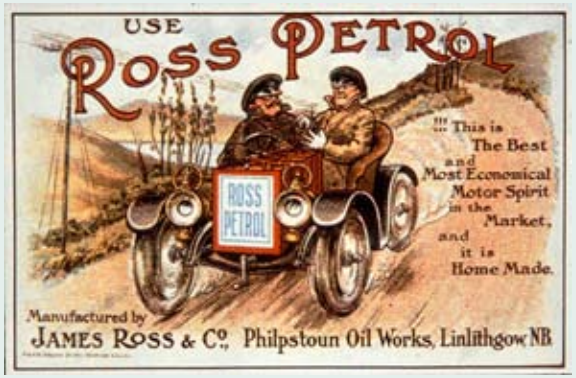
Forth Bridges and industry

From the Grangemouth refinery to the shipyard at Rosyth, directly to the north, the Forth is still an industrial area. Its industrial past, stretching back many years, is represented by the oil-shale bings near Livingston and former coal-fired power stations such as Longannet. The latter closed in 2016, but is still obvious to the north-west. None of this would have been possible without the area's fossil fuel-rich geology.



The Forth Bridges are at the narrowest point of the Forth for many kilometres. Why is it narrow here? It is due to the geology! Igneous rock headlands at North Queensferry, and Hound Point in the Dalmeny Estate on the southern shore, are more resistant to erosion than the softer sedimentary rocks along the coast. This igneous rock now provides suitable foundations for these impressive bridges.

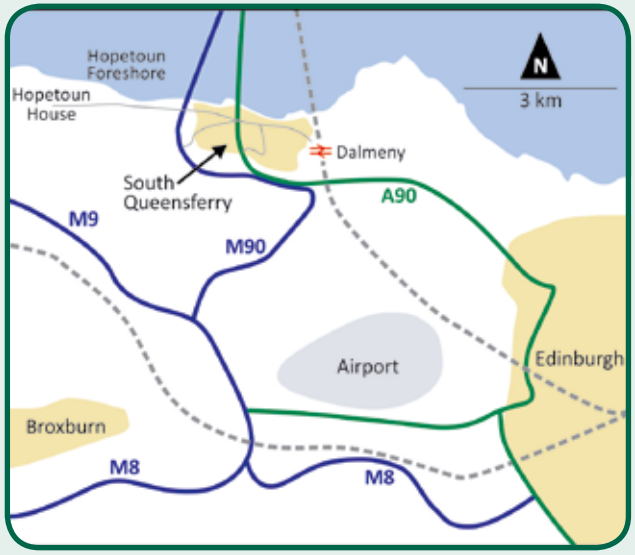
HOPETOUN
A LASTING IMPRESSION

Hopetoun House Ranger Service

Tom FitzPatrick, University of Edinburgh and members of the Lothian and Borders GeoConservation, a committee of the Edinburgh Geological Society, a charity registered in Scotland No SC008011.

How to get there

The Hopetoun foreshore is located on the south side of the Firth of Forth, approximately 1.5 km west of the Queensferry Crossing. You can get there from South Queensferry, which can be reached easily by bus or car, or train to Dalmeny Station. From South Queensferry follow the brown information signs to Hopetoun House, taking the road under the new bridge and along the coast for 3 km. Follow the right fork just before the Hopetoun Estate gates; 100 metres after this there is a small car park at Society Point. There are steps down to the rocky foreshore. Here, or at Nethermill Bridge (see map overleaf), are the only places where you can reach the foreshore.



Safety and Tides

Visit the coastline at your own risk. Parts of the route are across beach pebbles and boulders that can be slippery when wet. The area is tidal and access is difficult for about two hours either side of high tide. Granton tide timetables can be found on the BBC website at tinyurl.im/DaSZd.

Hopetoun Foreshore Geology Walk

West Lothian Council

Geological History

Scotland is the birthplace of modern geology and key aspects of the subject were developed here. For example, James Hutton (1726 – 1797) established that geological formations took much longer to lay down than the 6000 or so years that the then-contemporary estimates of the age of the Earth allowed. He also proposed that the geological processes like erosion, deposition and volcanic activity occurring today were the same as those that had operated in the past. In the 19th century this concept was developed as the *'Theory of Uniformitarianism'* popularised by Sir Charles Lyell; see Stop 3. Scotland has a varied and active geological history, ranging from rocks as much as three thousand million years old in the North-west Highlands, to recent beach deposits like those at Abercorn Point. The Hopetoun foreshore highlights two distinct geological periods when conditions here were very different: the Carboniferous Period and the Quaternary. In both cases though, sea level change affected the local environment.

Back in warmer climes : The Carboniferous Period 359-299 million years ago

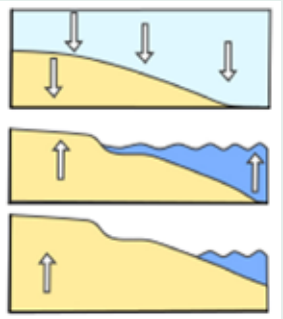
At this time Scotland sat just south of the Equator. The climate was mainly hot and wet, but with short drier periods. Sea level fluctuated, resulting in frequently changing environments, from land to sea, to rivers, to swamps, to shallow lakes and lagoons. Dense forests, which covered the land, are the source of much of Scotland's coal. Tectonic subsidence allowed over 5 km of Carboniferous sedimentary rocks to accumulate across the Central Belt. Volcanic activity was also widespread across this area: for example Arthur's Seat, Edinburgh and the Bathgate Hills, West Lothian.

The Quaternary: the last two million years

During the Quaternary Period, Scotland has been intermittently covered by a great ice sheet. These fluctuations were triggered by large-scale global climate change. The last major ice sheet peaked in size 21,000 years ago, reaching as far south as mid-Wales and The Wash in eastern England; evidence for this is seen across the UK. At times, Scotland was beneath at least 1 km of ice that covered even the highest mountains. Glaciers scoured the surface creating 'crag-and-tail' features like Binny Craig, near Livingston (which has a geology leaflet) and Castle Rock, Edinburgh. Many of Scotland's sea lochs, including the Firth of Forth, were formed by glaciers, which gouged out rock below present day sea level, for example to a depth of almost 200 metres below sea level off Bo'ness, 8 km to the west.

When the glaciers retreated, meltwater often cut deep gorges, like the one through which the River Almond flows upstream from Cramond. The huge weight taken off the land resulted in uplift, which formed the iconic raised beaches seen around the Scottish coast; including the Hopetoun Shore (Stops 4 and 6). Hopetoun's present landscape has been shaped by this glacial action.

How Raised Beaches form



Before 21,000 years ago – Thick ice sheet weighing land down for thousands of years. By 15,000 years ago this area was free of ice

7,000 years ago – Sea and land rise. Erosion and deposition by the sea forms a beach.

Last 6,000 years – Land continues to rise, lifting the beach out of the water creating a raised beach.

Local Geodiversity Site (LGS) and Site of Special Scientific Interest (SSSI)

The Forth Estuary is a biological and geological SSSI. The biological SSSI is to protect the important habitats for the many birds that come to feed and breed on the Forth's mudflats, sand dunes and rock islands every year.

A Local Geodiversity Site represents a particular landform, landscape or rock feature. The British Geological Survey and West Lothian Council have identified 50 sites across West Lothian that embody the area's geology and landscape; five of these are along the Hopetoun Foreshore. These are designated as important sites to demonstrate the variety of local geodiversity for planning, management and educational purposes.

Geological sites across the Forth have helped the understanding of Earth's history; including raised beaches, glacial erratics, volcanic activity and Carboniferous sedimentary rocks. Evidence for all of these can be seen in this leaflet. Both disturbing of the wildlife and hammering the rocks are not encouraged.

Local Sites and Amenities

Hopetoun House (www.hopetoun.co.uk), often referred to as Scotland's finest stately home, dates from the 17th century. It was designed by William Bruce who also designed Holyrood Palace in Edinburgh. Hopetoun House is very close to this geology walk. The grounds, house and cafe are open from Easter to September; an admission fee applies. South Queensferry has the nearest public conveniences, shops, pubs and cafes open all year.

Northern Gannet

Dunlin – breeding plumage

Birdlife on the Firth of Forth

The coastline of the Firth of Forth is a Site of Special Scientific Interest due to its geology and birdlife. Many habitats exist in the area for birds, from the islands, like the Bass Rock, which during the breeding season is white with gannets, to the mudflats off the Inner Forth, including Hopetoun. The mudflats annually host tens of thousands of migratory wintering birds, which join the resident breeding population. In the winter months during low tide they can be seen feeding on the food-rich mudflats. They include bar-tailed godwits and dunlin, which come from as far away as the Arctic to spend the winter months here.

The walk from Society Point to Abercorn Point explores two very different stories: the original formation of the rocks during the middle of the Carboniferous Period (345-326 million years ago) and changes that have happened during the current Quaternary Ice Age (the last two million years). The circuit along the foreshore (red line on map below) and back along the John Muir Way (green diamonds on map) is 5.5 km and will take 3-4 hours. A shorter alternative would be to walk to Stop 4 and back, which is about 1.6 km (1-1.5 hours).

Rocks on the beach can be slippery when wet. Take care, wear appropriate footwear.

Stop 1 Layers of time

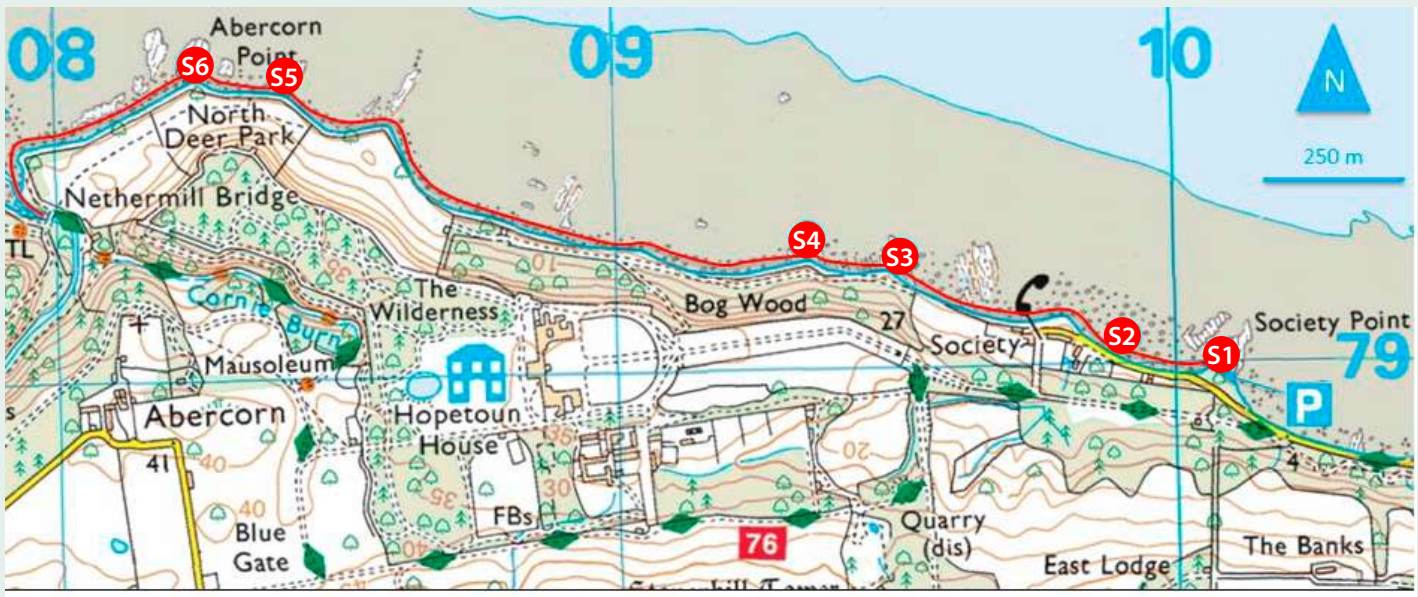
As you walk westwards along the shore, notice that the sedimentary layers are tilted towards you. This means that the rocks at Stop 3 are older than Stop 1, this gives us a chance to see how the climate and environment varied through part of the Carboniferous Period. Sedimentary rock types will vary depending on the environment in which they were deposited. From the geological history given do you think that there will be many different rock types? Yes, see the variety of rocks at Stops 1 and 2.

The old steps at Society Point are cut into sandstone. This rock is formed from sediment washed southwards from the Caledonian Mountains and deposited by an ancient river. The remnants of these mountains make up the Scottish Highlands and much of Scandinavia. The river deposited the sand in many layers or beds, which can still be seen today. This is the Binny Sandstone, which was quarried near Ecclesmachan in West Lothian and used in the construction of the National Gallery and The Scott Monument in Edinburgh, and many other 19th century buildings.

Stop 2 Search for oil-shale

Here there are dark beds of limestone, and a huge variety of pebbles. Some of the pebbles are of a special rock called oil-shale. It is dark black or brown and breaks easily into thin fragments. Some beds of oil-shale are visible here and there, but it has largely been eroded.

These rocks formed as freshwater lake deposits in Lake Cadell, (named for Henry Cadell, who investigated the geology of the oil-shales) which covered much of the Lothians during parts of the Carboniferous Period. The oil-shale formed in the middle of the lake from algal blooms dying and settling into water that had no oxygen. This meant that the algae did not decompose, and the carbon content is preserved today as hydrocarbons.



Hydrocarbons were extracted during the West Lothian oil-shale boom from the late18th century until 1962, ending with the closure of Westwood Colliery (Five Sisters Bing). Most of the time Lake Cadell received very little sand from rivers, so the sandstone layers seen at Stop 1 are rare. The limestone is also formed from algal blooms and other plant and animal material; however the water had oxygen so the organic matter decomposed. Plant fossils may be found in these rocks.

Stop 3 Ripples in time

'The Present is the Key to the Past' phrase summarises the Theory of Uniformitarianism, which has its origins in the work of pioneering Scots geologist James Hutton. Wave ripples within the sandstone were formed by river currents and have been preserved. Are there any modern wave ripples on the beach? The same processes that have created ripples in river and beach deposits throughout geological history form today's ripples. Small ripples like these have been seen on Mars and are one of the key pieces of evidence that the planet may have had liquid water.

Stop 4 Changing sea levels

Look towards Abercorn Point and you will see a large flat field inland from the shore; why is this? During the last glaciation, the weight of the ice had pushed the land down. Hopetoun became ice-free by 15,000 years ago and since then the land has been rising. Raised beaches formed around the coast of Scotland. The field behind Abercorn Point is a raised beach formed about 7,000 years ago. The land at Hopetoun is still rising very slowly at less than 1 mm per year. However sea level is now rising at a faster rate, driven by climate change.

A few small round boulders are dotted across the foreshore. These are boulders were moved by glaciers during the Ice Age and are known as glacial erratics, and when the ice melts the boulders are left behind.

Stop 5 Life on a raised beach

Looking closely at the small cliff here, what do you see? What shape are the pebbles and are there any fossils you recognise?

This is very similar to today's beach, but is actually part of the raised beach formed 7,000 years ago. It is composed of round pebbles, sand and mussel shells. The shells are often quite brittle because of their age. These are like present-day mussel shells on the modern beach and grew in a similar climate. Older sea bed deposits in eastern Scotland have Arctic shell fossils in comparison, reflecting the colder climate.

Stop 6 Could you move this boulder?

A prominent large, round boulder sits on Abercorn Point. This is another, rather impressive, glacial erratic of an igneous rock, probably dolerite, from one of the outcrops of this rock that lie to the west. It is the weight of three or four large cars and is testament to the carrying power of the ice.

West Lothian Geodiversity Sites

Sites important for their geological value used to be termed Regionally Important Geological & Geomorphological Sites (RIGS). However, RIGS are now called "Local Geodiversity Sites" and all these potential sites in West Lothian have been reviewed with the help of British Geological Survey, Lothian & Borders GeoConservation Group and Almond Valley Heritage Trust. As above, from the initial long list of several hundred potential geodiversity sites, these have been assessed and around 50 are considered to represent West Lothian's best geological resource and among these are the locations along the Hopetoun foreshore between Society Point and Abercorn Point.