Pentland Rocks!

The Geology of The Pentland Hills

Lothian and Borders GeoConservation

The Pentland Hills are a special place, a magnificent backdrop to the City of Edinburgh that can be seen and recognised from miles away.

It is hard to imagine that the story of these hills starts south of the Equator more than 400 million years ago at the bottom of a long-lost ocean; and that later this area became a desolate volcanic landscape subject to ferocious eruptions and clouds of volcanic ash; and that until quite recently it was repeatedly covered by glaciers.

How do we know this? How do we know that the Pentland Hills have not always been here, or looked as they are today? We know this from the rocks on the hillsides, in the streams, making up the walls, and on the paths you tread. Every rock is an important clue and helps us understand the past.

Rocks from the Sea

The story starts over 440 million years ago, in the Southern Hemisphere, where a large ocean called Iapetus (pronounced eye-ap-et-us) separated two barren continents. The northern continent, Laurentia, contained what we now call Scotland, North America and Greenland. The southern continent, Avalonia, was smaller and included England, Wales and some of northern Europe.

Over millions of years, rivers carried mud and silt into this ocean where it settled on the seabed, layer by layer, and eventually became sedimentary rocks, e.g. mudstone and siltstone. They are the oldest rocks of the Pentland Hills. All this happened very slowly, a metre thick layer of rock can represent thousands of years of sediment accumulation.

Life thrived in the Iapetus Ocean, including animals such as trilobites (which swam about or crawled along the sea floor and looked like large woodlice), graptolites, shrimps, corals, sea lilies and brachiopods. The fossils of these organisms are found in the some of the sedimentary rocks of the Pentlands.

Some of the rocks formed in lagoons close to the sea, and contain fossil brachiopods, one of which is named after the Pentland Hills: *Pentlandella pentlandica.*

Colliding continents

The surface of the Earth is always changing, and eventually the Iapetus Ocean crust started to be pushed beneath the adjacent continents as they moved towards each other around 420 million years ago. This squashed and hardened the sedimentary rocks on the sea floor, pushing them up into a series of folded layers. At The Howe, near Loganlea Reservoir, you can see where the rocks have been tilted and the once horizontal layers are now actually vertical.

In the process of this collision between continents great mountain ranges were created. Today we can see the eroded remnants in the Highlands and Southern Uplands of Scotland. In these mountainous areas great rivers transported boulders, pebbles, sand and mud from high to low ground.

Front cover image: from Hare Hill looking towards the north east

Thin beds of almost vertical siltstone exposed near The Howe. Photograph taken from path at NT 187 619 looking north west.

Some of this sediment accumulated in the Pentlands area, forming conglomerate (also known as "pudding stone"), a sedimentary rock made of fragments of different sizes.

A block of conglomerate by Logan Burn at NT 186 619 which has fallen from the waterfall above

The climate was hot and dry. Animal life was just starting to evolve to live on land and the only primitive plants were in low-lying damp areas.

Volcanic eruptions form the tough rock of the Pentland Hills

Most of the rock that forms the Pentland Hills is igneous, created from molten magma that formed deep beneath the surface and rose upwards. Some of this magma erupted as lava flows and ash clouds from volcanoes, and some was trapped beneath the surface. An early magma had high viscosity, (was very thick and sticky) and therefore could not flow very far, and simply piled up to create a dome. Black Hill is the remains of this dome and the rock is called microgranite.

Microgranite (known previously as felsite) from Black Hill. Note the weathered surface is a pink colour due to weathering and gives the scree on Black Hill a pink rather than black appearance.

Later volcanic eruptions formed the northern Pentland Hills. Lava and ash were spewed out building up layers of igneous rock that would eventually total over 1800 metres thick. Many of the volcanic episodes started with explosive eruptions throwing ash high into the air. This fell to the ground to be preserved as rhyolitic tuff, a light coloured rock that can be seen at the top

Brecciated trachyte from Torduff Hill

of Caerketton Hill. These eruptions were followed by lava flows up to 15 metres thick.

Some of the lava was very runny and flowed for miles, forming flat sheets of basalt. This lava was quarried locally at Silverburn and Torphin and used as aggregate for road building. Many other lavas were sticky and did not flow very far, like rhyolite. One lava at Torduff Hill, trachyte was so thick and sticky that parts of it solidified into rock while the rest was still flowing, so it now looks like a rock made up of lots of pieces stuck together.

Carnethy Porphyry

One lava flow resulted in an unusual rock type, the Carnethy porphyry. This can only be found in the disused quarry at NT 207 613. An impressive specimen can also be seen in the Information Centre at Flotterstone. This rock is the result of the slow cooling of magma while still within the crust beneath a volcano, allowing large crystals (phenocrysts) of feldspar to start forming. The magma was then erupted as a lava flow before it had completely solidified and the remaining molten material cooled quickly, forming small crystals around the phenocrysts. An igneous rock like this, with larger and smaller crystals, is known as a porphyry.

Carnethy porphyry

Rocks from the desert

After the volcanic eruptions stopped, the area became barren. Sand was eroded from older rocks and blown into valleys scoured by flash floods to be preserved as red

Devonian Red Sandstone

sandstone. These rocks, probably about 370 million years old, are the youngest surviving rocks of the Pentland Hills.

Ice Ages shape the hills

In the last two million years Scotland has been covered with ice many times. Glaciers, studded with sharp rocks, flowed over the tops and through the hills of the Pentlands from the west and south-west. The grinding action of these great ice sheets gave the Pentlands the rounded profile you see today.

When the ice eventually melted, 15,000 years ago, it produced a vast amount of water and these hills acted as a dam. Eventually the water broke through the hills creating deep valleys which drained into the sea, leaving the landscape much as we see it today. A pretty stream with wooden bridges now flows through The Green Cleugh and is all that remains of the gushing torrent which once filled this valley.

Other remains from this period are mounds of sand and gravel. These were left behind on land when the glaciers melted and washed away lighter rock fragments to the sea. This sand and gravel, for which Scotland is famous, goes into roads and construction.

Rocks back to the sea

At one time the Pentlands were a range of mountains thought to have been up to 2 kilometres high. There were forests, and probably dinosaurs, but all that remains is a range of hills with the tallest a mere 600 metres high. The rest is all gone, eroded by glaciers, wind, rain and frost, and washed away by rivers down to the sea.

Some rocks erode faster than others, and lava is especially hard which is why it has survived in the Pentlands so well. The global average erosion rate is roughly 1 millimetre every 30 years. It sounds tiny but it means that in a mere 2 million years the Pentlands could be a flat plain again.

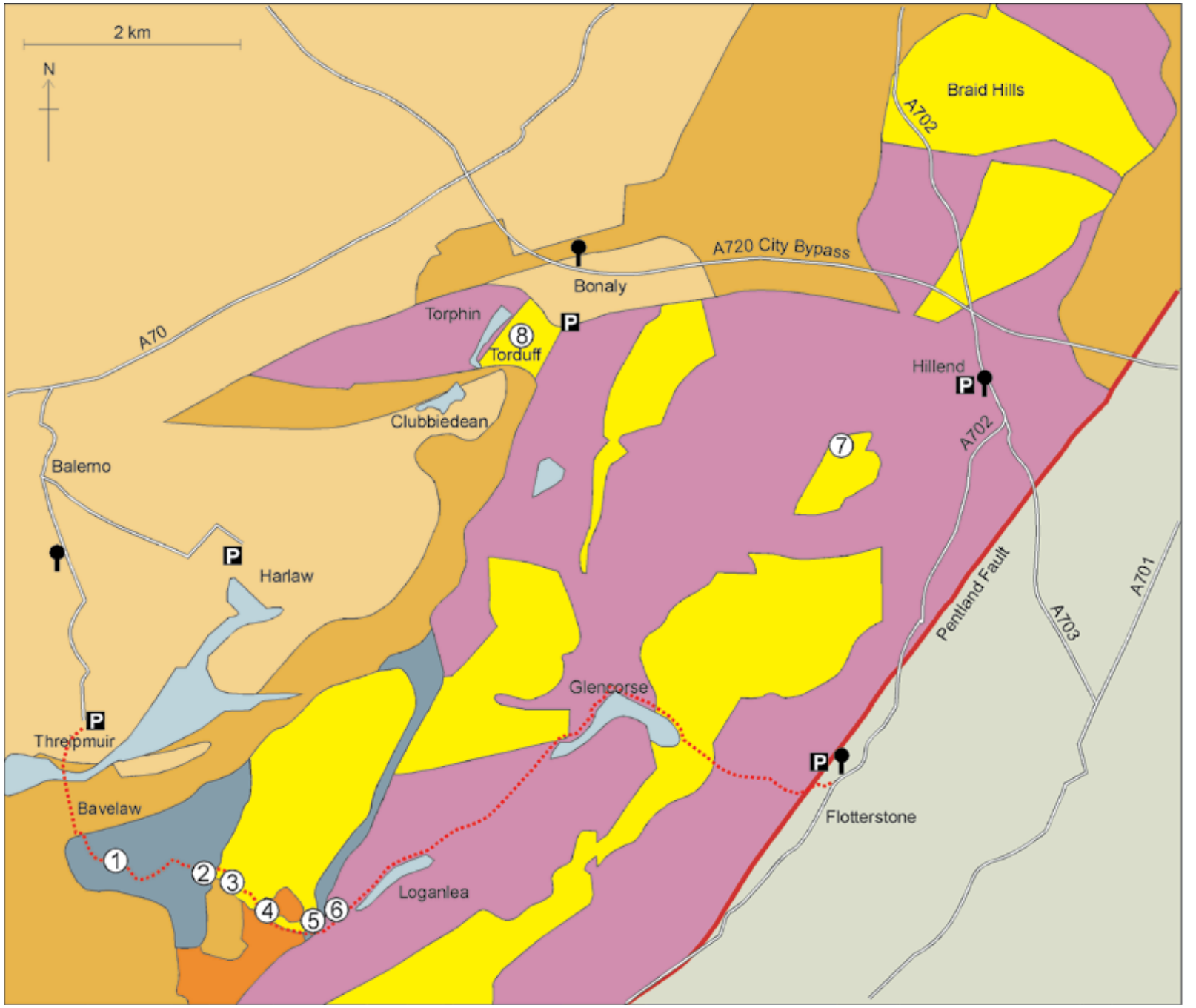
All over the Pentlands you will see patches of broken rocks where larger rocks have been shattered by the action of frost. This is called scree and the process will continue, the fragments becoming smaller and smaller, until they are light enough to wash down into streams and eventually out to sea. One day, millions of years hence, these may rise again and soar above the landscape as part of another great mountain range.

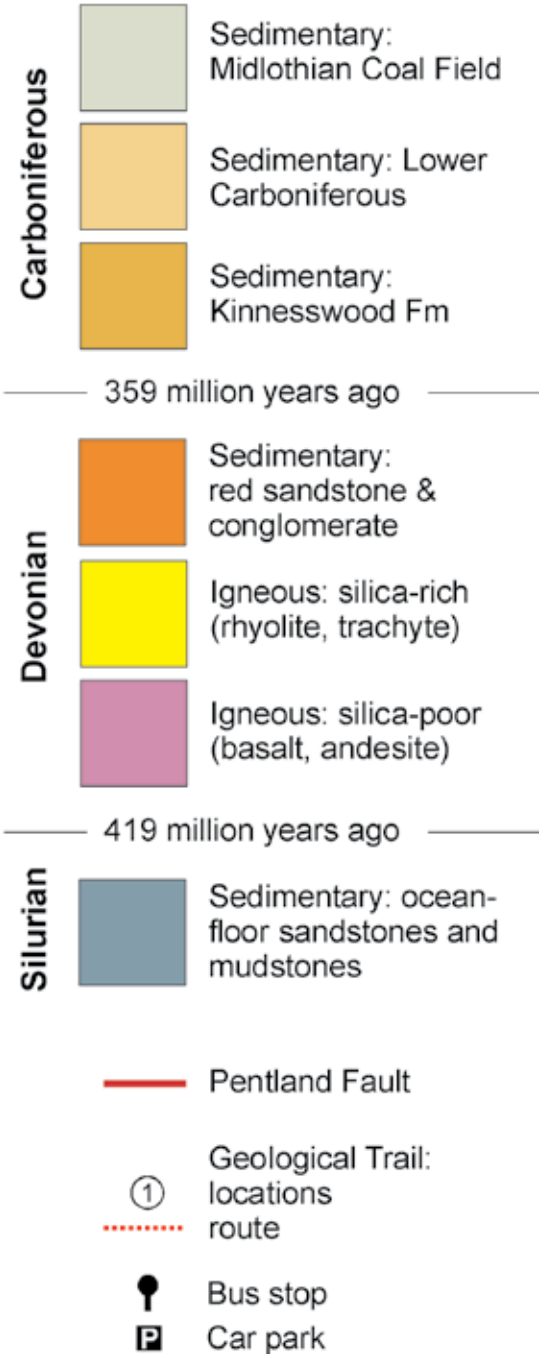
Our challenge to you ...

Now you know the story of the Pentland Hills so far. Most of the story comes from recent interpretation of rocks and other scientific discoveries, some in the last 50 years. There is still a lot we do not know or understand. So, when you visit, look at the landscape and the rocks. Does our story make sense? Can you add to it, or come up with new theories? Will you find a rock which gives us yet another clue to understanding the long history of the Pentland Hills?

Follow the geological trail from Bavelaw to Loganlea to find out more about the story of the Pentland Hills.

Geological map of the northern Pentland Hills





Geological map showing the different bed rock found at the surface in the northern Pentland Hills. The red dotted line shows the route of the Geological Trail in the second half of this leaflet.

Geological Trail

The Geological Trail takes you on a short walk from Bavelaw to Loganlea, discovering some of the important rock types and landscapes of the Pentland Hills. It takes about 1½ hours to follow the trail; from Loganlea you can continue through the Pentlands to Flotterstone, or return to the start point.

How to get there

The trail begins near Bavelaw Castle which is 14 km to the south west of Edinburgh city centre (see map page 6-7).

By Bus: Lothian Buses service 44 terminates at Cockburn Crescent, Balerno (bus stop code 36234964) and from here it is about a 4 km walk to the start of the trail. If you continue on to Flotterstone, the bus stop on the A702 at Flotterstone Inn (bus stop code 64323659) is served by Stagecoach West Scotland service 101 running between Dumfries and Edinburgh.

By Car: There is a public car park at Red Moss near the western end of Threipmuir reservoir (NT 167 639). From the car park it is a 2 km walk to the start of the trail.

Other localities of geological interest that are served by bus routes and car parks include Caerketton Hill (Lothian Buses service 4) and Torphin Hill (Lothian Buses service 10).

Bus routes and numbers change, so check for the latest information at www.lothianbuses.com and www.transportdirect.info.

Location 1:
Meltwater channels near Bavelaw Castle

The shallow, flat-bottomed valleys here are meltwater channels formed at the end of the last ice age, as water gathered here and drained eastwards through the Pentlands.The Geological Trail follows the main channel eastwards: you may notice in some places the channel goes uphill; this is because the meltwater was flowing at pressure under the ice. Since the ice melted some scree has accumulated in places, which has altered the shape of the channel.

View of meltwater channels looking east from near Bavelaw Castle at NT 168 626

Location 2:
Fault

The narrow gully on the left marks the site of a fault line. The rocks on the left-hand side of the gully are red sandstones, which have dropped during the faulting process to become level with the older rocks formed on the ocean floor in the Silurian Period. Some of the older rocks can be seen in the right-hand gully.

Location 2: Photograph taken from the path looking south at NT 175 625

Location 3:
Black Hill

Black Hill is composed of microgranite. This dark coloured rock breaks up to form sharp-edged fragments and weathers to the light colour seen on the scree slopes here.

Black Hill shows how rock type can affect vegetation. The microgranite rock is very hard and slow to break down so only very thin layers of soil with few nutrients can develop on the surface. The rock is rich in silica and makes acidic soil and heather is one of the few plants which can survive in these conditions, so Black Hill has the best heather cover of all the Pentland Hills.

View looking eastwards in Green Cleugh at NT 180 624 showing, on the left, the scree on the lower slopes of Black Hill

Location 4:
Conglomerate at The Pinnacle, above Green Cleugh.

The Pinnacle is made of Devonian conglomerate. Examples of this rock can be seen as fallen blocks along the path of Green Cleugh and in the stream bed.

The conglomerate contains pebbles of sandstone, lava and chert, all of which are derived from rocks older than the conglomerate. Younger dykes of microgranite have cut through the conglomerate in this area.

Photograph taken from the path in Green Cleugh at NT 185 621 looking north west.

Location 5:
Ocean floor sedimentary rocks near 'The Howe'

These sandstones, siltstones and mudstones originally formed on the floor of the Iapetus Ocean. The beds would originally have been horizontal, but are now almost vertical, evidence for compression associated with colliding continents as the ocean disappeared. Some fossils have been found in these sedimentary rocks, which is how we can work out how old they are.

Vertically bedded siltstones at NT 187 619 in relation to The Howe farmhouse.

Location 6:
Sandstone and Basaltic Lava at The Howe

Alternating layers of sandstone and lava can be seen near The Howe farmhouse just through the gate and on the north side of the tarmac road at NT 190 621

Below are two further localities at Caerketton Hill and Torduff Hill which could be visited either as an extension of this trail or by separate excursions (see 'How to get there' on page 8).

Location 7:
Cairn on Caerketton Hill

Picture taken looking NW from NT 241 661

The rocks of this man-made cairn are rhyolitic tuff collected from nearby quarries. One of these small quarries, now overgrown, can be seen near the top of the Hillend Ski lift.

There is another cairn nearby at NT 237 662 which is Bronze Age and a scheduled ancient monument so please do not disturb or remove rocks from these cairns.

Rhyolitic tuff is a silica rich ash and an igneous rock. The ash and small magma fragments were erupted explosively during volcanic activity and the rock shows a composite of fine and small fragments of ash which have consolidated into a hard rock over time.

Location 8:
Torduff Hill

Photo taken looking North from the top of Torduff Hill at NT 207 674 towards Edinburgh and the igneous rocks of Arthur's Seat and Salisbury Crags. The rock exposed here is a Trachytic lava which is an extrusive igneous rock.

This picture shows a close-up of the flow-banding (textured layers formed during the flow and cooling of the lava) in the trachyte at Torduff Hill

The leaflet is aimed at all visitors to the Pentlands who are interested in finding out more about the geological foundations of these hills. The Pentland Hills are a great place for school visits and teachers will find lots of potential for interdisciplinary learning. You can see the major characteristic features of the Scottish landscape, explain how these formed and how this helps us understand the impact of change on the physical world today.

The Pentland Hills Regional Park is managed by the City of Edinburgh Council Natural Heritage Service. If you need any further information about the Regional Park please contact Natural Heritage Service, Hermitage of Braid, 69a Braid Road, Edinburgh, EH10 6JF. Tel 0131 529 2401 **pentlandhills@edinburgh.gov.uk** or look at our website **www.pentlandhills.org**

USE YOUR CAMERA - no hammering, collecting or moving of specimens, please. Special consent for academic collecting can be obtained by calling Natural Heritage Service 0131 529 2401

Ordnance Survey maps. The most suitable is sheet 344 in the "Explorer" series, on a scale of 1:25,000, which covers all the locations mentioned in this booklet. On a scale of 1:50,000, Landranger Series, sheets 65 and 66 are required.

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