royal Society of Edinburgh in 1788. Although controversial, the data could not be ignored.



The discovery of radioactivity and its methods of dating further convinced scientists that the earth was millions or even billions of years old.

Thus the age of the earth is now accepted to be 4500 million years instead of the 6000 years proposed just over 350 years ago.

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- At this point in time, we believe that the geological processes that we observe today helped shape the past and will shape the future. However, catastrophic events, such as asteroid impacts, did occur in the past and might occur in the future.
 - What the earth will look like in the next million or billion years can be predicted, but with considerable uncertainty.



Meanwhile, we rejoice in the beauty
of God's creation.

